

SOUTH FLORIDA WATER MANAGEMENT DISTRICT



OPERATION PLAN

PERFORMANCE PLAN

TEN MILE CREEK

WATER PRESERVE AREA



January 2006

Gary Goforth, Inc.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT



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CERTIFICATION

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Date:

9/12/2011

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STRUCTURE REFERENCE

Structure Identification	Description	Normal Operations
S-382	7	24
S-383	9	25
S-384	15	26
Water supply return culvert	9	25
Emergency spillway	16	N/A
Seepage control	17	N/A
Fish Collection Ditch	17	N/A
Distribution and collection canals	17	N/A
Levees	17	N/A
Inspection Road	19	N/A
Gordy Road Control Structure	19	N/A
Boat ramps	19	N/A





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PLEASE NOTE

During the preparation of this *Operation Plan*, the following critical issues were identified that requires a change in previously proposed operations of S-383 to ensure that maximum project benefits can be achieved.

1. **Avoid Reservoir Dryout.** The draft Preliminary Water Control Plan (USACE 2003) calls for discharges from the reservoir to the treatment cell as the water level in the reservoir cell recedes to approximately 4 ft below the average ground elevation, to a stage of 14.0 ft. This operation is in direct conflict with one of the fundamental principles of other facilities associated with nutrient removal: avoid dryout in order to prevent the release of nutrients from the exposed soil. It also conflicts with the Water Quality section of the Final Design Documentation Report (see page 26): “As long as these reservoirs are managed so that drying is avoided, these nutrients will be bound to the sediments and kept there.” In general, for a reservoir/STA with a relatively flat bottom, a minimum depth of 0.5 ft above the average ground elevation should be maintained to minimize dryout and subsequent release of nutrients. However, in the case of the Ten Mile Creek reservoir cell with a variable ground elevation, it may be better to initially set the minimum depth at one foot above the average ground elevation, and refine this target after operational experience. Therefore, this *Operation Plan* recommends terminating releases through S-383 when the reservoir stage drops to 19.0 ft and initiating discharges when the stage rises to 19.0 ft. This change has the added benefit of significantly simplifying the operation of the S-383 structure during the wet season by allowing a uniform 35 cfs flow at all stages, instead of the previously proposed multiple flow rates at stages between 14.0 ft and 19.0 ft.
2. **Reduce Dry Season Releases as the Reservoir Storage Decreases.** The draft Preliminary Water Control Plan (USACE 2003) documents that the optimal balance occurs when dry-season releases to the treatment cell decrease with decreasing storage, yet in contrast, recommends a constant release of 35 cfs for all depths above 1.0 ft above the average ground elevation. Consistent with the above principle, the District simulation of the Water Preserve Area (Konyha 2002) incorporated a depth-dependent relationship that maximizes the water releases during the dry season and thereby prolongs the downstream estuarine benefits compared to the draft Preliminary Water Control Plan. Therefore, this *Operation Plan* recommends using the relationship used in the District simulation, modified with flows set to zero at stages above 29.0 ft, corresponding to the elevation of the emergency spillway crest.





Summary of Treatment Cell Start-up phase operations

- The target depth is between 0.5 ft and 1.0 ft, corresponding to a stage of 21.7 - 22.2 ft.
- With the gate at the S-384 structure closed, the gate or pumps at the S-383 structure should be operated to maintain the water level in the Treatment Cell to an average of 22.2 ft (i.e., a depth of 1.0 ft).

Summary of Normal Operations:

- The S-382 pumps should be turned on to capture stormwater runoff when the stage in Ten Mile Creek rises above 9.7 ft (see Table 3-1).
- During the wet season, when the reservoir stage is between 19 ft and 29 ft, the gate and pumps at S-383 should be operated to provide an average flow of 35 cfs to the treatment cell. When the reservoir stage is below 19 ft or above 29 ft, S-383 should be zero.
- During the dry season, when the reservoir stage is between 20.7 ft and 29 ft, the gate and pumps at S-383 should be operated to provide an average flow of $[2 * (\text{stage} - 18) - 5.4]$ to the treatment cell. When the reservoir stage is below 20.7 ft or above 29 ft, releases from S-383 should be zero.
- The gates in the Distribution Box downstream of S-383 should remain fully open.
- The gate at S-384 should be operated in concert with S-383 to maintain an average target depth of approximately 1.35 ft, corresponding to an average stage in the treatment cell of 22.5 ft.
- To minimize the occurrence of dryout, the gates at S-383 and S-384 should be closed when the stage in the reservoir cell falls to elevation 18.5 ft.
- To minimize dryout of the reservoir and treatment cells, S-382 should be operated to prevent the reservoir and treatment cell from drying out, subject to water availability in Ten Mile Creek. A minimum stage of 18.5 ft should be maintained in the reservoir cell and a minimum stage of 21.7 ft should be maintained in the treatment cell.

Summary of Extreme Flow Operations:

- Prior to extreme events,
 - the trash racks should be checked to ensure they are clear and working properly,
 - lower the water levels in the cells as much as practicable
- Terminate releases through S-383 and S-384 if the reservoir stage exceeds 29.0 ft
- As soon as safety permits after extreme events,
 - the operating status of all the pumps and gates should be checked,
 - repairs made if needed, and debris cleared if needed

Summary of Drought Operations:

- Maintain a minimum depth of 0.5 ft if water is available; this may necessitate lowering the “pump-on” set point for S-382, if needed.
- The S-384 gate should be closed when either the headwater stage drops to 22.0 ft or the reservoir stage drops to 18.5 ft.
- Following a dry out, keep the gate at S-384 closed for a period following reflooding to a stage of 22.0 ft, depending on the severity of dry out and the status of the vegetation:
 - if the vegetation is robust, the recommended period of closure following reflooding is approximately two weeks, although site specific conditions may require more or less time for the outflow concentration to drop below the inflow;
 - if the vegetation is damaged, the period of closure will likely be greater, to be determined by field conditions and phosphorus levels





1 PROJECT DESCRIPTION

1.1 BACKGROUND

The South Florida Water Management District (SFWMD), the U. S. Army Corps of Engineers (Corps), the Florida Department of Environmental Protection (FDEP), other agencies and private landowners are cooperating on efforts to improve water quality in the Indian River Lagoon watershed, including the St. Lucie Estuary. This cooperation includes studies and capital projects composing the Indian River Lagoon Project of the Comprehensive Everglades Restoration Plan (CERP), and related Critical Restoration Projects. Recent fresh water deliveries to the St. Lucie River estuary via Ten Mile Creek have been subject to great fluctuations in volume and timing, causing wide variations in salinity and stress to estuarine flora and fauna. The SFWMD and the Corps are collaborating to improve timing and volumes of freshwater deliveries to enhance estuarine water quality and productivity in the St. Lucie River estuary. The Ten Mile Creek Water Preserve Area (WPA) is a Critical Restoration Project authorized by Congress through Section 528 of the Water Resources Development Act of 1996. The WPA consists of a 550-acre reservoir cell followed by a 160-acre wetland treatment cell that will help regulate stormwater runoff volumes, reduce fine sediment and nutrient loadings, supplement dry season flows to enhance estuarine productivity, and provide irrigation water for upstream users after downstream environmental needs are met.

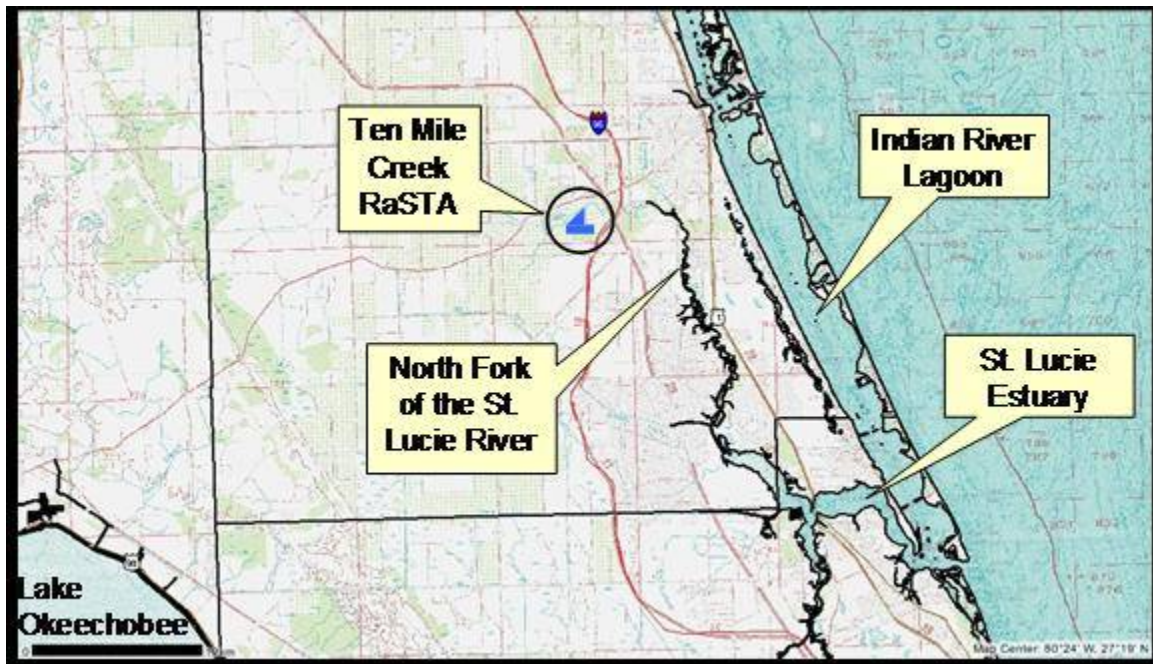
The Ten Mile Creek WPA is approximately 10 miles west of the Ft. Pierce (Figure 1-1), adjacent to Ten Mile Creek, and just west of the I-95/Florida Turnpike interchange. The project is located at the outlet of the 30,682 acre (48 square mile) Ten Mile Creek Basin. The average annual flow in Ten Mile Creek for the period 1965-1995 was estimated by the SFWMD as 40,165 acre feet per year (AF/yr), with approximately 15 cfs (10,867 AF/yr) as baseflow and the balance as stormwater runoff (Knight 1999). The WPA occupies approximately 710 acres, and the project site originally consisted of a citrus grove along with cattle pasture and some isolated wetlands scattered among low, shrubby uplands. The Ten Mile Creek WPA was designed by Post Buckley, Schuh and Jernigan (PBSJ) working under contract to the Corps, who was responsible for construction. Construction is presently underway with completion scheduled for early 2006. The SFWMD is the sponsor for the project and assisted in the funding of the capital works and will be responsible for operation and maintenance of the WPA. The anticipated long-term average phosphorus concentration reduction within the WPA was estimated during the design phase to approach 80% through a combination of the reservoir and treatment cell dominated by dense emergent vegetation (WSI 2002). Recent performance projections utilizing updated software (DMSTA2) suggests a more conservative concentration reduction of 66%.

After completion of construction and prior to turnover to the SWMD, the Corps will conduct an initial operational testing and monitoring period during which time data will be collected to demonstrate compliance with state water quality standards.





Figure 1-1. Ten Mile Creek Water Preserve Area location map.



1.2 OPERATIONAL OBJECTIVES

Long-term freshwater flows from Ten Mile Creek to the north fork of the St. Lucie River have been historically inconsistent, ranging from salinity depressing storm flows to lengthy closures of the Gordy Road water control structure to meet upstream basin irrigation needs. The farms and residences within the Ten Mile Creek basin require effective operation of the existing water control structures for flood control and water supply, but changes to the St. Lucie River's ecology have become increasingly evident as a result of the altered hydrology of this critical tributary. Additionally, degradation of the river's water quality has been observed and implicated in algae blooms and a reduction in estuary productivity, most notably by losses in seagrass and oyster bed coverage.

The primary operational objective of the WPA is **to control the quantity and timing of water deliveries** to the North Fork of the St. Lucie River by capturing and storing stormwater currently being discharged at unnatural rates. These uncontrolled discharges and excessive stormwater runoff are currently degrading the water quality and wildlife habitat of the St. Lucie estuary and Indian River Lagoon by radically upsetting salinity concentrations, increasing the deposition of sediments and nutrients, and reducing the amount of freshwater recharge into the aquifer. The primary benefit of the WPA will be to help re-create a more natural salinity range in the St. Lucie Estuary by establishing a more natural pattern of freshwater flows from Ten Mile Creek into the North Fork of the St. Lucie River. Stabilizing the salinity concentration will greatly enhance the estuary's ability to support sea grasses, oysters and nursery grounds for marine fish. Commercial and recreational fishing are very





important activities in this region and will be benefited by an improved estuary. The West Indian Manatee, an endangered species, is dependent on sea grasses as a primary food source. This project coupled with ongoing water quality improvement projects will help to reduce the future decline of sea grasses in the estuary.

Secondary operational objectives include **reduction of the sediment load** delivered to the estuary through sedimentation of suspended solids in the WPA. In addition, the stormwater will pass through a shallow water marsh for additional water quality treatment, primarily to **reduce nutrient levels**, before being released into the North Fork. Stored water will also **increase the amount of freshwater recharge into the aquifer**, and further reduce demand on the aquifer through releases back to the Ten Mile Creek basin in the drier winter months to **augment local water supply**.

The Corps has developed a draft Preliminary Water Control Plan for the Ten Mile Creek WPA to cover operations **during the operational testing and monitoring phase, and prior to turnover to the SFWMD** (Corps 2003). The operational testing and monitoring phase includes the critical initial reservoir filling. This *Operation Plan* is designed to cover the operations **after the project has been turned over to the SFWMD**. However, to assist in the establishment of desirable wetland vegetation, this *Operation Plan* contains suggested operations for the start-up of the treatment cell. Both plans were written with flexibility to allow refinements to the operations in order to achieve the desired project benefits while maintaining the existing level of flood protection in the Ten Mile Creek basin.

The Ten Mile Creek WPA encompasses approximately 700 acres adjacent to Ten Mile Creek, as shown in Figure 1-2. A flow schematic of the WPA is presented in Figure 1-3. The inflow pump station lifts water from Ten Mile Creek at the northern edge of the WPA and delivers it to a 526-acre reservoir cell for storage and initial water quality treatment. Approximately half of this water is passed into a 132-acre treatment cell, where additional water quality treatment occurs through natural biogeochemical processes. Water levels and flow rates through the reservoir and treatment cells are controlled by gated structures located at the western boundaries of each cell. Deep zone trenches at the inflow, center and outflow of the treatment cell are designed to help distribute flow evenly throughout the cell. Treated water is discharged back to Ten Mile Creek through a water control structure and approximately ½ mile of an existing drainage canal. A portion of the captured stormwater will be released back to Ten Mile Creek to meet water supply demands in the upstream basin if sufficient water is available in the reservoir to achieve the other project objectives.

Emergent wetland vegetation (cattail, bulrush, *sagitaria*, *pontedaria*, etc.) has already begun to colonize the treatment area, and an average operating depth of 1-1.5 feet should be conducive to sustaining these communities. The phosphorus concentration in Ten Mile Creek runoff exhibits considerable variability, with an average of approximately 245 parts per billion (ppb) (WSI 2002). Water quality performance estimates were generated during design, yielding a long-term estimated phosphorus concentration in the treatment cell outflow of approximately 50 ppb, roughly an 80% reduction compared to the inflow concentration





(WSI 2002). Recent performance projections utilizing updated software suggest a more conservative outflow concentration of 76 ppb, yielding a reduction of 70% within the WPA. The combined reservoir/treatment cell was also projected to lower the average total nitrogen concentration from about 1.6 to 1.2 mg/L (WSI 2002). The long-term phosphorus storage mechanism within the project will be the accretion of new organic sediment, and for this reason it is important to operate the reservoir and treatment cells to avoid dry out, which will oxidize the organic soils and release stored nutrients downstream.

In addition to the reduction of nutrient loads and concentrations, the Ten Mile Creek WPA will provide additional water quality and quantity benefits to downstream waters, including the removal of suspended solids, metals, and pesticides that would otherwise flow into the North Fork of the St. Lucie Estuary.

It is intended that the operational guidance in this plan be implemented with flexibility to make incremental changes in order to achieve desired project benefits while maintaining the existing level of flood protection in the Ten Mile Creek Basin.

Figure 1-2. Aerial of the Ten Mile Creek WPA.





Ten Mile Creek Water Preserve Area
Structures & Flow

Legend:

- Pump Station: Blue square
- Gated Culvert: Red square
- Emergency Overflow Weir: Yellow rectangle
- Inflow: Brown arrow
- Outflow: Yellow arrow
- Internal Flow: Green arrow
- Treated Flow: Light blue arrow
- Deep Zone: Orange line

Map Labels:

- Ten Mile Creek
- Reservoir Cell
- Treatment Cell
- S-382
- S-383
- S-384
- C-93
- C-95
- C-96
- C-101

Flow Description:

The diagram illustrates the water flow within the Ten Mile Creek Water Preserve Area. Water enters the Reservoir Cell from Ten Mile Creek via an Emergency Overflow Weir (S-382). Inflow is shown by brown arrows. Outflow is shown by yellow arrows. Internal flow within the Reservoir Cell is indicated by green arrows. Water is pumped from the Reservoir Cell to the Treatment Cell via a Pump Station (S-383). The Treatment Cell contains two Deep Zones (orange lines) and shows treated flow (light blue arrows). Water exits the Treatment Cell via a Gated Culvert (S-384) and flows into C-96. The area is bounded by C-93, C-95, and C-101.





A summary of the key operational parameters is presented in Table 1-1.

Table 1-1. Summary of Ten Mile Creek WPA Operational Parameters (from PBSJ 2002, WSI 2002 and this Plan).

Design Parameter	Reservoir Cell	Treatment Cell	Entire WPA
Water Preserve Area			
Effective Area (acres)	526	132	658
Total Area (acres)	550	160	710
Average ground elevation (ft NGVD) ¹	18 ±	21.2 ±	18.4 ±
Flow			
Average annual flow in Ten Mile Creek (AF/yr)	40,165		
Ave. annual baseflow in Ten Mile Creek (AF/yr)	10,867		
Nominal peak inflow with all pumps (cfs)	380	40	
Average pumped inflow (cfs)	22	11	
Average annual pumped inflow (acre feet/yr) ²	16,070	7,710	16,070
Average hydraulic loading rate (ft/yr)	31	59	
Average hydraulic loading rate (cm/d)	2.5	4.9	
Average water surface (ft NGVD) ²	24.6 ±	22.5 ±	
Mean depth at average water surface (ft) ²	7 ±	1.3 ±	
Volume at average water surface (AF)	3,844	167	3,469
Nominal hydraulic residence time (days) ²	83	8	
Nominal linear velocity through cell at average flow (ft/day)	56	303	
Target minimum depth (ft)	1.0	0.5	
Target minimum stage (ft NGVD)	18.5 ±	21.7 ±	
Estimated water supply returned to Ten Mile Creek basin (AF/yr) ²	3,583		3,583
Estimated seepage loss (AF/yr) ²	4,880	1,038	5,918
Estimated discharge from treatment cell (AF/yr) ²		6,736	6,736
Est. flow in Ten Mile Creek after WPA (AF/yr)			30,831
Levee and Emergency Spillway			
Perimeter levee crest (ft NGVD)	34.6	28.5	
Freeboard above average depth (ft)	11 ±	6 ±	
Emergency spillway crest (ft NGVD)	29.0	N/A	
Maximum depth at emergency spillway (ft)	4.8	N/A	
Length of emergency spillway (ft)	85	N/A	

¹ All ground and water surface elevations are referenced to the 1929 NGVD.

² Estimates from DMSTA2 simulation; slightly revised from estimates developed during design.





2 STRUCTURE AND CANAL DESCRIPTIONS

The following sections describe the associated project water control structures, canals and related features.

2.1 INFLOW CONTROL FACILITY

Pump Station. Structure S-382 is the inflow pump station for the Ten Mile Creek WPA and is located along the northern boundary of the WPA (see Figure 2-1). The pump station has three diesel-powered axial pumps with a combined nominal pumping capacity of 380 cfs. Two 54-inch diameter pumps have a nominal discharge capacity of approximately 160 cfs and a 36-inch diameter pump has a nominal capacity of 60 cfs. Each of the pumps discharges into the discharge drop structure via separate steel pipes buried under the crest of the levee. The drop structure consists of a concrete flume, a concrete weir with a fixed crest of 27.0 ft NGVD³, and a baffled discharge chute, shown in Figure 2-2. A cross section of the pump station is shown in Appendix A. The pump station contains a 15-300 KW generator to supply electrical service during commercial power outages.

Figure 2-1. Photograph of the headwater side of the S-382 pump station.



³ All elevations in this *Operation Plan* reference the 1929 National Geodetic Vertical Datum (NGVD).





Pump Station S-382 Information:

Number of pumps:	3
Discharge capacity (each 54-inch pump):	160 cfs at a static head of 19.5 ft
Discharge capacity (36-inch pump):	60 cfs at a static head of 19.5 ft
Design minimum headwater elevation:	9.5 ft NGVD
Design maximum tailwater elevation:	29.0 ft NGVD
Normal "on elevation":	When Ten Mile Creek rises to 9.7 ft NGVD
Normal "off elevation":	When Ten Mile Creek recedes to 9.7 ft NGVD or when reservoir stage is 29.0 ft NGVD
Motor size (54-inch pumps):	630 horsepower
Motor size (36-inch pumps):	260 horsepower
Pump station floor elevation:	35.0 ft NGVD

Figure 2-2. Photograph of reservoir side of S-382 showing the discharge drop structure and walkway to gate controls for the water supply release culvert.



Data Acquisition and Telemetry:

Presently the pumps are designed to work in manual or remote mode. Telemetry control for remote operation and real-time status of each pump is planned for completion in early 2006. Headwater and tailwater sensors provide stage data to the pump operation controls, and eventually, to remote operator at the S-127 control center and at the West Palm Beach operations control center. Headwater and tailwater staff gages are available for manual/local operation.

Trash Rake. The S-382 pump station is equipped with a self cleaning trash rake, visible in Figure 2-1. The trash rake is activated by a preset pressure differential across the screen.

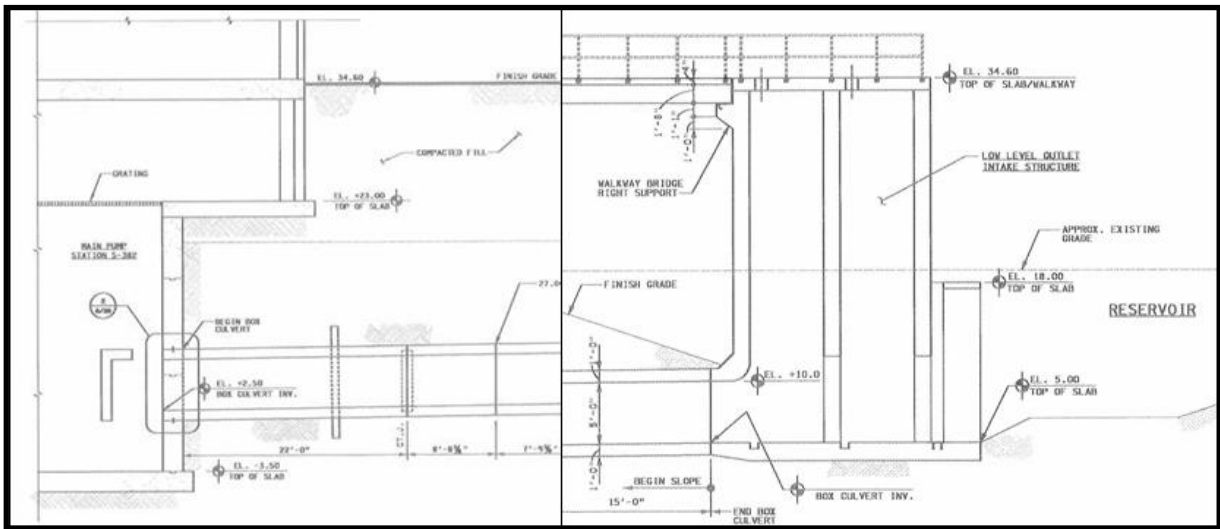




Trash removed from the screen is deposited on a concrete pad for subsequent removal and disposal.

Water Supply Return Culvert. S-382 also contains a 5-ft wide by 5-ft high gated box culvert for releasing water from the reservoir back into Ten Mile Creek to augment water supplies in the basin (see Figure 2-3). The design flow rate for this structure is 200 cfs with a 13 foot head difference. Flow is controlled by two 6-ft x 6-ft gates – an emergency gate in front and regulatory gate in back. Closing the emergency gate would prevent drainage of the entire reservoir if the regulatory gate was unable to close. *(Note – If not already hooked up, the generator in the S-382 pump house should be configured to power the gates during commercial power failure; this will allow remote operation when there are no personnel at the station.)* The 5-ft x 5-ft box culvert has an intake invert of 5.0 ft NGVD and an invert elevation at the pump station of 2.5 ft NGVD.

Figure 2-3. Cross section of water supply return structure.



2.2 INTERIOR CONTROL FACILITIES

Structure S-383 controls flow from the reservoir cell into the treatment cell. The facilities at S-383 are depicted in Figures 2-4 and 2-5 and include

- three separate intake bays with trash screens,
- a trash rake monorail system to remove debris from the screens (automatically triggered by the pumps operating and by manual control),
- a vertical lift gate to control gravity flow from the reservoir,
- two electric-driven auxiliary pumps for low level discharge of water to the treatment cell,
- a common bay that receives flow from the reservoir downstream of the gate and pumps,





- a single 54-inch culvert that conveys water to a common bay within a distribution box at the inlet to the treatment cell,
- a distribution box at the inlet to the treatment cell containing 8 independently controllable weir gates controlling flow to the discharge bays of the distribution box, and
- two 42-inch circular lift gates that control discharge into the distribution canal of the treatment cell.

The structure was designed to convey maximum discharge of 40 cfs under the following conditions:

- by gravity (under a minimum operating head of 0.5 ft) over a headwater range of 21.0 - 29.0 ft; or
- by auxiliary pumps (under a maximum operating head of 7.0 ft) over a headwater range of 14.0 - 21.0 ft.

Figure 2-4. Intake structure and related facilities for S-383.



A 4.5-ft wide x 4.5-ft high vertical lift gate controls gravity flow from the reservoir cell to a common discharge bay. An 18-inch diameter pump with a nominal capacity of 15 cfs and a 24-inch pump with a nominal capacity of 25 cfs are electric-driven and lift the water from the reservoir under low water conditions and discharge into the common discharge bay; flap gates are installed on each pump discharge pipe to prevent backflow (see Figure 2-6). A 54-inch diameter culvert conveys the water from the common discharge bay into a common bay in the distribution box at the inlet to the treatment cell. Eight independently controllable downward opening weir slide gates with an operating range of 21.0 – 24.0 ft, allow variable





discharge rates to the distribution canal via two 42-inch circular vertical lift gates (see Figures 2-7 and 2-8). SFWMD staff requested the eight individual weir gates to allow for more accurate flow measurements over the range of flows (6 – 40 cfs) anticipated. Rating curves were not developed for these gates during design; instead, the recommendation was to develop rating curves during the weir gate installation. At the present time (November 2005), the SFWMD had just initiated the development of the rating curves.

Figure 2-5. Structure S-383 during construction. Flow is from the reservoir on the right to the distribution box at the inlet to the treatment cell on the left.



Data Acquisition and Telemetry

Multiple sensors are available at S-383, including stage sensors for the headwater, pump intake bays, gravity intake bay, distribution box common bay and for the outlet of the distribution box (i.e., stage of the treatment cell inflow distribution canal.) In addition, gate position sensors are available to monitor the status remotely. In addition to providing operational information, these sensors will assist flow calibration and estimation purposes, which are critical to establishing accurate water and nutrient mass balances for the treatment cells.

The auxiliary pumps are designed to work in remote, local or automatic mode depending on conditions. Telemetry control for remote operation and real-time status of each pump is planned for completion in early 2006. Headwater and tailwater sensors provide stage data to the pump operation controls, and eventually, to remote operator at the S-127 control center





and at the West Palm Beach operations control center. Headwater and tailwater staff gages are available for manual/local operation.

Figure 2-6. Cross section of S-383 pump bays (upper) and gravity bay (lower).

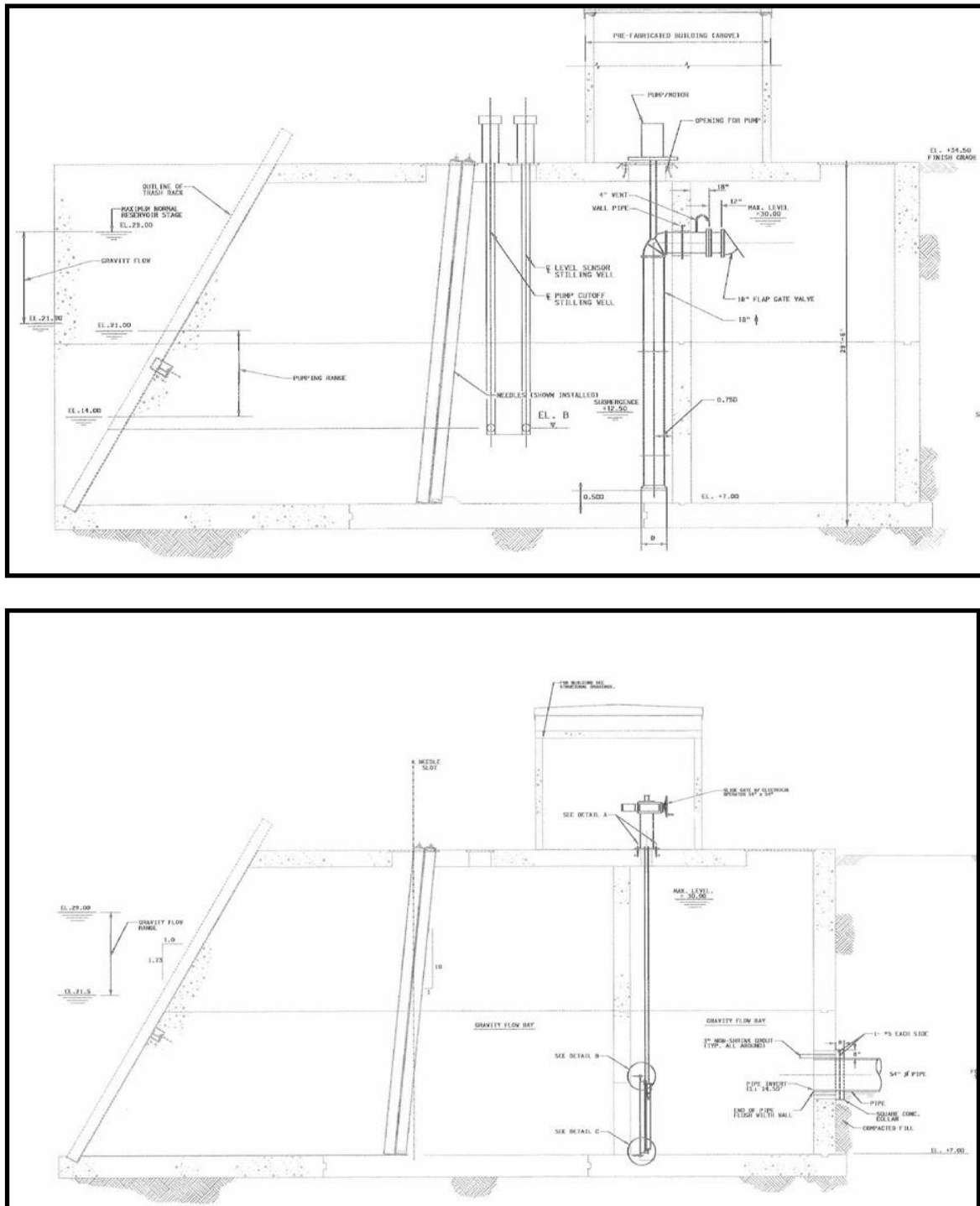
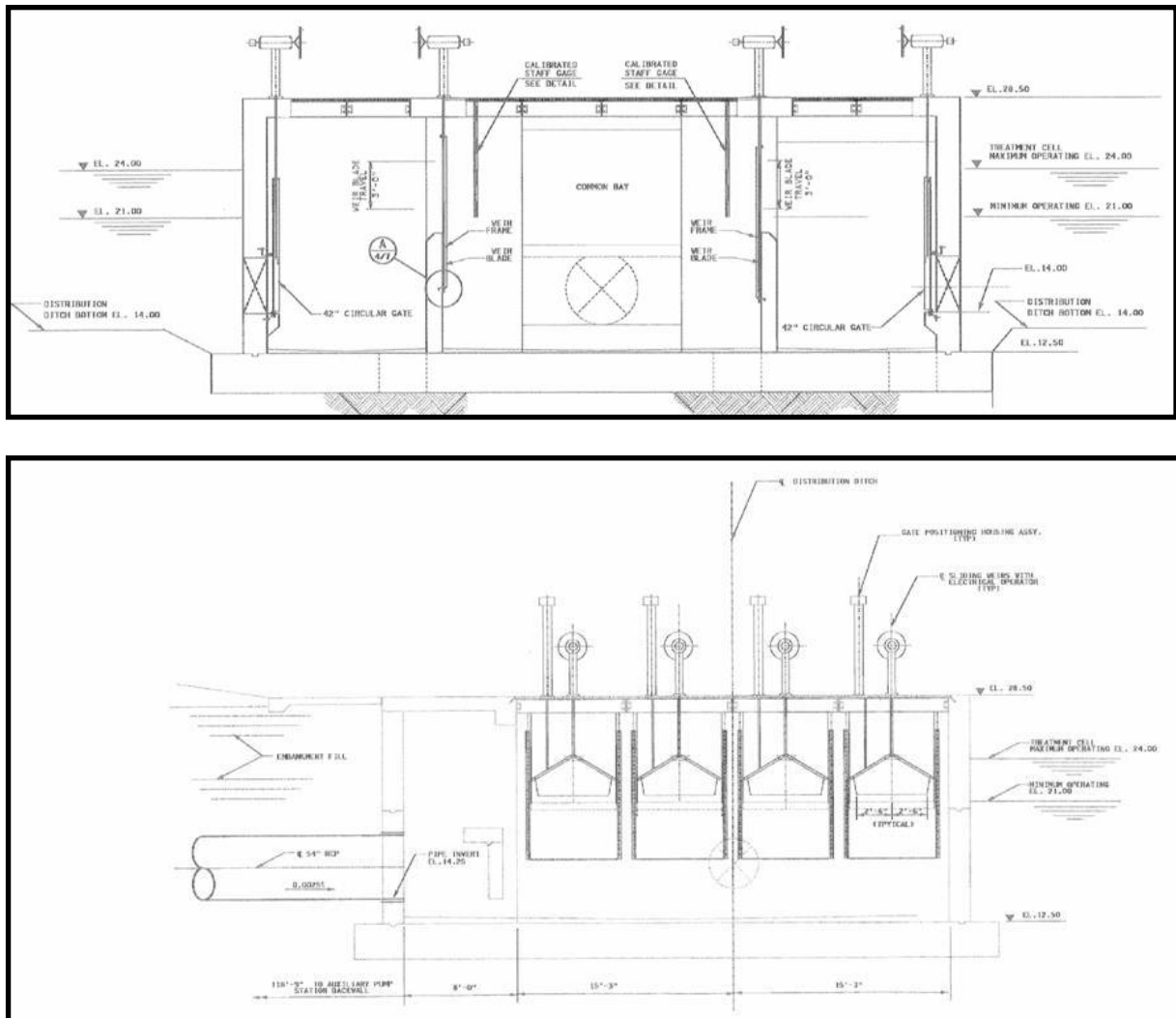


Figure 2-7. Cross Sections Through the Distribution Box (south on left in upper drawing and west on left in lower drawing).



Trash rack. Each of the three bays at S-383 are preceded by a trash rack to prevent debris from impeding operations (Figure 2-9). When the pumps are turned on, the traveling trash rake is automatically deployed at pre-set time intervals. In addition, manual operation is possible.





Figure 2-8. View of the Four Northern Downward Opening Weir Slide Gates Within the S-383 Distribution Box, with Gate Stem of Outlet Gate in Background.



Figure 2-9. Trash rake monorail system for the intake bays at S-383.





2.3 OUTFLOW CONTROL FACILITIES

Structure S-384. Structure S-384 controls flow from the treatment cell into Canal 96, which conveys the discharge approximately 0.5 miles north to Ten Mile Creek. This structure is located in the northeast corner of the perimeter levee (see Figure 2-10). Treated water is collected upstream of S-384 in a collection canal with a bottom elevation of 17.5 ft. The S-387 structure consists of a 5-ft x 5-ft vertical lift gate controlling flow into a 180-ft long 5-ft x 5-ft concrete box culvert, followed by a 22-ft long energy dissipation chamber (see cross sections in Appendix A). S-384 was designed to convey 40 cfs under low level headwater (21.0 ft) with a tailwater in Canal 96 corresponding to the 10-yr 72-hr storm event (20.2 ft). A rating curve for this condition is presented in Figure 2-10 and in Appendix A, and indicates that a minimal gate opening of between 1-1.5 ft should be sufficient to achieve the design discharge. SFWMD staff will develop additional rating curves for multiple headwater/tailwater and gate opening conditions.

Figure 2-10. Photograph of the headworks of S-384 and Rating Curve for S-384 Under Low Head Difference Condition (from PBSJ 2002c).



Gate Opening	Flow
ft	cfs
0.0	0
0.5	17.9
1.0	33.3
1.5	46.6
2.0	58.0
2.5	67.7
3.0	76.1
3.5	83.4
4.0	90.2
4.5	97.0
5.0	104.0

Design condition:
HW=21.0 ft and
TW = 20.2 ft





Structure information:

Culvert invert (HW): 14.0 ft NGVD

Culvert invert (TW): 13.0 ft NGVD

Height of Gate: 5.0 ft

Width of gate: 5.0 ft

Length of culvert: 233 ft

Data Acquisition and Telemetry:

Headwater and tailwater sensors and gate position indicator sensors are available to monitor the status remotely. In addition to providing operational information, these gages will assist flow calibration and estimation purposes, which are critical to establishing accurate water and nutrient mass balances for the treatment cells. Remote operation of the gate is also possible.

Emergency Spillway. The reservoir cell contains an 85-ft wide by 200-ft long emergency spillway located along the northern boundary, just east of the inflow pump station, as shown in Figure 2-11. The crest elevation is at 29.0 ft, which is 5.6 ft below the levee crest elevation. If the water elevation increases above 29.0 ft, water will flow over the spillway into an oxbow of Ten Mile Creek just downstream (east) of the S-382 pump station. A plan view and cross section of the spillway are presented in Appendix A.

Figure 2-11. Photograph showing the emergency spillway in relation to the inflow pump station.





2.4 SEEPAGE CONTROL FACILITIES

Shallow seepage from the reservoir and treatment cells will be collected in a 16-ft wide and 1-ft deep drain located along the outside toe of the perimeter levee. Deep seepage may be intercepted by the existing canal network (Canals 93, 95, 96 and 101), which will convey collected seepage to Ten Mile Creek. Collected seepage entering Ten Mile Creek through Canal 93 and Canal 95 (i.e., upstream of Gordy Road control structure

2.5 RELATED FACILITIES

Fish Collector Ditch. Ringing the inside toe of the reservoir cell levee is a fish collector ditch with a bottom width of 15 ft, a bottom elevation of 7.0 ft and a 3:1 side slope. This feature will provide refugia as water levels recede in the reservoir.

Distribution and Collection Canals. The treatment cell has a distribution canal located immediately downstream of the inflow structures and a collection canal immediately upstream of the outlet structure. The canal at the inflow of each cell is designed to distribute the inflow across the entire width of the cell. The canal at the outfall collects flow from across the entire width of the cell. In addition, there is a deep zone trench approximately half-way across the treatment cell designed to distribute the flow uniformly across the flow path (Figure 2-12). The canals were designed to have 15 ft. bottom widths and 3H to 1V side slopes, and have a bottom elevation of $14.0 \pm$ ft, roughly 7 ft below the average ground elevation.

Figure 2-12. The deep zone trench in the middle of the treatment cell.



Levees. The WPA is bounded on all sides by a perimeter levee. The levee surrounding the reservoir cell has a crest elevation of 34.6 ft with a 12-ft wide access road on the crown.





Rectangular 12-ft wide by 24-ft long turnouts are located long the levee road at 1000-ft intervals to allow vehicles to safely pass. The inside slope of the reservoir cell levee is armored with a soil cement layer, with a bench at elevation 18.5 ft, and a 3.5:1 side slope (see Figure 2-13). The portion near the top of the levee is stepped to give added protection against wave action. The levee surrounding the treatment cell has a crest elevation of 28.5 ft, has a 3.5:1 side slope and a 12-ft wide access road on the crown. Rectangular 12-ft wide by 24-ft long turnouts are located long the levee road at 1000-ft intervals to allow vehicles to safely pass. The inside slope of the treatment cell levee is not armored.

The reservoir cell levee crest elevation was established to accommodate the higher of

1. the wave runup on top of the maximum design water surface (29.0 ft), which yielded an elevation of 33.5 ft, or
2. the Probable Maximum Precipitation event (36 inches) routed through the emergency spillway plus a 3-ft freeboard, which yielded an elevation of 34.6 ft.

The 3-ft freeboard on top of the PMP event resulted in the more extreme requirement, so the levee crest was set at 34.6 ft (PBSJ 2002c).

The relationship between stage, area and volume for the reservoir cell is presented in Table 2-1 (WSI 2002). Based on the information contained in that table, the average ground elevation within the reservoir cell is approximately $18 \pm$ ft. The relationship between stage, area and volume in the treatment cell is also presented in Table 2-1 (WSI 2002). Based on the information contained in that table, the treatment cell has an average ground elevation of approximately $21 \pm$ ft, with natural variability and an existing slope from the south to the north of the cell. For the treatment cell levee, the crest was set at 3.0 ft above the maximum normal water surface elevation (25.5 ft), or 28.5 ft.

Figure 2-13. The armored inside slope of the reservoir cell showing the stepped top.





Inspection road. Surrounding the perimeter levee is a 12-ft wide inspection road.

Boat ramps. A boat ramp is located on the northeast corner of the perimeter levee of the treatment cell 2, adjacent to S-384. Another boat ramp is located within the reservoir cell adjacent to the S-382 pump station.

Table 2-1. Stage-Area-Volume Relationship for the Reservoir and Treatment Cells.

Stage ft NGVD	Area acres	Volume acre feet
7.0	5	0
12.0	19	59
12.0	94	59
18.5	111	726
18.5	509	726
20.0	511	1,490
22.0	514	2,516
24.0	518	3,548
26.0	521	4,596
28.0	524	5,631
29.0	526	6,156
30.0	527	6,682
32.0	530	7,740
34.0	534	8,803
34.6	535	9,124

Stage ft NGVD	Area acres	Volume acre feet
14.0	5	0
18.5	19	18
18.5	94	18
20.0	111	214
22.0	509	477
24.0	511	743
26.0	514	1,011
28.5	518	1,350

Gordy Road Structure. Located just downstream of the S-382 inflow pump station, the Gordy Road Structure is the easternmost water control structure on Ten Mile Creek (Figure 2-14). As such it separates the tidal portion of the creek from the upstream basin. The structure is owned and operated by the North St. Lucie River Water Control District's (NSLRWCD). The Gordy Road Control Structure, known as S-71-1 by NSLRWCD is a 4-bay radial gate spillway owned and operated by NSLRWCD. The outside gates are two 18-foot wide radial gates, with a crest elevation of 9.3 ft-NGD and inverts of the gates are at elevation 3.0 ft-NGVD. The inside gates are two 18-foot wide radial gates, with crest elevations of 10.0 ft-NGVD and invert elevations of 3.0 ft-NGVD. This structure is generally operated to maintain an upstream pool elevation of 9.5 ft-NGVD to 10.5 ft-NGVD during the dry season when Ten Mile Creek is used to supply irrigation demands. During the wet season, the Ten Mile Creek is maintained as low as 6.5 ft to increase its storage capacity (PBSJ 2002c). A discharge rating curve for the structure was developed and is presented in Table 2-2 below (PBSJ 2002c). Additional operating details for this structure and other pertinent structures operated by NSLRWCD can be found by contacting the NSLRWCD office at (772)-461-5050.





Figure 2-14. Gordy Road Structure, looking upstream.



Table 2-2. Rating Curve for the Gordy Road Control Structure (PBSJ 2002c).

Headwater Stage (ft)	Flow (cfs)
9.0	0.0
9.1	0.0
9.2	0.0
9.3	0.8
9.4	5.9
9.5	13.5
9.6	23.0
9.7	34.0
9.8	46.4
9.9	59.9
10.0	76.2
10.1	95.3
10.2	117.9
10.3	144.0
10.4	172.0
10.5	203.8
10.6	237.0
10.7	272.0
10.8	308.9
10.9	347.6
11.0	387.8





3 OPERATIONS

PLEASE NOTE

During the preparation of this *Operation Plan*, the following critical issues were identified that requires a change in previously proposed operations of S-383 to ensure that maximum project benefits can be achieved.

1. **Avoid Reservoir Dryout.** The draft Preliminary Water Control Plan (USACE 2003) calls for discharges from the reservoir to the treatment cell as the water level in the reservoir cell recedes to approximately 4 ft below the average ground elevation, to a stage of 14.0 ft. This operation is in direct conflict with one of the fundamental principles of other facilities associated with nutrient removal: avoid dryout in order to prevent the release of nutrients from the exposed soil. It also conflicts with the Water Quality section of the Final Design Documentation Report (see page 26): “As long as these reservoirs are managed so that drying is avoided, these nutrients will be bound to the sediments and kept there.” In general, for a reservoir/STA with a relatively flat bottom, a minimum depth of 0.5 ft above the average ground elevation should be maintained to minimize dryout and subsequent release of nutrients. However, in the case of the Ten Mile Creek reservoir cell with a variable ground elevation, it may be better to initially set the minimum depth at one foot above the average ground elevation, and refine this target after operational experience. Therefore, this *Operation Plan* recommends terminating releases through S-383 when the reservoir stage drops to 19.0 ft and initiating discharges when the stage rises to 19.0 ft. This change has the added benefit of significantly simplifying the operation of the S-383 structure during the wet season by allowing a uniform 35 cfs flow at all stages, instead of the previously proposed multiple flow rates at stages between 14.0 ft and 19.0 ft.
2. **Reduce Dry Season Releases as the Reservoir Storage Decreases.** The draft Preliminary Water Control Plan (USACE 2003) documents that the optimal balance occurs when dry-season releases to the treatment cell decrease with decreasing storage, yet in contrast, recommends a constant release of 35 cfs for all depths above 1.0 ft above the average ground elevation. Consistent with the above principle, the District simulation of the Water Preserve Area (Konyha 2002) incorporated a depth-dependent relationship that maximizes the water releases during the dry season and thereby prolongs the downstream estuarine benefits compared to the draft Preliminary Water Control Plan. Therefore, this *Operation Plan* recommends using the relationship used in the District simulation, modified with flows set to zero at stages above 29.0 ft, corresponding to the elevation of the emergency spillway crest.





Introduction. The Corps has developed a draft Preliminary Water Control Plan for the Ten Mile Creek WPA to cover operations **during the operational testing and monitoring phase, and prior to turnover to the SFWMD** (Corps 2003). The operational testing and monitoring phase includes the critical initial reservoir filling. This *Operation Plan* is designed to cover the operations **after the project has been turned over to the SFWMD**. However, to assist in the establishment of desirable wetland vegetation, this *Operation Plan* contains suggested operations for the start-up of the treatment cell. Both plans were written with flexibility to allow refinements to the operations in order to achieve the desired project benefits while maintaining the existing level of flood protection in the Ten Mile Creek basin.

The operational objectives of the WPA are summarized below:

1. **control the quantity and timing of water deliveries** to the North Fork of the St. Lucie River to improve the estuarine salinity and related conditions by capturing and storing stormwater from the Ten Mile Creek basin. This objective includes maximizing pre-storm available storage, particularly prior to tropical storms, hurricanes and other extreme rainfall events;
2. **reduce the sediment load** delivered to the estuary through sedimentation of suspended solids;
3. **reduce nutrient levels** entering the North Fork of the St. Lucie River;
4. **increase the amount of freshwater recharge into the aquifer** as a by product of above ground storage; and
5. **augment local water supply** through releases back to the Ten Mile Creek basin during dry weather, if sufficient water is available in the reservoir to achieve the other project objectives.

Hydrologic analyses conducted during the design of the project indicated the optimal balance of these often-competing objectives occurs when pumps try to capture one-half of storm runoff (not baseflow) (USACE 2003).

This section describes the general operations associated with the Ten Mile Creek WPA, classified in the following modes:

1. Treatment cell start-up operations
2. Normal operations
3. Extreme flow operations
4. Drought operations, and
5. Operations to take one or more treatment cells out of service

3.1 TREATMENT CELL START-UP OPERATIONS

General. After completion of construction and prior to turnover to the SFWMD, the Corps will operate the WPA during an initial operational testing and monitoring period during which time data will be collected to demonstrate compliance with state water quality





standards. The Corps of Engineers will be responsible for developing an initial reservoir filling plan and will monitor the piezometers extensively during this critical period. As such, the initial filling phase is not covered in this *Operation Plan*. However, suggested operations for treatment cell start-up are provided herein to assist in the establishment of desirable treatment wetland vegetation.

The goal during the treatment cell start-up is to provide hydrologic conditions conducive to wetland vegetation growth, while avoiding release of total phosphorus, nitrogen and mercury. The state environmental permit issued to the Corps for initial operation precludes flow-through operations until phosphorus, nitrogen and mercury concentrations demonstrate a net improvement compared to the source water in Ten Mile Creek. In addition, the FDEP permit requires that pesticide samples be taken in the water column and sediment at the inflow and outflow structures before discharges are to occur from the STA.

Operations During Startup. The WPA outlet structure, S-384, should remain closed during the startup phase and all ten (10) gates in the S-383 Distribution Box should be fully opened. When the average stage in the Treatment Cell (determined by the arithmetic average of the tailwater stage of S-383 Distribution Box and the headwater stage of S-384) falls below 21.7 ft (i.e., a depth of 0.5 ft), the gate or auxiliary pumps at S-383 should be operated to convey sufficient water from the reservoir cell to maintain approximately 1.0 ft water depth in the Treatment Cell. When the average stage in the Treatment Cell rises to approximately 22.2 ft (i.e., a depth of 1.0 ft), the gate at S-383 should be closed or the pumps shut off. ***It is critical to keep depths between 0.5 and 1.0 ft (corresponding to a stage between 21.7 ft – 22.2 ft) during the start up phase to ensure proper growing conditions with minimal high-water damage to the young vegetation.***

Once net improvement for phosphorus, nitrogen and mercury removal is demonstrated, and the pesticide samples are collected, the gate at S-384 can be opened to allow the treated water to flow into Canal 96 and returned to Ten Mile Creek. From this point forward, the project structures can now be operated based on the normal operations in the following section.

Summary of Treatment Cell Start-up phase operations

- The target depth is between 0.5 ft and 1.0 ft, corresponding to a stage of 21.7 - 22.2 ft.
- With the gate at the S-384 structure closed, the gate or pumps at the S-383 structure should be operated to maintain the water level in the Treatment Cell to an average of 22.2 ft (i.e., a depth of 1.0 ft).

3.2 NORMAL OPERATIONS

Water levels in the WPA will be adjusted through operation of the inflow pumps, operation of the gate and pumps at S-383 and modulation of the gate at the S-384 outlet structure. Initial operating guidelines are provided below. This guidance should be revisited periodically and





revised based on field observations and WPA performance. The water surface profile through the WPA is presented in Appendix A.

3.2.1 S-382 Operations

During normal operations, the S-382 pumps will primarily operate based on the water level of Ten Mile Creek, just upstream of the pump station. Although the pump station can be remotely operated, it is anticipated that initially the operations will be manual, with a daily decision based on morning water level readings (PBSJ 2002c). Should remote operations be implemented, these operation guidelines would be adjusted to allow real-time pump operations to be controlled by either instantaneous water level data or remote control.

When the water level in the Ten Mile Creek is between 9.7 and 10.1 ft at the time of the morning reading, the 60-cfs pump (Pump #1) at S-382 should be operated for an 8-hr period. This will capture a daily average of approximately 20 cfs of the flow in Ten Mile Creek. If the stage in the reservoir cell rises to 29.0 ft during the day, which is the crest of the emergency spillway, the S-382 pump should be shut off.

If the stage in Ten Mile Creek increases above 10.1 ft, the 60-cfs pump (Pump #1) should be turned on until the stage recedes to 9.7 ft. If the stage in Ten Mile Creek increases above 10.6 ft, the first 160-cfs pump (Pump #2) should be turned on. If the stage in Ten Mile Creek increases above 10.8 ft, the second 160-cfs pump (Pump #3) should be turned on. Operated in this fashion, the pumps at S-382 will be a full capacity before the NSLRCWCD operates the Gordy Road control structure at stage of 11.0 ft. When the stage in Ten Mile Creek recedes to 10.7 ft, Pump #3 should be turned off. When the stage in Ten Mile Creek recedes to 10.3 ft, Pump #2 should be turned off. When the stage in Ten Mile Creek recedes to 9.7 ft, Pump #1 should be turned off.

Table 3-1. S-382 Pump Operating Thresholds.

Pump Operating Threshold	Water Level (ft NGVD)	Purpose For Operating Threshold
Pumps On	Between 9.7 and 10.1	Pump #1 on for eight hours
	Rises to 10.1	Pump #1 on
	Rises to 10.6	Pump #2 on
	Rises to 10.8	Pump #3 on
Pumps off	Recedes to 10.7	Pump #3 off
	Recedes to 10.3	Pump #2 off
	Recedes to 9.7	Pump #1 off
High Reservoir Stage	Rises to 29.0	All pumps stop





Water Supply Operation. The NSLRWCD may request water from the WPA back to Ten Mile Creek to meet agricultural irrigation demands in the basin. If sufficient water is available in the reservoir to achieve the other project objectives, and if the S-382 headwater is below 9.0 ft, then the Low Level Outlet Structure gates can be opened to allow a maximum of 200 cfs from the reservoir to Ten Mile Creek. These water supply operations will cease when the headwater stage reaches 9.5 ft, or when insufficient water remains in the reservoir to meet the other project objectives.

3.2.2 S-383 Operations

Wet Season Operations (June 1 – September 30). Under most conditions, if the stage in the reservoir is above 19.0 ft, the S-383 gate or auxiliary pumps (depending on the relative stage in the reservoir cell and treatment cell) should be operated to allow a discharge of 35 cfs to the treatment cell. The S-383 gate should be closed if the pumps are turned on to prevent backflow and recirculation. The weir gates and the outlet gates in the Distribution Box should be fully open at all times.

It should be noted that the draft Preliminary Water Control Plan (USACE 2003) calls for discharges from the reservoir to the treatment cell as the water level in the reservoir cell recedes to approximately 4 ft below the average ground elevation, to a stage of 14.0 ft. This operation is in direct conflict with one of the fundamental principles of other facilities associated with nutrient removal: avoid dryout in order to prevent the release of nutrients from the exposed soil. It also conflicts with the Water Quality section of the Final Design Documentation Report (see page 26): “As long as these reservoirs are managed so that drying is avoided, these nutrients will be bound to the sediments and kept there.” In general, for a reservoir/STA with a relatively flat bottom, a minimum depth of 0.5 ft above the average ground elevation should be maintained to minimize dryout and subsequent release of nutrients. However, in the case of the Ten Mile Creek reservoir cell with a variable ground elevation, it may be better to initially set the minimum depth at one foot above the average ground elevation, and refine this target after operational experience. ***Therefore, this Operation Plan recommends terminating releases through S-383 when the reservoir stage drops to 19.0 ft and initiating discharges when the stage rises to 19.0 ft.*** This change has the added benefit of significantly simplifying the operation of the S-383 structure by allowing a uniform 35 cfs flow at all stages, instead of the previously proposed multiple flow rates at stages between 14.0 ft and 19.0 ft, and that varied from wet season to dry season.

Dry Season Operations (October 1 – May 31). The draft Preliminary Water Control Plan (USACE 2003) documents that the optimal balance occurs when dry-season releases to the treatment cell decrease with decreasing storage, yet in contrast, recommends a constant release of 35 cfs for all reservoir depths above 1.0 ft above the average ground elevation. Consistent with the principle of decreased releases with decreasing storage, the District simulation of the Water Preserve Area (Konyha 2002) incorporated a depth-dependent relationship that maximizes the water releases during the dry season and thereby prolongs the downstream estuarine benefits compared to the draft Preliminary Water Control Plan. ***Therefore, this Operation Plan recommends using the dry season relationship used in the***

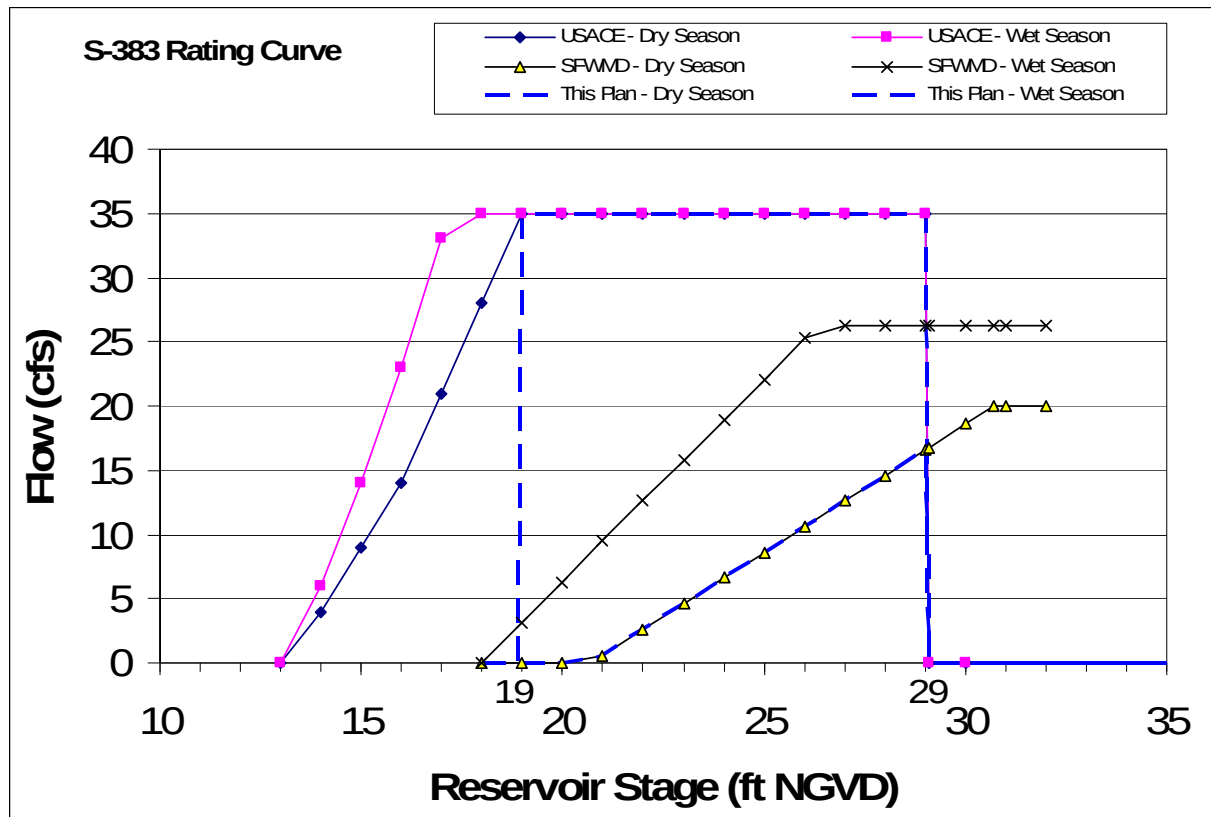




District simulation, modified with flows set to zero at stages above 29.0 ft, corresponding to the elevation of the emergency spillway crest.

S-383 release (cfs) = 0 for stage < 20.7 ft
S-383 release (cfs) = 2 * (stage – 18) – 5.4 for stages between 20.7 ft and 29 ft
S-383 release (cfs) = 0 for stage > 29 ft

Figure 3-1. Comparison of S-383 Rating Curves.



If the outlet gate at S-384 is closed, discharges through S-383 should be modulated to ensure the average depth in the treatment cell does not exceed 1.35 ft, corresponding to an average stage of 22.55 ft NGVD. The average stage in the treatment cell can be determined by taking the arithmetic average of the tailwater at the Distribution Box and the headwater at S-384.

3.2.3 S-384 Operations

The target water depth to optimize the nutrient removal performance in the treatment cell is approximately 1.35 ft, corresponding to an average stage of about 22.5 ft (WSI 2002). The gate at S-384 should be operated in concert with S-383 to discharge roughly the same capacity as S-383 while maintaining the target average depth in the treatment cell. Since the target flow rate through S-383 is 35 cfs, a gate opening of 1 foot or less at S-384 should be adequate for most conditions. ***Because of frequent low tailwater conditions in Canal 96 at the S-384***





outlet and out of the need to avoid erosive velocities, the S-384 gate should rarely be opened more than one foot.

An important aspect of the treatment cell operation is avoiding treatment cell dry out, as dry out typically results in a release of phosphorus and nitrogen. Although the period of record analysis performed by the SFWMD during design of the WPA indicated infrequent periods of zero flow from the reservoir to the treatment cell, the operation of S-384 needs to avoid drying out the treatment cell. The ideal minimum water depth is 0.5 ft in the treatment cell, corresponding to an average stage of about 21.7 ft. However, to conserve water and compensate for evapotranspiration and seepage losses, it is recommended to close the S-384 gate when the stage in the reservoir cell falls to 18.5 ft and inflows to the treatment cell ceases, even if the stage in the treatment cell is at its target of 22.5 ft.

Subject to water supply conditions in the Ten Mile Creek basin, there may be times when S-382 should be operated outside the normal operating set points described in Table 3-1, specifically, turning on the pumps when the Ten Mile Creek stage is below 9.7 ft in order to prevent the reservoir and treatment cell from drying out. Should the treatment cell dry out, please refer to section 3.4.1 for operations following dry out.

Summary of Normal Operations:

- The S-382 pumps should be turned on to capture stormwater runoff when the stage in Ten Mile Creek rises above 9.7 ft (see Table 3-1).
- During the wet season, when the reservoir stage is between 19 ft and 29 ft, the gate and pumps at S-383 should be operated to provide an average flow of 35 cfs to the treatment cell. When the reservoir stage is below 19 ft or above 29 ft, S-383 should be zero.
- During the dry season, when the reservoir stage is between 20.7 ft and 29 ft, the gate and pumps at S-383 should be operated to provide an average flow of $[2 * (\text{stage} - 18) - 5.4]$ to the treatment cell. When the reservoir stage is below 20.7 ft or above 29 ft, releases from S-383 should be zero.
- The gates in the Distribution Box downstream of S-383 should remain fully open.
- The gate at S-384 should be operated in concert with S-383 to maintain an average target depth of approximately 1.35 ft, corresponding to an average stage in the treatment cell of 22.5 ft.
- To minimize the occurrence of dryout of the treatment cell, the gates at S-383 and S-384 should be closed when the stage in the reservoir cell falls to elevation 18.5 ft.
- To minimize dryout of the reservoir and treatment cells, S-382 should be operated to prevent the reservoir and treatment cell from drying out, subject to water availability in Ten Mile Creek. A minimum stage of 18.5 ft should be maintained in the reservoir cell and a minimum stage of 21.7 ft should be maintained in the treatment cell.





3.3 EXTREME FLOW OPERATIONS

Discretion in the operation of the WPA structures is reserved by the SFWMD Operations staff to account for excess precipitation and regional conditions. The levee surrounding the reservoir cell has been designed to accommodate direct rainfall, wind and wave setup associated with a Probable Maximum Precipitation event; depending on the wind and wave effects and the slope of the backwater profile, the stage in the reservoir cell may exceed the crest of the emergency spillway (29.0 ft) and discharges to Ten Mile Creek will occur. Should the stage in the reservoir cell rise to 29.0 ft, the pumps at S-382 should be shut off, and the S-383 gate and S-384 gate should be closed to avoid worsening existing conditions (PBSJ 2002c, USACE 2003).

Pre-storm Drawdown. In anticipation of high runoff rates from the Ten Mile Creek Basin due to tropical storms, hurricanes or other extreme events, water levels in the reservoir and treatment cells should be drawn down as much as practicable in order to provide the maximum storage capacity. In no case shall the discharge from S-384 exceed 100 cfs. ***Because of frequent low tailwater conditions in Canal 96 at the S-384 outlet, and out of the need to avoid erosive velocities, the S-384 gate should only be opened more than one foot after careful consideration of the tailwater stage.***

Summary of Extreme Flow Operations:

- Prior to extreme events,
 - the trash racks should be checked to ensure they are clear and working properly,
 - lower the water levels in the cells as much as practicable
- Terminate releases through S-383 and S-384 if the reservoir stage exceeds 29.0 ft
- As soon as safety permits after extreme events,
 - the operating status of all the pumps and gates should be checked,
 - repairs made if needed, and
 - debris cleared if needed

3.4 DROUGHT OPERATIONS

Subject to water availability, operations of the WPA should maintain water depths at a minimum of 0.5 feet above the average ground elevation in the both the reservoir and treatment cells to minimize potential negative effects of dry out on project performance. This corresponds to a stage of approximately 18.5 ft in the reservoir cell and 21.7 ft in the treatment cell. The ability to maintain this minimum water elevation is determined primarily by the availability of water from the upstream watershed and on local rainfall. Subject to water supply conditions in the Ten Mile Creek basin, there may be times when S-382 should be operated outside the normal operating thresholds points described in Table 3-1, specifically, turning on the pumps when the Ten Mile Creek stage is below 9.7 ft in order to prevent the treatment cell from drying out. In the extreme case that there is no water available from the upstream watershed and/or from rain, the cells may dry out. The severity and duration of the dry conditions that may lead to reduced project performance is currently unknown, as is the





magnitude and duration of the potential depression of project performance. Analysis of the monthly compliance monitoring data collected at the project outflow monitoring station will be useful in making these determinations.

Operations Following WPA Dry Out. There will be times when there are insufficient flows and/or stages in Ten Mile Creek to operate the S-382 inflow pump for long enough duration to keep the treatment cells from drying out. Following reflooding after a dry out, treatment wetlands typically exhibit a spike in outflow concentrations, a result of phosphorus remineralization processes that occur with exposed sediment. To minimize the magnitude of this flux leaving the Ten Mile Creek WPA, it is recommended to keep the S-384 gate closed for approximately two weeks after dry out and following reflooding to a stage of 22.0 ft measured at the S-384 headwater; although site specific conditions may require more or less time for the outflow concentration to drop below the inflow. This recommendation should be revisited periodically to ensure it is achieving water quality goal of annual net improvement. The severity and duration of the dry conditions that may lead to reduced project performance is currently unknown, as is the magnitude and duration of the potential depression of project performance. Analysis of the weekly grab sample data collected at S-384 will be useful in making these determinations.

Management activities following a dry out will vary depending on the severity of the drought and the attendant loss of vegetation. For mild to moderate loss of vegetation, the inundation regime described in Section 3.1 above can be followed (i.e., slowly raising depths to 1.0 ft). For severe loss of vegetation, it may be necessary to limit the initial depth to 0.5 ft to promote re-establishment desirable emergent vegetation. The length of time to retain water in the WPA before initiating flow-through should be based on achieving a net reduction in the weekly phosphorus concentrations. This recommendation should be revisited periodically to ensure it is achieving water quality goal of annual net improvement.

Summary of Drought Operations:

- Maintain a minimum depth of 0.5 ft if water is available; this may necessitate lowering the “pump-on” set point for S-382, if needed.
- The S-384 gate should be closed when either the headwater stage drops to 22.0 ft or the reservoir stage drops to 18.5 ft.
- Following a dry out, keep the gate at S-384 closed for a period following reflooding to a stage of 22.0 ft, depending on the severity of dry out and the status of the vegetation:
 - o if the vegetation is robust, the recommended period of closure following reflooding is approximately two weeks, although site specific conditions may require more or less time for the outflow concentration to drop below the inflow;
 - o if the vegetation is damaged, the period of closure will likely be greater, to be determined by field conditions and phosphorus levels





3.5 TREATMENT CELLS OUT OF SERVICE

After flow-through operations begin, the WPA may be taken off-line for vegetation management or other activities in order to improve the phosphorus removal performance. Pumping at S-382 may be reduced or stopped during activities for performance enhancement, and S-383 may be adjusted to reduce or stop flow to the treatment cell depending on the management activities underway (please refer to the associated *Ten Mile Creek WPA Vegetation Management Plan* for additional details). Depending on the severity of the management operations, the reflooding operations may or may not require similar actions as in the start-up phase, i.e., demonstrating a 4-week net improvement in phosphorus.

3.6 DEVIATIONS FROM THE OPERATION PLAN

This *Operation Plan* for the Ten Mile Creek WPA is meant to be updated regularly based on field observations of stage-flow relationships, structure flow calibrations, WPA performance, CERP's comprehensive monitoring and assessment program and other factors. Discretion in the operation of the WPA structures is reserved by the SFWMD Operations staff to deviate from these guidelines to account for flood protection, excess precipitation and regional conditions. It is anticipated that after the first year of flow-through operation, and annually thereafter, this *Operation Plan* will be reviewed to identify any needed revisions.

3.6.1 Deviations from the Preliminary Water Control Plan

The Corps of Engineers developed a Preliminary Water Control Plan for the Ten Mile Creek WPA to cover operations during the **operational testing and monitoring phase, and prior to turnover to the SFWMD** (USACE 2003). Deviations from that Plan may require advanced notification and approval from the Corps, as discussed below.

3.6.2 Deviation from Normal Operation

The United States Army Corps of Engineers (USACE), Jacksonville District Engineer is occasionally requested to deviate from the normal regulation of the project. Prior approval for a deviation is to be obtained from the Jacksonville District Office (SAJ) except as noted below. The Jacksonville District Office will in turn obtain the necessary approvals from the South Atlantic Division (SAD) except as noted below. Deviation requests usually fall into the following categories:

3.6.2.1 EMERGENCIES. Some emergencies that can be expected include drowning and other accidents, failure of project facilities, and flushing of pollutants. Antecedent conditions, as well as forecasted storm events, may result in SFWMD declaring an Emergency Authorization Order which would result in an Emergency Deviation. Necessary action under emergency conditions is taken immediately, unless such action would create an equal or worse condition. The Jacksonville District Office should be informed as soon as practicable. Written confirmation should be furnished after the incident. SAJ will report these deviations to SAD.

3.6.2.2 UNPLANNED MINOR DEVIATIONS. There are unplanned instances where there is a temporary need for a minor deviation from normal regulation, although they are not





considered emergencies. A change in releases is sometimes necessary for construction, maintenance, or inspection. These requested deviations are usually for duration of a few hours to a few days. Each request is analyzed on its own merits. Consideration is given to upstream watershed conditions, potential flood threat, conditions of lakes, and possible alternative measures. In the interest of maintaining good public relations, the request is complied with, providing there are no adverse effects on the overall project regulation for authorized project purposes. Approval for minor deviations will normally be obtained from the Jacksonville District by telephone. A written confirmation will be furnished after the deviation is completed. SAJ will report these deviations to SAD.

3.6.2.3 PLANNED DEVIATIONS. Each condition should be analyzed on its own merits. Sufficient data on flood potential, lake and watershed conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes will be presented to the Jacksonville District along with recommendations for review and approval. SAJ will report these deviations to SAD and obtain approval.

In light of the uncertainty in specifying operating criteria necessary to optimize the multiple project objectives of the Ten Mile Creek WPA, the SFWMD should seek the authority to refine the operations described in this plan without seeking Corps approval, as long as those operations are within the overall range of water depths and flows anticipated in the project design documents.





4 OPERATING PERMITS

4.1 COMPREHENSIVE EVERGLADES RESTORATION PLAN REGULATION ACT PERMITS

The Florida Department of Environmental Protection (FDEP) issued a Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permit 0192879-001-GL to the Corps for the construction phase of the Ten Mile Creek WPA, including an initial operational testing and monitoring period. Presently the FDEP and the SFWMD are negotiating the operations phase permit for the project (0192879-002-GL). This *Operation Plan* covers the operations phase and must be consistent with the requirements of the permit issued to the SFWMD. Specific conditions of the draft operation phase permit that are relevant to operations include the following.

Specific Condition 4 requires that the SFWMD operate and maintain the project in accordance with design documents and the Operation, Maintenance, Repair, Replacement and Rehabilitation Manual (OMRR&R Manual, USACE 2005).

Specific Condition 6 indicates that the operation phase shall become effective upon the project turnover. Specific Condition 7 mandates that the **initial** operations, referring to the **initial operational testing and monitoring period**, shall be in accordance with the Preliminary Water Control Plan (PWCP) for Deep Storage Area (USACE 2003). Modifications to the PWCP will be conducted according to procedures in the WCP. The resulting Long-Term WCP should be provided to the FDEP no more than 30 days after it is finalized and prior to initiating any modified operations. ***It is recommended to replace the requirement for a Long-Term WCP in the final FDEP permit with this Operation Plan.***

Specific Condition 9 requires that no later than 6 months after project turnover, the SFWMD shall submit a final OMRR&R Manual, containing specific provisions for operation of the WPA. The project shall be operated to be consistent with the St. Lucie Estuary minimum flows and level, as defined in Rule 40E-8, F.A.C.

Specific Condition 14 requires that SFWMD must submit a mercury and pesticide monitoring plan prior to initiating operations.

Additional information on the permits is found in the *Performance Plan for the Ten Mile Creek WPA* (GGI 2005).





5 COORDINATION

As with most large water resource projects, effective coordination within the agency and among the various agencies will be critical to ensure the WPA operational objectives are achieved. The nature of this coordination will change as the project goes through the initial operational and testing period, and is then transferred to the SFWMD by the Corps.

5.1 INITIAL OPERATIONAL TESTING AND MONITORING PERIOD

In accordance with the Project Cooperation Agreement executed between the Corps and the SFWMD, prior to turnover of the project to the SFWMD, the Corps will conduct an **initial operational testing and monitoring period**. During this period, data will be collected to demonstrate that the project achieves the designated benefits. This period is further divided into two phases – a start-up phase (no discharge) and a flow-through phase once discharge commences. Prior to initiating flow-through (discharge) activities, phosphorus, nitrogen and mercury will be monitored to demonstrate that the WPA is achieving a net improvement in both constituents. In addition, pesticide sampling will occur as a condition for moving into the flow-through phase. Once the District Engineer determines that the project is performing as designed, the Corps will transfer the project to the SFWMD for subsequent operations, maintenance, repair, replacement and rehabilitation, commencing the **operations phase**.

5.1.1 On-going data review and operational feedback

In accordance with the project PCA, the operation of the WPA during start-up will be a joint effort of the Corps and the SFWMD. A **Project Coordination Team** consisting of Corps and SFWMD staff was established in accordance with the Project Cooperation Agreement, and this team will establish a protocol for communicating the start up operations between the agencies prior to the initiation of start up. Key aspects are to identify who will be the respective tactical contact points, and the appropriate type and frequency of start up communication. The frequency of telephone conferences and meetings will likely be weekly at first as issues surrounding structure operations may arise; experience in other new systems suggests that the frequency will likely decrease to approximately once per month by the end of the start-up phase.

Once flow-through operations begin, the weekly/monthly communications will include operational feedback (pump operations, gate openings, flow rates and water levels) in addition to the performance discussion. By that time, the criteria for project transfer from the Corps to the SFWMD should be finalized.





5.1.2 Interagency coordination

In addition to the day-to-day project coordination, by virtue of the fact that the Ten Mile Creek WPA is a feature of an integrative set of water quality protection projects, project staff will necessarily be communicating and coordinating with other SFWMD staff (e.g., Coastal Estuaries Division), the Corps (CERP and related activities), and FDEP (for permitting and other wetland protection purposes).

An initial list of potential contact persons from these agencies is presented below.

STA Project Manager: Maura Merkall, Lead Project Manager, (561) 682-6179 mmerkall@sfwmd.gov; South Florida Water Management District, 3301 Gun Club Road; West Palm Beach, FL 33406.

Program Manager: Dave Unsell, Lead Project Manager, (561) 682-6888; dunsell@sfwmd.gov; South Florida Water Management District; 3301 Gun Club Road; West Palm Beach, FL 33406.

Okeechobee Field Station: Terry Peters, Interim Director, 863-462-5280 x 3102; rpeters@sfwmd.gov; and Bruce Chessser, Interim Director of Field Operations, x 3114; bchesser@sfwmd.gov; Okeechobee Field Station, Okeechobee, FL

Operations Department: Tom Kosier, Environmental Operations Section (561) 682-6533; tkosier@sfwmd.gov; South Florida Water Management District; 3301 Gun Club Road; West Palm Beach, FL 33406

Water quality monitoring: W. Patrick Davis **Field Project Manager** (863) 462-5280 x 3171; wpdavis@sfwmd.gov; Okeechobee Water Quality Field Section, 1000 NE 40 Avenue, Okeechobee, FL 34972.

U. S. Army Corps of Engineers: Stephanie Jenkins; Hydraulic Engineer (904) 232-1612; Stephanie.L.Jenkins@saj02.usace.army.mil; US Army Corps of Engineers, Jacksonville District, ENHW, 701 San Marco Blvd, Jacksonville, Florida 32207.

Florida Department of Environmental Protection: Kim Shugar, Program Administrator, (561) 681-6706; kimberly.shugar@dep.state.fl.us; FDEP-Southeast District, 400 N. Congress Avenue, Suite 200, West Palm Beach, Florida 33401.

5.2 OPERATIONS PHASE

Once the Corps transfers the project over to the SFWMD, the **Operations Phase** commences. Most, if not all, of the same degree of communication and coordination that began in the **initial operational testing and monitoring period** will continue.





5.2.1 On-going data review and operational feedback

The frequency and type of the weekly/monthly meetings during the Operations Phase may not differ from the earlier phases, depending on the status of the WPA and whether or not there are significant refinements to the operations based on previous experience or permit requirements. During the summer, the performance evaluation for the previous water year should be drafted for including in the draft of the annual South Florida Environmental Report.

5.2.2 Interagency coordination

Depending on the Corps continued role and responsibilities after the project is turned over to the SFWMD, their involvement in the weekly/monthly coordination conferences may change in the Operations Phase. There may or may not be a shift in the other agency contacts shown in section 5.1.2 above, depending on the status of the WPA and other needs.

5.3 COORDINATION WITH OTHER PLANS

The SFWMD, the Corps, the FDEP, other agencies and private landowners are cooperating on efforts to improve water quality in the Indian River Lagoon, and throughout the south Florida ecosystem. This cooperation includes studies and capital projects composing the CERP, and Critical Restoration Projects. The operations, monitoring and reporting associated with the Ten Mile Creek WPA will be coordinated with several other plans, including:

1. The Indian River Lagoon SWIM Plan
2. The Indian River Lagoon Feasibility Study
3. Draft Preliminary Water Control Plan for the Ten Mile Creek Deep Water Storage Area, USACE 2003.
4. Ten Mile Creek Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual, as required by the Project Cooperation Agreement between the Corps and SFWMD, USACE 2005.
5. Vegetation Management Plan for the Ten Mile Creek WPA, Wetland Consulting Services, Inc. 2005.
6. Performance Plan for the Ten Mile Creek WPA, Gary Goforth, Inc. 2005.
7. St. Lucie Minimum Flows and Level (Draft), SFWMD 2002.
8. District staff indicate that the St. Lucie Estuary, North Fork Adaptive Management Plan will be written in cooperation with RECOVER.
9. Florida Department of Natural Resources. North Fork of the St. Lucie River Aquatic Preserve Management Plan. May 22, 1984. 118 pp.





6 REFERENCES

- Florida Department of Environmental Protection, CERPRA permit No. 0192879-001-GL, issued to the U.S. Army Corps of Engineers.
- Florida Department of Environmental Protection, draft CERPRA permit No. 0192879-002-GL, issued to South Florida Water Management District.
- Gary Goforth, Inc., 2005. Performance Plan for the Ten Mile Creek STA, prepared for the South Florida Water Management District, November 2005.
- Memorandum of Understanding Between the SFWMD and the North St. Lucie River Water Control District Concerning the NSLRWCD Surface Water Management System and the Ten Mile Creek Critical Restoration Project, July 9, 2002.
- Post Buckley, Shuh and Jernigan, 2002a. Design Documentation Report for Ten Mile Creek Project Water Preserve Area St. Lucie County, Florida, Final (100%) Corrected Design, prepared for the U.S. Army Corps of Engineers, April 30, 2002.
- Post Buckley, Shuh and Jernigan, 2002b. Plans for Ten Mile Creek Water Preserve Area St. Lucie County, Final 100% Plans, February 13, 2002.
- Post Buckley, Shuh and Jernigan, 2002c. Ten Mile Creek Operation, Maintenance, Repair, Replacement and Rehabilitation Manual, prepared for the USACE, April 30 2002.
- Knight, R. 1999. Draft Assessment of the Water Quality and Environmental Benefits of the Proposed Ten Mile Creek Water Preserve Area, prepared for SFWMD.
- U. S. Army Corps of Engineers, Critical Project Letter Report, April 1998, approved 5/22/98.
- U. S. Army Corps of Engineers, Project Cooperation Agreement between the Department of the Army and South Florida Water Management District for Construction of Ten Mile Creek Water Preserve Area Critical Restoration Project, January 7, 2000.
- U. S. Army Corps of Engineers, Draft - Preliminary Water Control Plan for the Ten Mile Creek Deep Water Storage Area, December 2003.
- U. S. Army Corps of Engineers, Ten Mile Creek Operation, Maintenance, Repair, Replacement and Rehabilitation Manual, March 2005.
- Wetland Consulting Services, Inc., Vegetation Management Plan for the Ten Mile Creek STA, Draft October 2005.
- Wetland Solutions, Inc., Ten Mile Creek Water Preserve Area – Updated Water Quality Assessment Final Report, prepared for the SFWMD, June 2002.



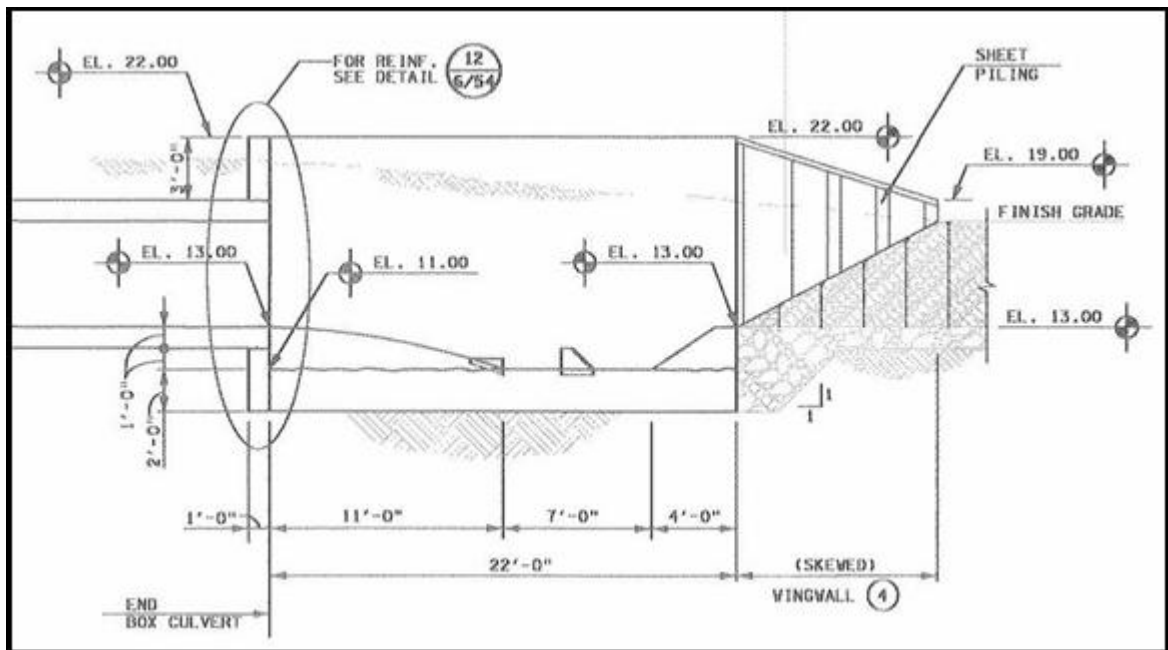
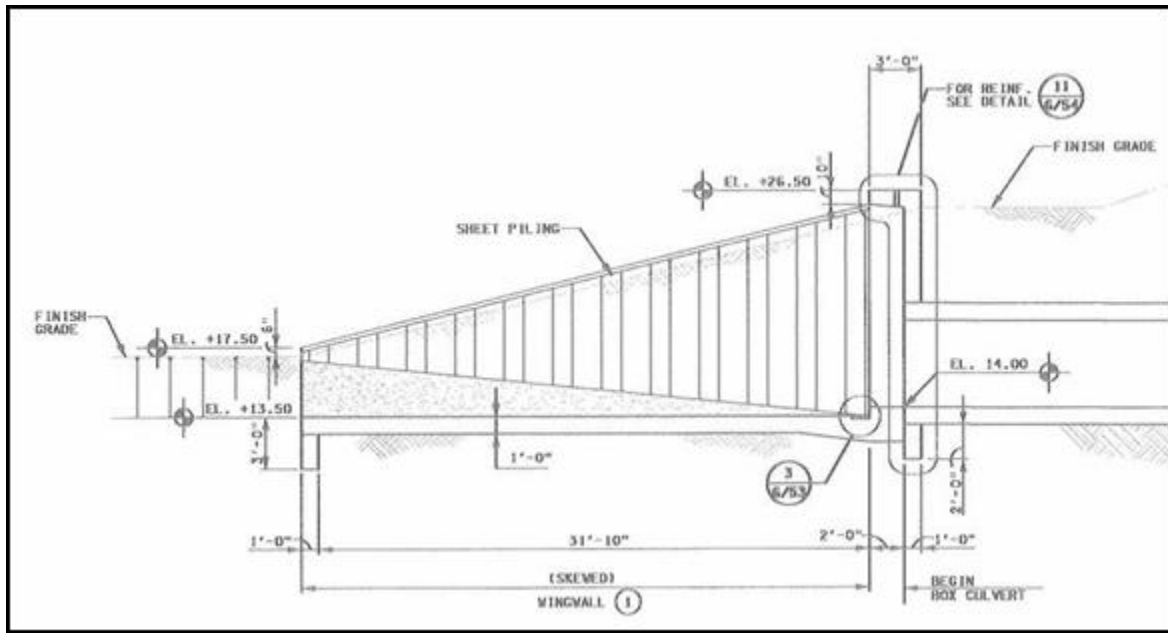


Cross Section of S-382 Pump Station.



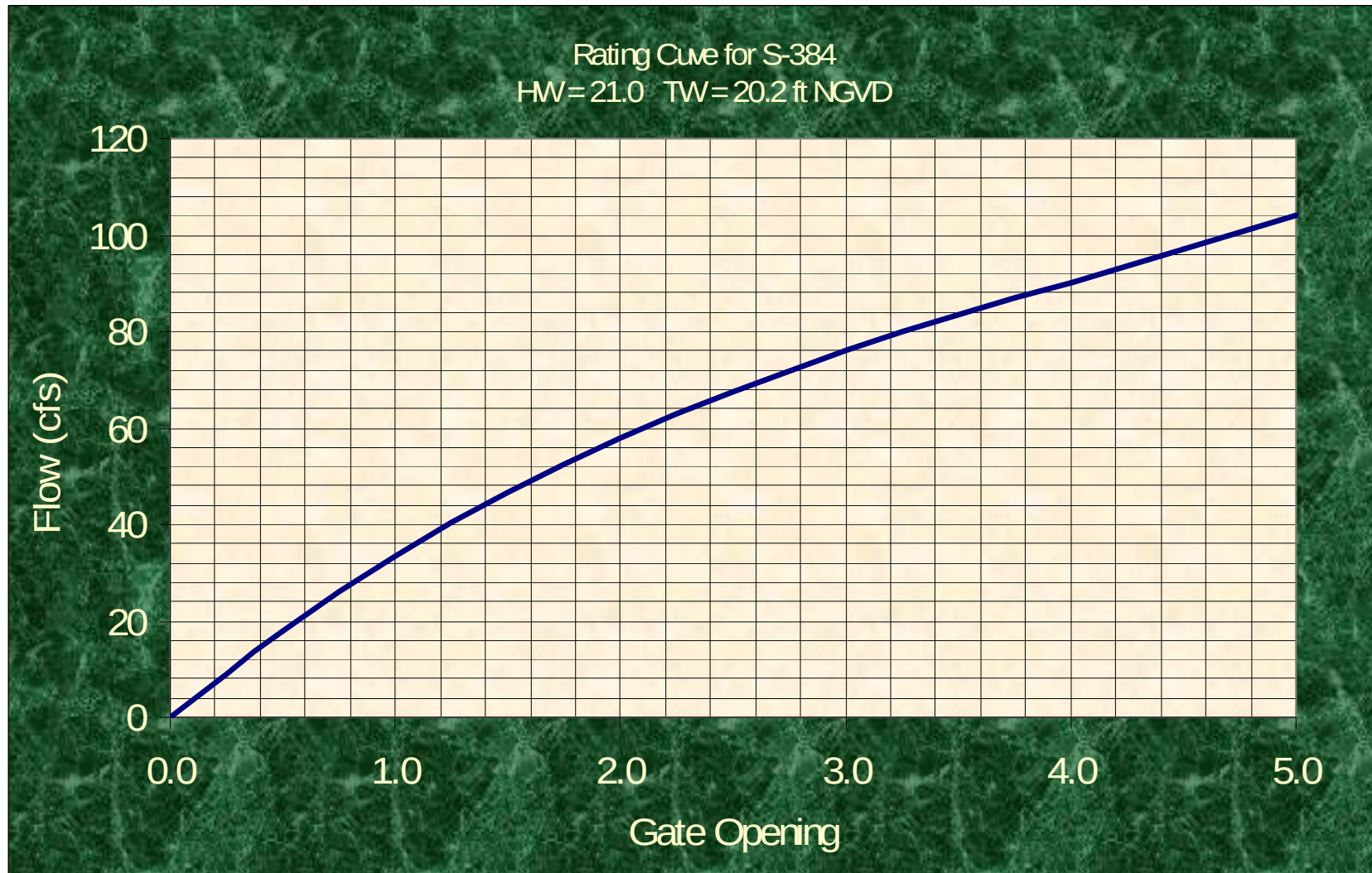


Cross Section of S-384 Showing Headworks (upper) and Discharge Features (lower).





Rating Curve for S-384 Under Low Head Difference Condition (from PBSJ 2002c)

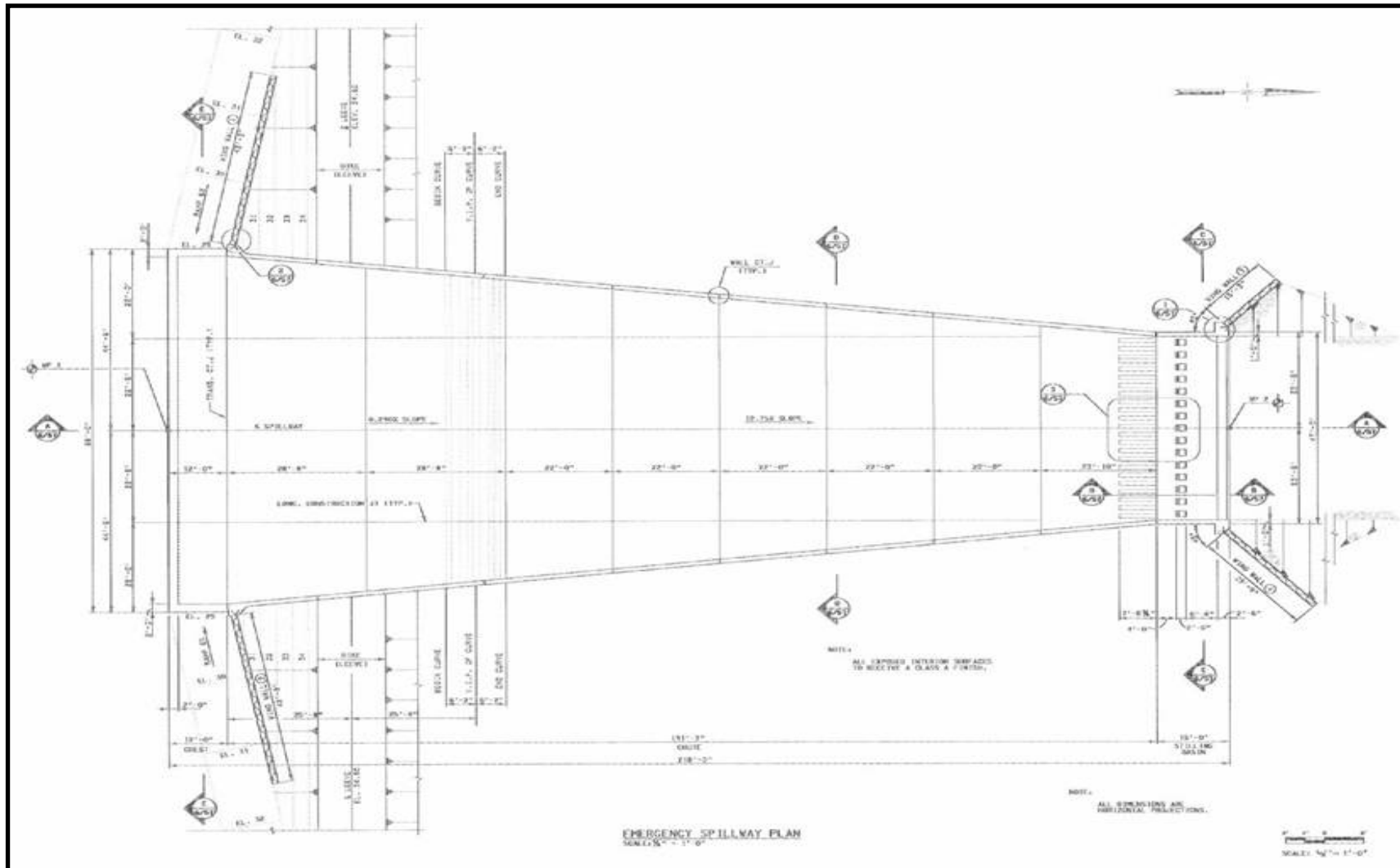


Plan view of the emergency spillway.





Ten Mile Creek WPA Operation Plan

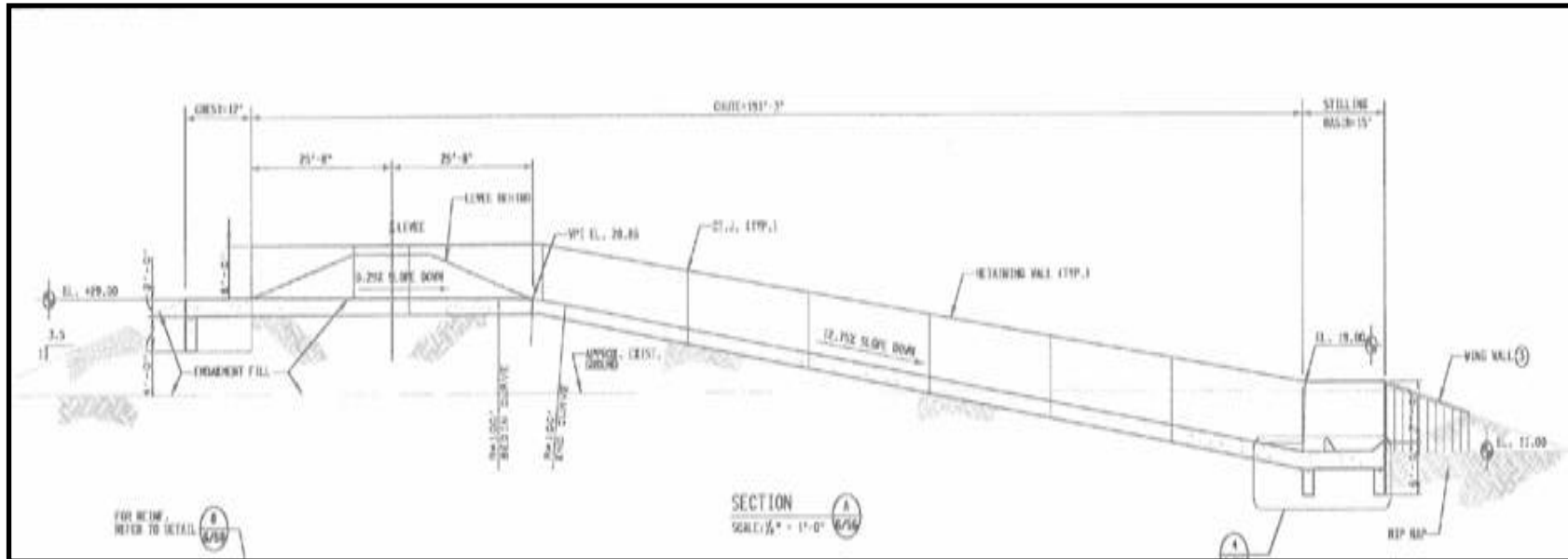


Cross section through the emergency spillway.



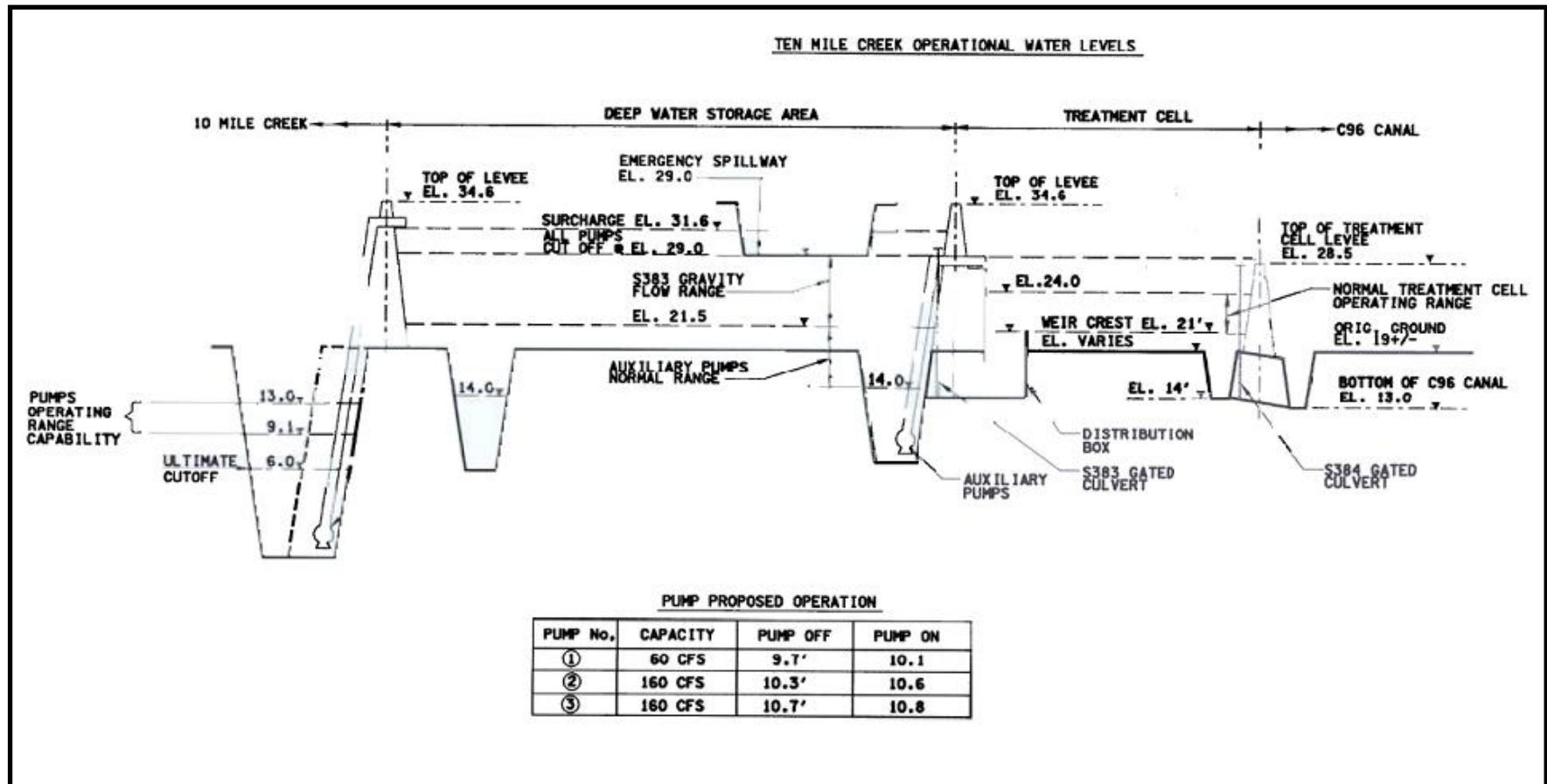


Ten Mile Creek WPA Operation Plan





Ten Mile Creek WPA Operation Plan



SOUTH FLORIDA WATER MANAGEMENT DISTRICT



PERFORMANCE PLAN
TEN MILE CREEK
WATER PRESERVE AREA



January 2006

Gary Goforth, Inc.



CERTIFICATION

I hereby certify, as a Professional Engineer in the State of Florida, that the information in this Operation Plan was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the South Florida Water Management District or others 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.

A handwritten signature in black ink, appearing to read "GFG", followed by a horizontal line.

Date: 9/12/2011

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

Gary Goforth, Inc.

10924 SW Hawkview Circle

Stuart, FL 34997

Certificate of Authorization #26236





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PLEASE NOTE

During the preparation of this *Performance Plan*, the following critical issues were identified that requires a change in previously proposed operations of S-383 to ensure that maximum project benefits can be achieved.

- 1. Avoid Reservoir Dryout.** The draft Preliminary Water Control Plan (USACE 2003) calls for discharges from the reservoir to the treatment cell as the water level in the reservoir cell recedes to approximately 4 ft below the average ground elevation, to a stage of 14.0 ft. This operation is in direct conflict with one of the fundamental principles of other facilities associated with nutrient removal: avoid dryout in order to prevent the release of nutrients from the exposed soil. It also conflicts with the Water Quality section of the Final Design Documentation Report (see page 26): "As long as these reservoirs are managed so that drying is avoided, these nutrients will be bound to the sediments and kept there." In general, for a reservoir/STA with a relatively flat bottom, a minimum depth of 0.5 ft above the average ground elevation should be maintained to minimize dryout and subsequent release of nutrients. However, in the case of the Ten Mile Creek reservoir cell with a variable ground elevation, it may be better to initially set the minimum depth at one foot above the average ground elevation, and refine this target after operational experience. Therefore, the Operation Plan recommends terminating releases through S-383 when the reservoir stage drops to 19.0 ft and initiating discharges when the stage rises to 19.0 ft. This change has the added benefit of significantly simplifying the operation of the S-383 structure during the wet season by allowing a uniform 35 cfs flow at all stages, instead of the previously proposed multiple flow rates at stages between 14.0 ft and 19.0 ft.
- 2. Reduce Dry Season Releases as the Reservoir Storage Decreases.** The draft Preliminary Water Control Plan (USACE 2003) documents that the optimal balance occurs when dry-season releases to the treatment cell decrease with decreasing storage, yet in contrast, recommends a constant release of 35 cfs for all depths above 1.0 ft above the average ground elevation. Consistent with the above principle, the District simulation of the Water Preserve Area (Konyha 2002) incorporated a depth-dependent relationship that maximizes the water releases during the dry season and thereby prolongs the downstream estuarine benefits compared to the draft Preliminary Water Control Plan. Therefore, the *Operation Plan* recommends using the relationship used in the District simulation, modified with flows set to zero at stages above 29.0 ft, corresponding to the elevation of the emergency spillway crest.

In addition, although not explicitly required by the draft permit, it is recommended that the SFWMD monitor flow and nutrients at S-383, the outlet from the reservoir into the treatment cell. This will enable direct estimates of nutrient removal performance of each cell, which will allow operational feedback to optimize removal performance. Without such sampling it will be impossible to monitor and evaluate the performance of the treatment area as required in Specific Condition 11 of the draft operating permit from FDEP.





1 PROJECT DESCRIPTION

1.1 BACKGROUND

The South Florida Water Management District (SFWMD), the U. S. Army Corps of Engineers (Corps), the Florida Department of Environmental Protection (FDEP), other agencies and private landowners are cooperating on efforts to improve water quality in the Indian River Lagoon watershed, including the St. Lucie Estuary. This cooperation includes studies and capital projects composing the Indian River Lagoon Project of the Comprehensive Everglades Restoration Plan (CERP), and related Critical Restoration Projects. Recent fresh water deliveries to the St. Lucie River estuary via Ten Mile Creek have been subject to great fluctuations in volume and timing, causing wide variations in salinity and stress to estuarine flora and fauna. The SFWMD and the Corps are collaborating to improve timing and volumes of freshwater deliveries to enhance estuarine water quality and productivity in the St. Lucie River estuary. The Ten Mile Creek Water Preserve Area (WPA) is a Critical Restoration Project authorized by Congress through Section 528 of the Water Resources Development Act of 1996 and consists of a 550-acre reservoir cell followed by a 160-acre wetland treatment cell that will help regulate stormwater runoff volumes, reduce fine sediment and nutrient loadings, supplement dry season flows to enhance estuarine productivity, and provide irrigation water for upstream users after downstream environmental needs are met.

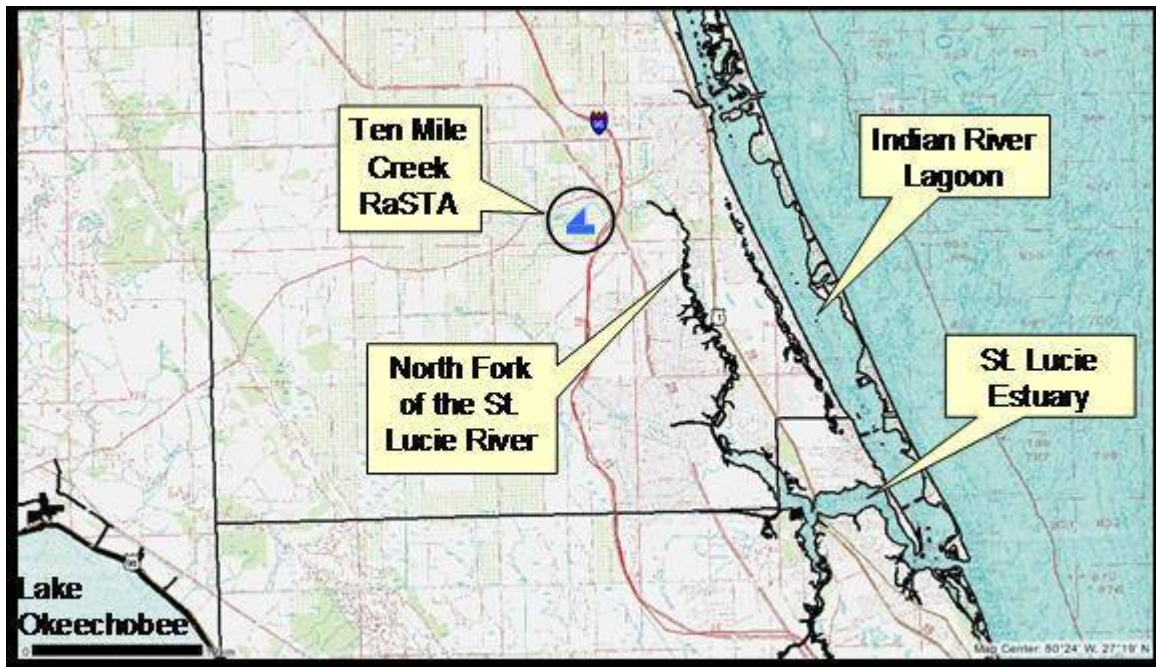
The Ten Mile Creek WPA is approximately 10 miles west of the Ft. Pierce (Figure 1), adjacent to Ten Mile Creek, and just west of the I-95/Florida Turnpike interchange. The project is located at the outlet of the 30,682 acre (48 square mile) Ten Mile Creek Basin. The WPA occupies approximately 710 acres, and the project site originally consisted of a citrus grove along with cattle pasture and some isolated wetlands scattered among low, shrubby uplands. The Ten Mile Creek WPA was designed by Post Buckley, Schuh and Jernigan (PBSJ) working under contract to the Corps, who was responsible for construction. Construction is presently underway with completion scheduled for early 2006. The SFWMD is the sponsor for the project and assisted in the funding of the capital works and will be responsible for operation and maintenance of the WPA.

After completion of construction and prior to turnover to the SWMD, the Corps will conduct an initial operational testing and monitoring period during which time data will be collected to demonstrate compliance with state water quality standards.





Figure 1. Ten Mile Creek WPA location map.



Long-term freshwater flows from Ten Mile Creek to the north fork of the St. Lucie River have been historically inconsistent, ranging from salinity depressing storm flows to lengthy closures of the Gordy Road water control structure to meet upstream basin irrigation needs. The farms and residences within the Ten Mile Creek basin require effective operation of the existing water control structures for flood control and water supply, but changes to the St. Lucie River's ecology have become increasingly evident as a result of the altered hydrology of this critical tributary. Additionally, degradation of the river's water quality has been observed and implicated in algae blooms and a reduction in estuary productivity, most notably by losses in seagrass and oyster bed coverage.

The primary operational objective of the WPA is **to control the quantity and timing of water deliveries** to the North Fork of the St. Lucie River by capturing and storing stormwater currently being discharged at unnatural rates. These uncontrolled discharges and excessive stormwater runoff are currently degrading the water quality and wildlife habitat of the St. Lucie estuary and Indian River Lagoon by radically upsetting salinity concentrations, increasing the deposition of sediments and nutrients, and reducing the amount of freshwater recharge into the aquifer. The primary benefit of the WPA will be to help re-create a more natural salinity range in the St. Lucie Estuary by establishing a more natural pattern of freshwater flows from Ten Mile Creek into the North Fork of the St. Lucie River. Stabilizing the salinity concentration will greatly enhance the estuary's ability to support sea grasses, oysters and nursery grounds for marine fish. Commercial and recreational fishing are very important activities in this region and will be benefited by an improved estuary. The West Indian Manatee, an endangered species, is dependent on sea grasses as a primary food source.





This project, coupled with ongoing water quality improvement projects, will help to reduce the further decline of sea grasses in the estuary.

Secondary operational objectives include **reduction of the sediment load** delivered to the estuary through sedimentation of suspended solids in the WPA. In addition, the stormwater will pass through a shallow water marsh for additional water quality treatment, primarily to **reduce nutrient levels**, before being released into the North Fork. Stored water will also **increase the amount of freshwater recharge into the aquifer**, and further reduce demand on the aquifer through releases back to the Ten Mile Creek basin in the drier winter months to **augment local water supply**.

The Ten Mile Creek WPA encompasses approximately 710 acres adjacent to Ten Mile Creek, as shown in Figure 2. The inflow pump station lifts water from Ten Mile Creek at the northern edge of the WPA and delivers it to a 526-acre reservoir cell. Approximately half of this water is passed into a 132-acre treatment cell, where water quality treatment occurs through natural biogeochemical processes. Water levels and flow rates through the reservoir and treatment cells are controlled by gated structures located at the western boundaries of each cell. Deep zone trenches at the inflow, center and outflow of the treatment cell are designed to help distribute flow evenly throughout the cell. Treated water is discharged back to Ten Mile Creek through a water control structure and approximately ½ mile of an existing drainage canal. A portion of the captured stormwater will be released back to Ten Mile Creek to meet water supply demands in the upstream basin.

Emergent wetland vegetation (cattail, bulrush, *sagitaria*, *pontedaria*, etc.) has already begun to colonize the treatment area, and an average operating depth of 1-1.5 feet should be conducive to sustaining these communities. Concentrations of nutrients in Ten Mile Creek runoff exhibits considerable variability, with an average phosphorus concentration of approximately 245 parts per billion (ppb) and an average total nitrogen concentration of approximately 1.6 mg/L (WSI 2002). The long-term nutrient storage mechanism within the project will be the accretion of new organic sediment, and for this reason it is important to operate the reservoir and treatment cells to avoid dry out, which will oxidize the organic soils and release stored nutrients downstream.

In addition to the reduction of nutrient loads and concentrations, the Ten Mile Creek WPA will provide additional water quality and quantity benefits to downstream waters, including the removal of suspended solids, metals, and pesticides that would otherwise flow into the North Fork of the St. Lucie Estuary.

1.2 PERFORMANCE OBJECTIVES

The primary operational objective of the WPA is **to control the quantity and timing of water deliveries** to the North Fork of the St. Lucie River by capturing and storing stormwater currently being discharged at unnatural rates. Secondary operational objectives include **reduction of the sediment load** delivered to the estuary through sedimentation of suspended solids in the WPA. In addition, the stormwater will pass through a shallow water





marsh for additional water quality treatment, primarily to **reduce nutrient levels**, before being released into the North Fork. Stored water will also **increase the amount of freshwater recharge into the aquifer**, and further reduce demand on the aquifer through releases back to the Ten Mile Creek basin in the drier winter months to **augment local water supply**.

Figure 2. Aerial of the Ten Mile Creek WPA.



From a performance perspective, there are three quantitative targets established in the (draft) operating permit issued to the SFWMD:

1. Prior to discharge, the WPA must demonstrate a **net improvement** in mercury, phosphorus, and nitrogen.
2. After discharges have begun, the WPA will be in a **stabilization phase** until the 12-month flow-weighted average total phosphorus and nitrogen concentrations at the outflow do not exceed, or are equal to, the 12-month flow-weighted average total phosphorus and nitrogen concentrations at the inflow.
3. Once the WPA has achieved the stabilization defined above, it shall be operated to **optimize the water quality performance** set forth in the final report entitled





“Assessment of Water Quality and Environmental Benefits of the Proposed Ten Mile Creek Water Preserve Area” prepared by Robert L. Knight.

Nutrient removal performance for the Ten Mile Creek WPA was estimated during the design by Wetland Solutions, Inc., utilizing a 31-yr inflow data set developed by the SFWMD (WSI 2002). The long-term average annual influent phosphorus concentration was estimated as approximately 245 parts per billion (ppb) at Ten Mile Creek, yielding a long-term average annual phosphorus load to the WPA of approximately 4,857 kg/yr. The data set utilized by WSI indicated that approximately 16,070 acre feet per year could be pumped into the WPA for storage and treatment, with approximately 3,630 acre feet per year returned to the local basin to satisfy water supply demand. The earlier report estimated that approximately 7,810 acre feet per year were discharged to the treatment cell at an average TP concentration of 90 ppb. Using the 2002 version of DMSTA, a long-term average annual TP outflow concentration of 50 ppb was estimated (WSI 2002). As part of preparing this Performance Plan, the TP performance projections from the 2002 WSI report were re-evaluated using the updated DMSTA2 simulation model. The new simulation results indicated in a long-term average annual inflow of 15,130 acre feet per year and 245 ppb, and with water supply demand of 2,690 acre feet per year and a seepage estimate of 4,880 AF/yr. The new DMSTA projects higher TP concentrations and loads leaving the reservoir and the treatment cell than the 2002 WSI report. The new DMSTA2 simulation projects 7,778 acre feet per year leaving the reservoir at 178 ppb, compared to 7,810 AF/yr at 90 ppb from the WSI report. This difference is likely a result of a combination of factors: a modified reservoir algorithm in DMSTA2, a more conservative performance calibration data set in the updated DMSTA2 model, and a performance penalty that increases with increasing depth. The new simulation projects discharges leaving the treatment cell at 72 ppb, compared to 50 ppb from the WSI report. The difference in outflow concentrations is likely due to multiple factors, including the difference in treatment cell inflow concentrations (178 ppb vs. 90 ppb) and differences in the phosphorus removal algorithms between the two DMSTA versions (including different effective settling rates for emergent vegetation, revised performance penalty for depth, and the addition of a penalty for higher concentrations). Using the updated projections, it is estimated that the net TP load reduction of the WPA, including water supply releases as reductions to the stream flow, will be approximately 3,988 kg/yr, or approximately 87% of the inflow load. When combined with the approximately 60% of the Ten Mile Creek flow is not captured by the WPA, the 3,988 kg/yr load reduction attributable to the WPA equates to a load reduction of approximately 33% of the estimated annual load in Ten Mile Creek at the project site. The combined reservoir/treatment cell was also projected to lower the average total nitrogen concentration from about 1.6 to 1.2 mg/L (WSI 2002).

The actual annual performance within the Ten Mile Creek WPA may vary significantly from these forecast long-term averages due to the variability in the flows and nutrient levels within Ten Mile Creek, as well as the inherent variability in the biological removal processes within the reservoir and STA.





With regard to performance, there are two distinct phases for the Ten Mile Creek WPA. In accordance with the Project Cooperation Agreement executed between the Corps and the District, prior to turnover of the project to the District, the Corps will conduct an **initial operational testing and monitoring period**. During this period, data will be collected to demonstrate that the project achieves the designated benefits. Once the District Engineer determines that the project is performing as designed, the Corps will transfer the project to the District for subsequent operations, maintenance, repair, replacement and rehabilitation, commencing the **operations phase**. The following sections describe the performance objectives specific to those two periods.

1.2.1 Initial Operational Testing and Monitoring Period

The initial operational testing and monitoring period consists of a start-up phase (pre-discharge) and a flow-through (discharge) phase. The operational goal during WPA startup is to provide hydrologic conditions conducive to wetland vegetation growth, while avoiding release of total phosphorus, nitrogen and mercury. The performance objective during start-up is to demonstrate a net improvement in all three of these parameters (see Section 2.1.1 below for details). The CERPRA permit issued to the Corps by the FDEP precludes flow-through operations until phosphorus, nitrogen and mercury concentrations demonstrate a net improvement compared to the source water in Ten Mile Creek. In addition, the permit requires that a pesticide sample be taken in the water column and sediment at the inflow and outflow structures before discharges are to occur from the WPA.

Once the phosphorus, nitrogen and mercury data demonstrate a net improvement, discharges will begin, and the second phase of the initial operational testing and monitoring period will begin. During this phase, the nutrient removal performance of the WPA will be monitored through extensive water quality sampling. In addition, the FDEP permit requires monitoring and assessment of numerous other water quality constituents (FDEP 2005).

During the **initial operational testing and monitoring period**, data will be collected to demonstrate that the project achieves the designated benefits. Once the District Engineer determines that the project is performing as designed, the Corps will transfer the project to the SFWMD for subsequent operations, maintenance, repair, replacement and rehabilitation, commencing the **operations phase**.

1.2.2 Operations Phase

Concentrations of phosphorus and nitrogen in Ten Mile Creek runoff exhibits considerable variability, with a long-term average for phosphorus of approximately 245 ppb, and for nitrogen of approximately 1.6 mg/L (WSI 2002). The long-term nutrient storage mechanism within the WPA will be through accretion of new organic sediment, **hence it is critical that operations minimize the frequency and magnitude of dry out conditions**. A summary of the performance characteristics developed during the design of the project are summarized in Table 1. In addition to the reduction of nutrient loads, the Ten Mile Creek WPA will provide additional water quality and quantity benefits to downstream waters, including the removal of suspended solids, metals, and pesticides that would otherwise flow into the lake.





Table 1. Summary of WPA Performance Parameters (PBSJ 2002, WSI 2002 & this Plan).

Design Parameter	Reservoir Cell	Treatment Cell	Entire WPA
Water Preserve Area			
Effective Treatment Area (acres)	526	132	658
Total Area (acres)	550	160	710
Average ground elevation (ft NGVD) ¹	18 ±	21.2 ±	18.4 ±
Flow			
Average pumped inflow (cfs)	22	11	
Average annual pumped inflow (acre feet/yr) ²	15,130	7,778	15,130
Average hydraulic loading rate (cm/d) ²	2.6	4.9	
Mean depth at average water surface (ft) ²	5.7 ±	1.25 ±	
Nominal hydraulic residence time (days) ²	73	7	
Average annual rainfall (inches/yr)	53	53	53
Average annual evapotranspiration (inches/yr)	51	51	51
Estimated water supply returned to basin (AF/yr) ²	2,690	0	2,690
Estimated seepage loss (AF/yr) ²	4,880	1,330	6,210
Estimated discharge from treatment cell (AF/yr) ²		6,560	6,560
Phosphorus			
WPA			
Average inflow concentration (ppb)	245	178	245
Average pumped inflow load (kg/yr) ²	4,573	1,704	4,573
Average inflow loading rate (g/m ² /yr) ²	2.2	3.2	
Average atmospheric deposition (mg/m ² /yr)	20	20	
Effective settling rate (m/yr) ²	5	16.8	
Estimated outflow concentration (ppb) ²	178	72	72
Estimated outflow load (kg/yr) ²	1,704	585	585
Estimated load removal (kg/yr) ²	2,869	1,119	3,988
Estimated TP load reduction (%) ²	63%	66%	87%
Estimated TP conc. reduction (%) ²	27%	60%	70%
Ten Mile Creek			
Average annual flow before WPA (AF/yr)			40,498
Average annual load before WPA (kg/yr)			12,239
Average annual flow after WPA (AF/yr)			31,928
Estimated load after WPA (kg/yr) ²			8,252
Estimated concentration after WPA (ppb) ²			210
Estimated load reduction (kg/yr) ²			3,988
Estimated overall load reduction (%) ²			33%

¹ All ground and water surface elevations are referenced to the 1929 NGVD.

² Based on updated DMSTA2 modeling; some values are slightly revised from those developed during the design of the project. More than half of the reservoir inflow was simulated as returned to Ten Mile Creek basin for water supply or contributing to groundwater recharge. The load reduction estimate includes these components as removal.





2 PERMIT INFORMATION AND REPORTING REQUIREMENTS

2.1 INITIAL OPERATIONAL TESTING AND MONITORING PHASE

The Florida Department of Environmental Protection (FDEP) issued a Comprehensive Everglades Restoration Regulation Act (CERPRA) permit 0192879-001-GL to the Corps for the construction of the Ten Mile Creek WPA. For the purpose of the permit, the construction phase includes the initial operational testing and monitoring period. The nutrient performance-related monitoring requirements of the permit are discussed below.

2.1.1 Performance Monitoring Requirements for the Start-up (pre-discharge) Period

Net improvement in nutrient concentrations. Figure 3 identifies the monitoring locations for water levels, flow, phosphorus and nitrogen samples. Total phosphorus and nitrogen will be sampled weekly at the inflow (S-382) and outflow (S-384) structures, both grab and flow-proportioned composite samples, for the duration of the pre-discharge period. The automatic samplers will be programmed to collect samples on a time composite basis during the period of pre-discharge.

Prior to initiating flow-through (discharge) activities, nutrients will be monitored to demonstrate that the WPA is achieving a net improvement in phosphorus and nitrogen. This net improvement shall be deemed to occur when the 4-week geometric mean concentration collected at the outflow structure (S-384) is less than the 4-week geometric mean collected at the inflow structure (S-382). If the project has not achieved a net improvement of phosphorus and nitrogen within two months after beginning pre-discharge activities, reports of the 4-week geometric mean differences will be transmitted to the FDEP. If net improvement has not been demonstrated after six months, the vegetation conditions shall be evaluated and strategies to achieve the net improvement are to be identified.

Mercury net improvement shall be demonstrated when the concentration of total mercury and methyl mercury at the mid-point of the WPA are not significantly greater than the concentration of the corresponding species at the inflow to the WPA. In addition, the permit requires that a pesticide sample be taken in the water column and sediment at the inflow and outflow structures before discharges are to occur from the WPA.

Once the net improvement in nutrients and mercury has been demonstrated, the FDEP shall be notified and discharges from the WPA may commence.

2.1.2 Performance Monitoring Requirements for the Flow-through (discharge) Period

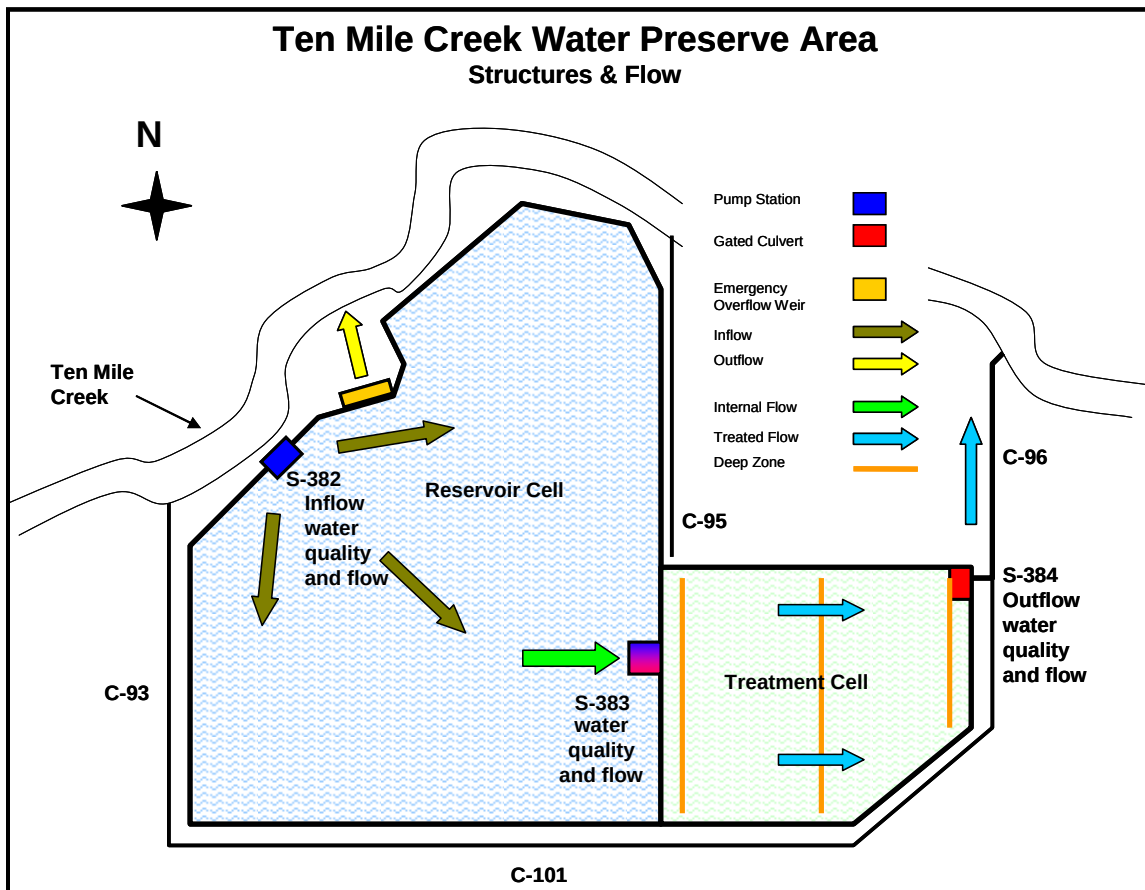
During the Flow-through Period, the focus of the WPA performance monitoring will be on establishing flow-weighted mean concentrations and loads entering and leaving the WPA. Total water column phosphorus and nitrogen samples will be collected weekly at the inflow





and outflow structures. Water quality data at the WPA outlet will be obtained on the upstream side of the S-384 discharge structure. Samples will be collected by an automatic sampler and weekly grab samples. The S-384 structures will be instrumented to provide computed flow rates by using upstream and downstream stage sensors in combination with gate opening information. A MOSCAD remote terminal unit will total the discharge and trigger the automatic sampler.

Figure 3. Schematic of Ten Mile Creek Hydrologic and Water Quality Monitoring Sites.
Note: Monitoring at S-383 is not presently required by permit, but recommended for optimal performance and operational management.



Data from these samples will be evaluated for the permit as follows:

1. Rolling 3-month flow-weighted mean total phosphorus and nitrogen concentrations for the WPA shall be calculated for the outflow and inflow structures;
2. The flow-weighted mean outflow concentrations of total phosphorus and nitrogen for the WPA at the outflow structure shall be compared to flow-weighted mean concentrations at the inflow structure using the student's t-test with a 95% confidence interval on log transformed data.





If the evaluation indicates that the flow-weighted mean outflow concentration is less than the flow-weighted mean inflow concentration, then the discharges from the project shall be deemed to be in compliance with Specific Condition 15A. If after six months, discharges from the WPA are not achieving a net reduction in total phosphorus and nitrogen, the vegetation conditions shall be evaluated and strategies to achieve the net improvement are to be identified.

In addition to nutrients, the permit contains conditions requiring either a net improvement in concentrations, or discharges to be at or below applicable criteria. For dissolved oxygen the permit requires demonstration that the WPA is not responsible for degradation of dissolved oxygen in downstream receiving waters. Additional details are found in the FDEP construction permit. ***Although not explicitly required by the permit, it is recommended that the SFWMD monitor flow and nutrients at S-383, the outlet from the reservoir into the treatment cell once flow-through operation begins. This will enable direct estimates of nutrient removal performance of each cell, which will allow operational feedback to optimize removal performance.***

2.1.3 Reporting Requirements

All water quality submittals required by the FDEP construction permit shall be transmitted to the FDEP in an Annual Report. Specific Condition 19 of the FDEP permit contains the minimum information to be contained in the Annual Reports. A summary of the nutrient-related monitoring requirements is shown in Table 2.

Table 2. Summary of Nutrient-related Performance Monitoring.

Structure	Headwater Stage	Tailwater Stage	Flow	Nutrients
S-382	Continuous	Continuous	Based on pump curves and stage data	Flow proportioned composite and weekly grab
S-383	Continuous	Continuous	Calculated based on stage data and gate opening	<i>Not required, but recommended: Flow proportioned composite and weekly grab</i>
S-384	Continuous	Continuous	Calculated based on stage data and gate opening	Flow proportioned composite and weekly grab

2.2 OPERATIONS PHASE

Presently the FDEP and the SFWMD are finalizing the operations, maintenance and monitoring permit for the project (0192879-002-GL). Accordingly, the WPA Performance Plan must be consistent with the requirements of those permits.





2.2.1 Performance Monitoring Requirements for the Operations Phase

It is anticipated that the nutrient performance-related monitoring requirements will be similar to those described in Section 2.1.2 and shown in Table 2 and Figure 3 above.

Note: Although not explicitly required by the draft permit, it is recommended that the SFWMD monitor flow and nutrients at S-383, the outlet from the reservoir into the treatment cell. This will enable direct estimates of nutrient removal performance of each cell, which will allow operational feedback to optimize removal performance. Without such sampling it will be impossible to monitor and evaluate the performance of the treatment area as required in Specific Condition 11 of the draft operating permit from FDEP.

Data will be collected to monitor flow rates and nutrient removal rates within the WPA, as well as to gather other water quality information. Inflow volumes to the WPA will be determined by the manufacturer's pump curves and system head determined from water levels transmitted from sensors at the pump station. A flow proportioned composite water sample will be collected weekly at the inflow station, along with a weekly grab sample. At S-383, a gate level sensor, monitored in conjunction with the headwater and tailwater level sensors, provides discharge information from the reservoir to the treatment cell. A similar arrangement of water and gate level sensors at the outfall of Cell 2 (S-384) provides total effluent discharge. In addition to providing operational information, these data are critical to establishing accurate water and nutrient mass balances for the treatment cells. The three flow measurements, one at the inflow, one at the inflow to the treatment cell, and one at the discharge end of the STA, in conjunction with local rainfall measurements, will enable the calculation of quantities of water treated and combined losses from seepage and evapotranspiration. Stage readings across the WPA will also be helpful in assessing static and dynamic surface water profiles, allowing verification of estimates developed during design.

2.2.2 Reporting Requirements

It is anticipated that all water quality submittals required by the FDEP permit shall be transmitted to the FDEP in an Annual Report. Furthermore, it is assumed that the Ten Mile Creek WPA performance report will be included in the South Florida Ecosystem Report, published annually by the District. The FDEP permit to be issued to the District for the WPA will contain the minimum information to be contained in the Annual Reports.

An example of an annual report that was recently prepared for STA-2 of the Everglades Construction Project is reprinted in Appendix 1 (Goforth et al. 2005). The format of that report has evolved over the last several years with valuable input from the peer-review panel that annually reviews the draft document. The report contains a summary of the annual operations, vegetation management, phosphorus performance, mercury, as well as a summary of other water quality parameters monitored at the STA, and is based on a May 1 – April 30 water year. The Ten Mile Creek WPA manager should review the report in Appendix 1 to identify which features may be relevant to the Ten Mile Creek WPA.





3 NUTRIENT PERFORMANCE ANALYSES

In addition to the permit-required monitoring and reporting, there is a minimal amount of analyses and reporting that the District may wish to conduct to better understand the nutrient removal capability of the Ten Mile Creek WPA. This includes both a basic water budget and nutrient mass budget information for the reservoir and treatment cell, and the WPA as a whole. This information will be invaluable in developing appropriate adaptive management remedies should the nutrient performance not achieve expectations. In addition, the information gained from this prototype WPA can potentially be applied to many of the remaining reservoir-assisted STAs contained in the overall CERP program.

Nutrient removal performance for the Ten Mile Creek WPA was estimated during the design by Wetland Solutions, Inc., utilizing a 31-yr inflow data set developed by the SFWMD (WSI 2002). The long-term average annual influent phosphorus concentration was estimated as approximately 245 parts per billion (ppb) at Ten Mile Creek, yielding a long-term average annual phosphorus load to the WPA of approximately 4,857 kg/yr. The data set utilized by WSI indicated that approximately 16,070 acre feet per year could be pumped into the WPA for storage and treatment, with approximately 3,630 acre feet per year returned to the local basin to satisfy water supply demand. The earlier report estimated that approximately 7,810 acre feet per year were discharged to the treatment cell at an average TP concentration of 90 ppb. Using the 2002 version of DMSTA, a long-term average annual TP outflow concentration of 50 ppb was estimated (WSI 2002). As part of preparing this Performance Plan, the TP performance projections from the 2002 WSI report were re-evaluated using the updated DMSTA2 simulation model. The new simulation results indicated in a long-term average annual inflow of 15,130 acre feet per year and 245 ppb, and with water supply demand of 2,690 acre feet per year and a seepage estimate of 4,880 AF/yr. The new DMSTA projects higher TP concentrations and loads leaving the reservoir and the treatment cell than the 2002 WSI report. The new DMSTA2 simulation projects 7,778 acre feet per year leaving the reservoir at 178 ppb, compared to 7,810 AF/yr at 90 ppb from the WSI report. This difference is likely a result of a combination of factors: a modified reservoir algorithm in DMSTA2, a more conservative performance calibration data set in the updated DMSTA2 model, and a performance penalty that increases with increasing depth. The new simulation projects discharges leaving the treatment cell at 72 ppb, compared to 50 ppb from the WSI report. The difference in outflow concentrations is likely due to multiple factors, including the difference in treatment cell inflow concentrations (178 ppb vs. 90 ppb) and differences in the phosphorus removal algorithms between the two DMSTA versions (including different effective settling rates for emergent vegetation, revised performance penalty for depth, and the addition of a penalty for higher concentrations). Using the updated projections, it is estimated that the net TP load reduction of the WPA, including water supply releases as reductions to the stream flow, will be approximately 3,988 kg/yr, or approximately 87% of the inflow load. When combined with the approximately 60% of the Ten Mile Creek flow is not captured by the WPA, the 3,988 kg/yr load reduction attributable to the WPA equates to a load reduction of approximately 33% of the estimated annual load in Ten Mile Creek at the project site. The combined reservoir/treatment cell was also projected to lower the average total nitrogen concentration from about 1.6 to 1.2 mg/L (WSI 2002).





The actual annual performance within the Ten Mile Creek WPA may vary significantly from these forecast long-term averages due to the variability in the flows and nutrient levels within Ten Mile Creek, as well as the inherent variability in the biological removal processes within the reservoir and STA.

3.1.1 Performance Assessment

It is recommended that a weekly assessment of WPA flows and nutrient levels be performed by the Ten Mile Creek WPA project manager. The District has many good flow and nutrient load analytical tools that facilitate frequent evaluations, e.g., the Load Program developed by Environmental Resource Assessment. The Ten Mile Creek WPA project manager may want to discuss setting up a weekly automated batch file to generate the latest information.

In addition to the Load Program, a simple spreadsheet can be quickly created and maintained. For example, the summary presented in Table 3 was developed based on the DMSTA2 simulations, and could serve as a general WPA-overall template for phosphorus and nitrogen reporting. The table identifies the simple components of the water budget, although, estimates of rainfall, evapotranspiration and seepage could be added on an annual basis to complete the water budget. The table also outlines the basic components of the nutrient budget for the WPA, although the change in biomass and sediment storage of nutrients, and loss through seepage, will need to be estimated through other means.

Figure 4 presents a summary of the 31-yr simulated flows entering the reservoir and treatment cells of WPA, taken from the DMSTA2 model output. The figure also depicts the 30-day average depths for the two cells. Exceedance frequency distributions for depth and stage for both the reservoir and treatment cells are presented in Appendix 2.

Figure 5 presents the simulated 12-month rolling mean phosphorus concentrations and loads at the entering and leaving the cells of the WPA.





Table 3. Summary of DMSTA2 Simulated Performance.

	Value
Inflow to WPA	
Flow (AF/yr)	15,130
Percent of Ten Mile Creek	37%
TP Load (kg/yr)	4,573
TP Conc (ppb)	245
Reservoir Cell	
Discharge to STA (AF/yr)	7,778
TP Load (kg/yr)	1,704
TP Conc (ppb)	178
Reservoir Cell	
Water Supply Discharge (AF/yr)	2690
TP Load (kg/yr)	589
TP Conc (ppb)	178
Treatment Cell	
Discharge to STA (AF/yr)	6,560
TP Load (kg/yr)	585
TP Conc (ppb)	72
WPA Reduction	
TP Load Reduction (kg/yr)	3,987
Removal Efficiency	87%
TP Conc (ppb)	72
TP Conc reduction	70%
Ten Mile Creek After WPA	
Flow (AF/yr)	31,928
TP Load (kg/yr)	8,252
TP Conc (ppb)	210
Ten Mile Creek Reduction	
TP Load Reduction (kg/yr)	3,987
TP Load Reduction	33%
TP Conc Reduction (ppb)	35
TP Conc Reduction	14%





Figure 4. Time series of DMSTA2 simulated inflows (upper chart) and depths (lower chart) into the Ten Mile Creek WPA.

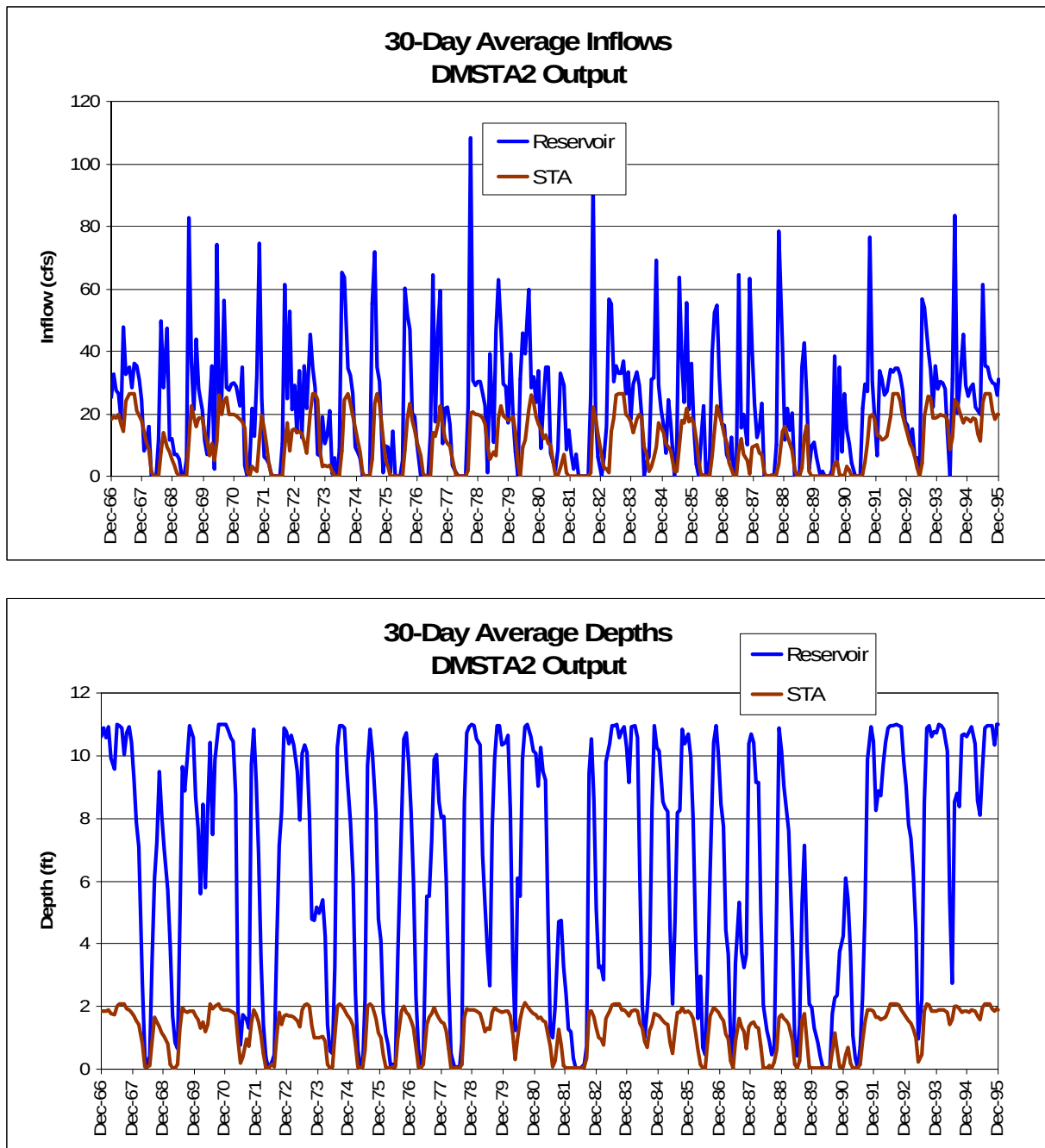
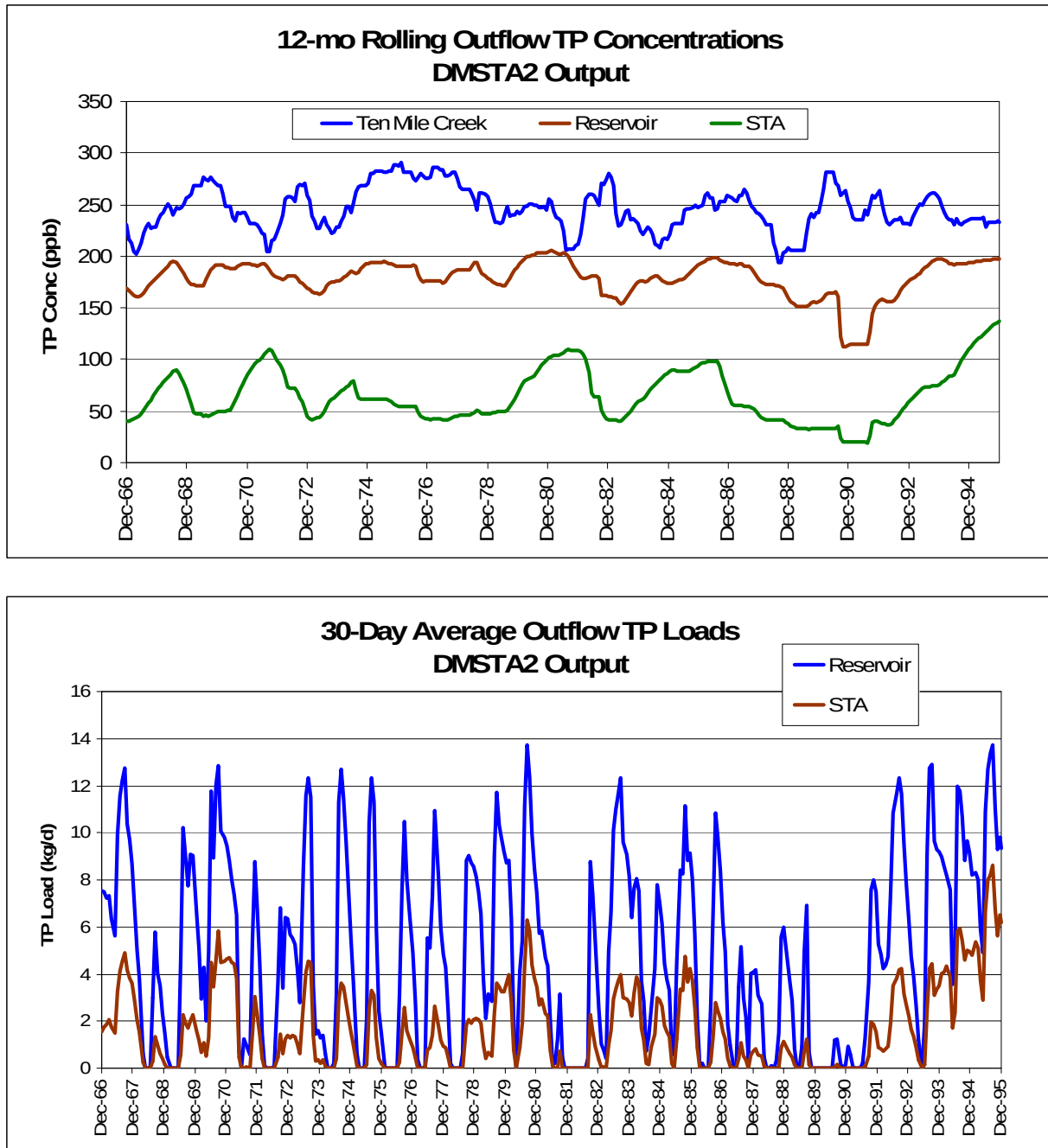




Figure 5. DMSTA2 simulated 12-month rolling phosphorus concentrations (upper chart) and loads (lower chart) at Ten Mile Creek WPA.





4 COORDINATION

As with most large water resource projects, effective coordination within the agency and among the various agencies will be critical to ensure the WPA operational objectives are achieved. The nature of this coordination will change as the project goes through the initial operational and testing period, and is then transferred to the SFWMD by the Corps.

4.1 INITIAL OPERATIONAL TESTING AND MONITORING PERIOD

In accordance with the Project Cooperation Agreement executed between the Corps and the SFWMD, prior to turnover of the project to the SFWMD, the Corps will conduct an **initial operational testing and monitoring period**. During this period, data will be collected to demonstrate that the project achieves the designated benefits. This period is further divided into two phases – a start-up phase (no discharge) and a flow-through phase once discharge commences. Prior to initiating flow-through (discharge) activities, phosphorus, nitrogen and mercury will be monitored to demonstrate that the WPA is achieving a net improvement in both constituents. In addition, pesticide sampling will occur as a condition for moving into the flow-through phase. Once the District Engineer determines that the project is performing as designed, the Corps will transfer the project to the SFWMD for subsequent operations, maintenance, repair, replacement and rehabilitation, commencing the **operations phase**.

4.1.1 On-going data review and operational feedback

In accordance with the project PCA, the operation of the WPA during start-up will be a joint effort of the Corps and the SFWMD. A **Project Coordination Team** consisting of Corps and SFWMD staff was established in accordance with the Project Cooperation Agreement, and this team will establish a protocol for communicating the start up operations between the agencies prior to the initiation of start up. Key aspects are to identify who will be the respective tactical contact points, and the appropriate type and frequency of start up communication. The frequency of telephone conferences and meetings will likely be weekly at first as issues surrounding structure operations may arise; experience in other new systems suggests that the frequency will likely decrease to approximately once per month by the end of the start-up phase.

Once flow-through operations begin, the weekly/monthly communications will include operational feedback (pump operations, gate openings, flow rates and water levels) in addition to the performance discussion. By that time, the criteria for project transfer from the Corps to the SFWMD should be finalized.





4.1.2 Interagency coordination

In addition to the day-to-day project coordination, by virtue of the fact that the Ten Mile Creek WPA is a feature of an integrative set of water quality protection projects, project staff will necessarily be communicating and coordinating with other SFWMD staff (e.g., Coastal Estuaries Division), the Corps (CERP and related activities), and FDEP (for permitting and other wetland protection purposes).

An initial list of potential contact persons from these agencies is presented below.

STA Project Manager: Maura Merkal, Lead Project Manager, (561) 682-6179 mmerkal@sfwmd.gov; South Florida Water Management District, 3301 Gun Club Road; West Palm Beach, FL 33406.

Program Manager: Dave Unsell, Lead Project Manager, (561) 682-6888; dunsell@sfwmd.gov; South Florida Water Management District; 3301 Gun Club Road; West Palm Beach, FL 33406.

Okeechobee Field Station: Terry Peters, Interim Director, 863-462-5280 x 3102; rpeters@sfwmd.gov; and Bruce Chesser, Interim Director of Field Operations, x 3114; bchesser@sfwmd.gov; Okeechobee Field Station, Okeechobee, FL

Operations Department: Tom Kosier, Environmental Operations Section (561) 682-6533; tkosier@sfwmd.gov; South Florida Water Management District; 3301 Gun Club Road; West Palm Beach, FL 33406

Water quality monitoring: W. Patrick Davis **Field Project Manager** (863) 462-5280 x 3171; wpdavis@sfwmd.gov; Okeechobee Water Quality Field Section, 1000 NE 40 Avenue, Okeechobee, FL 34972.

U. S. Army Corps of Engineers: Stephanie Jenkins; Hydraulic Engineer (904) 232-1612; Stephanie.L.Jenkins@saj02.usace.army.mil; US Army Corps of Engineers, Jacksonville District, ENHW, 701 San Marco Blvd, Jacksonville, Florida 32207.

Florida Department of Environmental Protection: Kim Shugar, Program Administrator, (561) 681-6706; kimberly.shugar@dep.state.fl.us; FDEP-Southeast District, 400 N. Congress Avenue, Suite 200, West Palm Beach, Florida 33401.

4.2 OPERATIONS PHASE

Once the Corps transfers the project over to the SFWMD, the **Operations Phase** commences. Most, if not all, of the same degree of communication and coordination that began in the **initial operational testing and monitoring period** will continue.





4.2.1 On-going data review and operational feedback

The frequency and type of the weekly/monthly meetings during the Operations Phase may not differ from the earlier phases, depending on the status of the WPA and whether or not there are significant refinements to the operations based on previous experience or permit requirements. During the summer, the performance evaluation for the previous water year should be drafted for including in the draft of the annual South Florida Environmental Report.

4.2.2 Interagency coordination

Depending on the Corps continued role and responsibilities after the project is turned over to the SFWMD, their involvement in the weekly/monthly coordination conferences may change in the Operations Phase. There may or may not be a shift in the other agency contacts shown in section 4.1.2 above, depending on the status of the WPA and other needs.





5 REFERENCES

- Florida Department of Environmental Protection, CERPRA permit No. 0192879-001-GL, issued to the U.S. Army Corps of Engineers.
- Florida Department of Environmental Protection, draft CERPRA permit No. 0192879-002-GL, issued to South Florida Water Management District.
- Gary Goforth, Inc., 2005. Operation Plan for the Ten Mile Creek WPA, prepared for the South Florida Water Management District, November 2005.
- Post Buckley, Shuh and Jernigan, 2002. Design Documentation Report for Ten Mile Creek Project Water Preserve Area St. Lucie County, Florida, Final (100%) Corrected Design, prepared for the U.S. Army Corps of Engineers, April 30, 2002.
- U. S. Army Corps of Engineers, Project Cooperation Agreement between the Department of the Army and South Florida Water Management District for Construction of Ten Mile Creek Water Preserve Area Critical Restoration Project, January 7, 2000.
- U. S. Army Corps of Engineers, Draft - Preliminary Water Control Plan for the Ten Mile Creek Deep Water Storage Area, December 2003.
- Wetland Solutions, Inc., Ten Mile Creek Water Preserve Area – Updated Water Quality Assessment Final Report, prepared for the SFWMD, June 2002.





**APPENDIX 1. EXCERPT FROM 2005 SOUTH FLORIDA ENVIRONMENTAL
REPORT**



Chapter 4: STA Performance, Compliance and Optimization

Gary Goforth, Kathleen Pietro, Michael Chimney, Jana Newman,
Tim Bechtel, Guy Germain and Nenad Iricanin

SUMMARY

As of June 2004, over 35,000 acres of Stormwater Treatment Areas (STAs) have been constructed by the South Florida Water Management District (District or SFWMD) (**Figure 4-1**). Almost 30,000 acres were in flow-through operation and removing total phosphorus (TP) that otherwise would have gone into the Everglades Protection Area (EPA). During Water Year 2004 (WY2004) (May 1, 2003 through April 30, 2004), Stormwater Treatment Areas 1 West, 2, 3/4, 5, and 6 Section 1 (STA-1W, STA-2, STA-3/4, STA-5, and STA-6) STA-1W, STA-2, STA-3/4, STA-5, and STA-6) treated more than 778,000 acre-feet (ac-ft) of water and removed more than 88 metric tons of TP. Inflow concentrations averaged 133 parts per billion (ppb), while the outflow concentrations averaged 41 ppb. This resulted in an overall 69-percent removal rate. STA performance varied, with outflow concentrations ranging from 12 to 14 ppb for STA-6 and STA-2, respectively, to almost 100 ppb for STA-5.

Since the initiation of STA operations in 1994 through the end of April 2004, the STAs have reduced the TP load by about 427 metric tons. A summary is provided in **Table 4-1**. The most significant milestone during this last reporting period was the completion of STA-3/4, the world's largest constructed wetland at over 16,500 acres. On January 15, 2004, the 6,500-acre Flow-way 1 of STA-3/4 passed the start-up requirements of the operating permits, and on February 25, 2004, the first discharges of treated water from this STA began. On June 7, 2004, the 3,500-acre Cell 3 began discharging. On September 16, 2004, the remaining 5,500 acre Flow-way 2 began discharging. The initial 12-month (October 1, 2003 to September 30, 2004) performance of STA-3/4 was exceptional, with over 445,000 ac-ft of water treated to an average outflow concentration of 14 ppb.

The SFWMD began the design and implementation of enhancements to STA-3/4, intended to further lower phosphorus levels. Key components include additional levees and water control structures, refined operations, and revisions to the vegetation communities, including a 400-acre demonstration Periphyton-Based Stormwater Treatment Area (PSTA) within the footprint of STA-3/4. These enhancements, along with enhancements to the other five STAs, will continue through the end of 2006. The construction of Stormwater Treatment Area 1 East (STA-1E) was substantially completed by the U.S. Army Corps of Engineers in June 2004. Initial flooding of STA-1E began in summer 2004. A 6-month to 18-month vegetation start-up period is anticipated before STA-1E is expected to discharge to the Arthur R. Marshall Loxahatchee National Wildlife Refuge, depending on growth of the vegetation.

The Everglades Protection Area Tributary Basins Long-Term Plan for Achieving Water Quality Goals (see Chapter 8 of the *2005 South Florida Environmental Report – Volume I*) recommends structural, vegetative and operational enhancements for each STA, and provides a

predicted range of long-term average outflow phosphorus concentrations once the enhancements are completed. Refinement of the operational strategies for the STAs is required to optimize their phosphorus removal performance and to ensure that they are not subject to overload from inflow volume or nutrients. In addition, assessment of annual or long-term performance is aided by a comparison of actual loading to the loading that was anticipated during the design of the treatment areas, and the subsequent design of the STA enhancements. A recent paper developed the “operational design envelope” for inflow volume and phosphorus loads that were anticipated for each STA (Goforth, 2004), and can be found on the District’s Website at http://www.sfwmd.gov/org/ema/toc/archives/docs/design_envelope_STA_051004.pdf.

As part of the adaptive implementation process envisioned by the District’s STA optimization program, it is anticipated that further refinements to the recommended water quality improvement measures would be made at the earliest achievable dates as more scientific and engineering information was obtained. Investigations are underway in each STA that are summarized in later sections of this report. General operational principles that are currently performed in the STA operations are as follows:

- Try to ensure inflows (flows and TP loads) are within the design envelope
- Avoid dryout and maintain a minimum of 15 cm depth
- Avoid keeping the water stage too deep for too long by limiting depth to a maximum of 137 cm for 10 days
- Maintain target depths between storm events:
 - o Emergent: 38 cm
 - o SAV: 45 cm
- Frequent field observations by site managers

A complete set of references regarding STA operations can be found online at http://www.sfwmd.gov/org/ema/everglades/consolidated_00/ecr2000/intro.pdf, and the 1995 Basis for Design paper is found online at <http://www.walker.net/pdf/stadesign.pdf>.

An overview of the STA operations, vegetation management, phosphorus performance, water quality monitoring, and permit compliance for each of the STAs is presented in this chapter. Water quality parameters that are addressed include nutrients, physical parameters including but not limited to pH, turbidity, dissolved oxygen (DO), pesticides, major ions, and mercury. This information documents compliance with appropriate conditions of the Everglades Forever Act and the U.S. Environmental Protection Agency’s National Pollution Discharge Elimination System permits. Water quality monitoring within and downstream of the treatment areas demonstrated that the five STAs in operation are in full compliance with state operating permits. A summary of STA operations and issues is presented in **Table 4-2**. Appendices presented with this chapter provide additional details of the monitoring program, as required by state operating permits.

Table 4-1. Stormwater Treatment Area (STA) hydrology and total phosphorus (TP) removal for Water Year 2004 (WY2004). Start-up operations started in October 2003 and flow-through began in February 2004 for STA-3/4.

	STA-1W	STA-2	STA-3/4	STA-5	STA-6	All STAs
Total Inflow Volume (ac-ft)	292,690	256,938	23,303	153,080	52,674	778,685
Hydraulic Loading Rate (cm/d)	3.7	3.3	0.3	3.1	5.1	3.4
Flow-weighted Mean Inflow TP (ppb)	141	77	49	255	53	133
TP Loading Rate (g/m ² /yr)	1.9	0.9	0.05	2.9	1.0	2.0
Total inflow TP Load (mt)	50.7	24.3	1.4	48.1	3.4	127.9
Total Outflow Volume (ac-ft)	297,603	284,780	27,708	136,466	35,549	782,106
Flow-weighted Mean Outflow TP (ppb)	47	14	16	97	12	41
Total Outflow TP Load (mt)	17.1	5.0	0.55	16.4	0.5	39.6
Hydraulic Residence Time (d)	16.1	13.5	N/A	18.9	11.0	15.4*
TP Retained (mt)	33.7	19.2	0.9	31.7	2.9	88.3
TP Removal Rate (g/m ² /yr)	1.25	0.74	0.03	1.90	0.83	1.2
Load Reduction (%)	66 %	79 %	61	66 %	85 %	69%
TP Retained to Date (mt)	240	51	0.9	110	25	427
TP Outflow to Date (ppb)	38	16	16	105	19	40

Note: "TP retained to date" is based on the period of record for each STA. The STA-1W record begins in WY1995; the STA-2 record begins in WY2002; the STA-5 record begins in WY2001; and the STA-6 record begins in WY1998. STA-3/4 begins in October of WY2004.

Table 4-2. Summary of STA operations and issues. Operational phases: (1) Start-up, inundate for vegetation growth. No discharge, phase ends when cell demonstrated net improvement in phosphorus and mercury. (2) Stabilization: discharge, phase ends when 12-month outflow TP $\leq$ 50 ppb. (3) Post-stabilization: after stabilization phase.

STA	Operational Status	Other Issues
STA-1E	Under construction by USACE. Substantially completed in June 2004. Initial flooding began in summer 2004	Working with USACE and FDEP to finalize operating permits
STA-1W	Fully operational; in stabilization phase; in WY2004, there was a diversion of 17,000 ac-ft and 3.1 mt of TP with a flow-weighted mean TP average of 148 ppb into the Refuge because the capacity of the STA-1W inflow structure was exceeded	Had STA-1E been operational, the TP loads and concentrations from the EAA prior to entering the Refuge would have been lower; performance enhancements are under way
STA-2	Fully operational; in stabilization phase	Design of an additional 2,015-acre flow-way is under way
STA-3/4	Start-up operations began in October 2003; construction was completed in 2004	Performance enhancements are under way, including vegetation conversion and construction of a PSTA demonstration project
STA-5	Fully operational; in stabilization phase; in WY2004, there was a diversion of 37,630 ac-ft and 17 mt of TP with a flow-weighted mean TP average of 367 ppb through G-406	Performance enhancements are under way; design of an additional 2,565-acre flow-way is under way
STA-6	Fully operational; in post-stabilization phase	STA-6 Section 2 is in final design

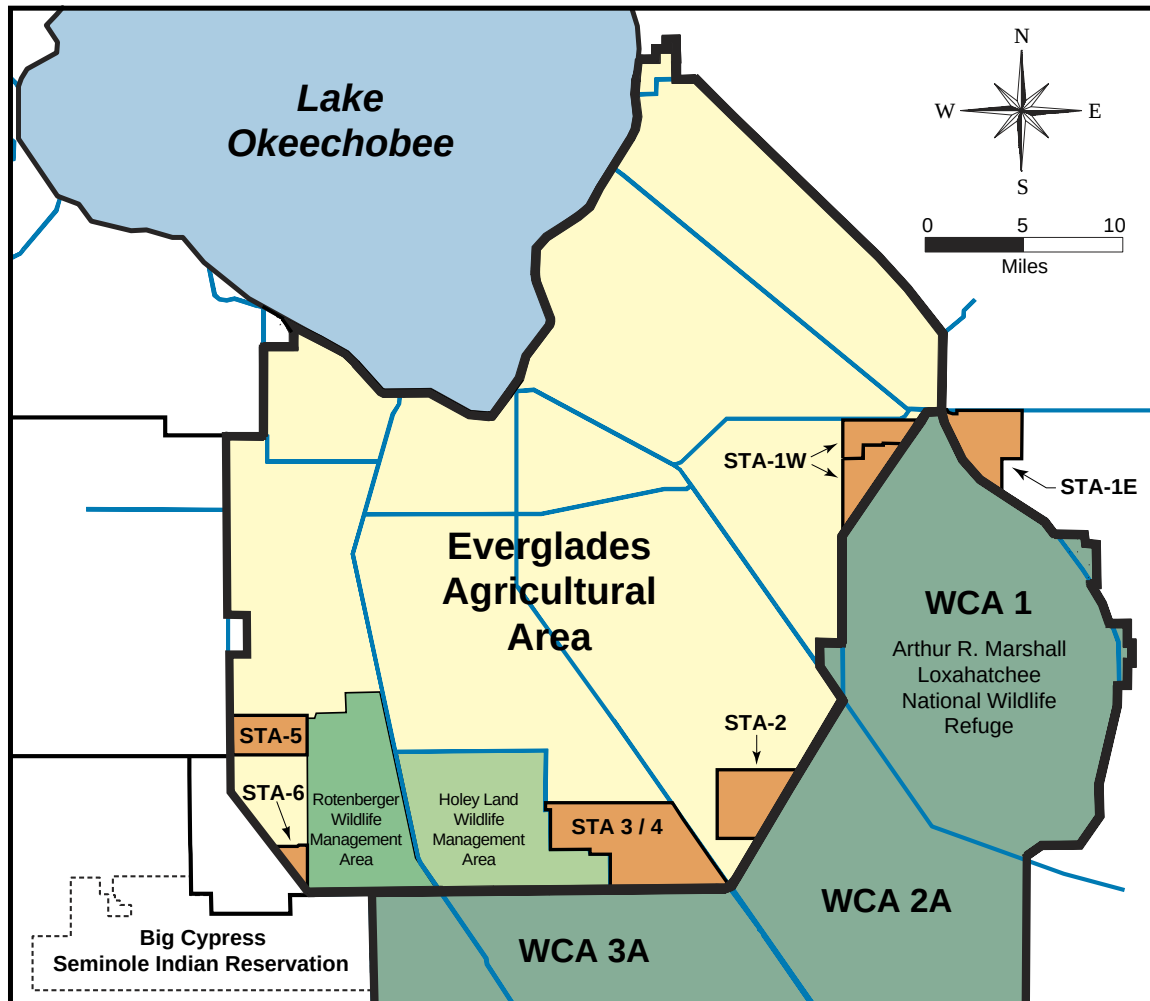


Figure 4-1. Location of STAs.

STA-2

Stormwater Treatment Area 2 (STA-2) contains approximately 6,430 acres of effective treatment area arranged in three parallel flow-ways. The eastern flow-way (Cell 1) consists of approximately 1,990 acres of effective treatment area. The center flow-way (Cell 2) consists of approximately 2,220 acres of effective treatment area. The western flow-way (Cell 3) consists of approximately 2,220 acres of effective treatment area. A schematic of STA-2 is presented in **Figure 4-11**. Based on the simulated 1965–1995 period of flow, the STA should receive a long-term average of approximately 232,759 ac-ft. Actual deliveries will vary based on hydrologic conditions in the basins.

Water enters STA-2 from the S-6 and G-328 pump stations, is distributed by the inflow canal across the north end of the treatment cells, and flows via gravity south through the three treatment cells. Treated water is collected and discharged to WCA-2A via the G-335 outflow pump station. Discharges are directed to areas within WCA-2A that are already impacted by elevated nutrient levels.

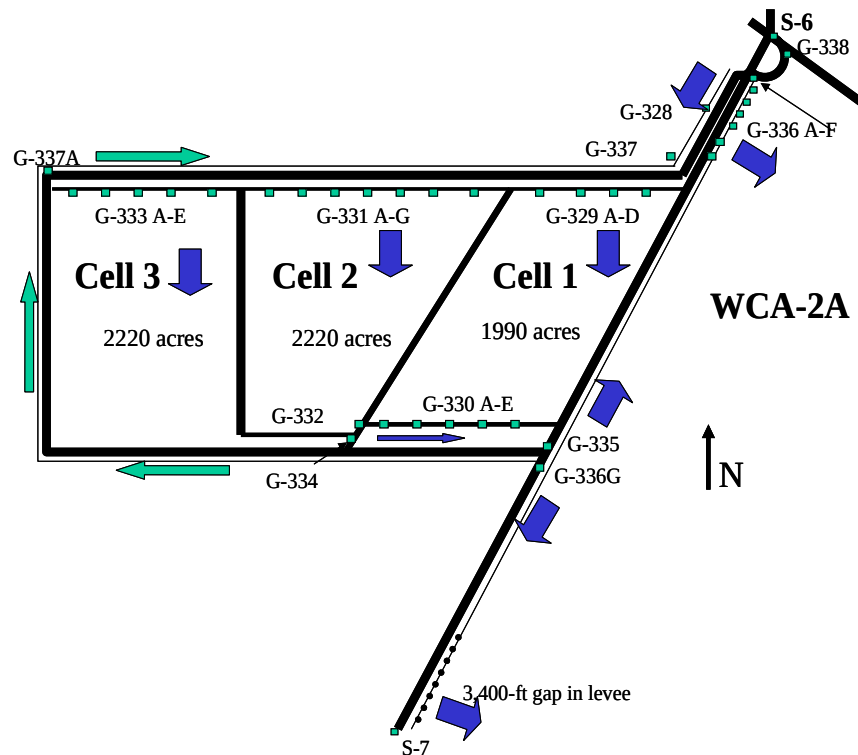


Figure 4-11. Schematic of STA-2 (not to scale).

STA-2 OPERATIONS

Start-up operations for STA-2 began upon the completion of the three treatment cells in 1999. At that time, water levels were maintained for optimal growth of desired vegetation. Inflow to STA-2 began in June 1999 from G-328, the 450 cubic feet per second (cfs) pump station. Construction of 3,040 cfs outflow pump station G-335 was completed in 2000, with the final operational testing completed in October 2000. The final construction component (connection of the S-6 pump station to the inflow canal) was completed during the dry season of 2001, a schedule that minimized the potential downtime of pump station S-6. The outflow structures in Cell 1 (G-330s) were retrofitted with weir plates to increase water depths in the cell, which should reduce the frequency and duration of drydowns within the cell.

During WY2004, approximately 256,938 ac-ft of water was captured and treated by STA-2. This was about 25 percent more than the anticipated average annual flow contemplated during design, although annual variability was anticipated. This inflow loading was equal to an average hydraulic load of 3.3 cm/d over the treatment area. The annual volume of treated water discharged to WCA-2A was 284,780 ac-ft. The difference between the inflow and outflow volumes reflects the net contributions of direct rainfall, ET, seepage losses to adjacent lands, deep percolation, and flow measurement error. A summary of monthly flows is presented in **Figure 4-12**. No flows were diverted around STA-2 during WY2004.

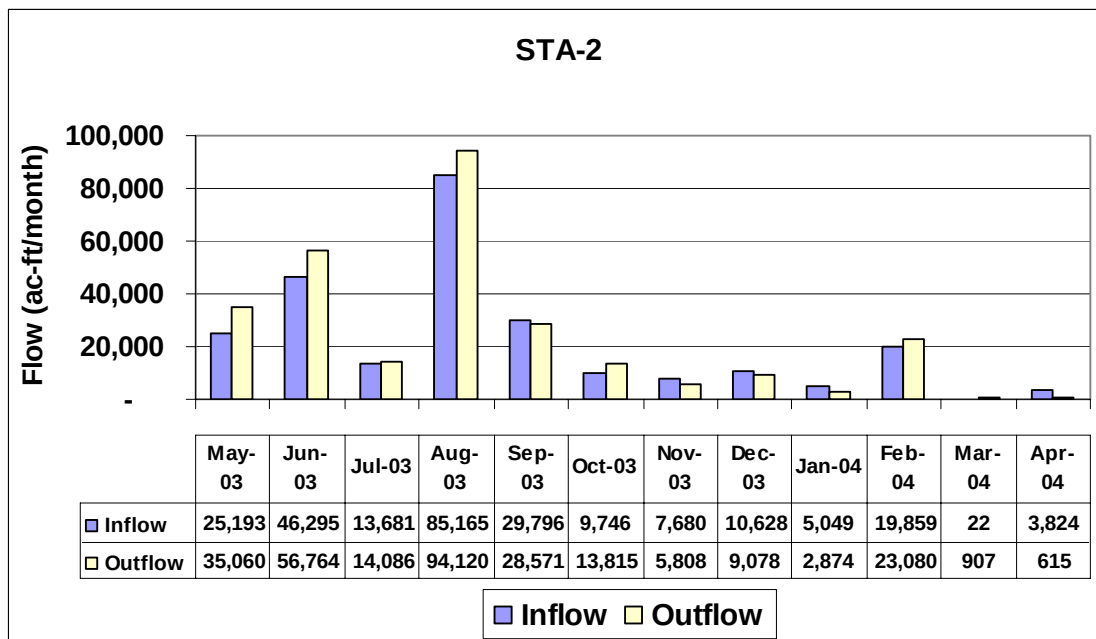


Figure 4-12. Summary of WY2004 flows for STA-2 (Note: 1 hm³ = 810.7 ac-ft).

STA-2 VEGETATION MANAGEMENT

Specific Condition 13(b) of the EFA permit requires that the annual report include information regarding the application of herbicides to exclude and/or eliminate undesirable vegetation within the treatment cells. For this reporting period, the District treated 782 acres and applied a total of 163.0 gallons of the herbicide glyphosate to control torpedograss and cattail, and 95.75 gallons of diquat to control FAV and cattail in Cells 2 and 3. Both aerial and ground-based spray equipment were used to apply these herbicides. Additionally, two submersed treatments were conducted on hydrilla (*Hydrilla verticillata*) in STA-2, Cell 3 using the active ingredient endothall. Two formulations were used: (1) 393 liquid gallons of Aquathol K, and (2) 2,571 granular pounds of Aquathol Super K.

STA-2, Cell 3 has a total area of 2,270 acres and is dominated by SAV; however, 500 acres of emergent cattail marsh exists in the south east section. Vegetation coverage maps from December 2003 are found in Appendix 4-12 of the 2005 SFER – Volume I. It has been identified in the Long-Term Plan that this emergent portion be converted to SAV. Due to the performance of this cell and the pending results of the STA-3/4 demonstration project this conversion will be deferred.

Vegetation management will focus on keeping FAV at maintenance control levels in all STAs. FAV “shades out” or impedes beneficial submersed and emergent vegetation which is necessary for proper STA performance. Along with the FAV treatments, emphasis will also be placed on controlling expanding emergent vegetation, mainly torpedograss and cattail, which appears in SAV cells.

STA-2 PERMIT WATER QUALITY MONITORING

Monitoring data collected for STA-2 demonstrate that STA-2 was in compliance with the EFA and NPDES operating permits for WY2004 and that discharges do not pose any known danger to public health, safety, or welfare. The EFA and NPDES operating permits were issued for this project on September 29, 2000. Each treatment cell in STA-2 operates independently, and the permits authorize discharges when net improvement in TP and mercury is demonstrated for each cell. STA-2 Cells 2 and 3 passed the net improvement start-up tests for TP and mercury on September 13 and November 9, 2000, respectively. Cell 1 was the last of the treatment cells to meet the start-up criteria listed in the permit for mercury. After the FDEP, the USEPA, and other agencies reviewed the Cell 1 mercury situation, it was determined that the most effective way to reduce mercury concentrations in Cell 1 was to move as much water through the cell as possible to increase sulfur levels. On August 9, 2001, a draft permit modification was issued to initiate flow-through operations for Cell 1. Data collected in December 2002 and January 2004 demonstrated that Cell 1 passed the start-up test listed in the permit based on the stations identified for that purpose. Additional monitoring continues to increase the understanding of mercury in the STA. Currently STA-2 is in the stabilization phase, having demonstrated net improvement in TP and mercury. In addition, Specific Condition 14(B) of the EFA permit states that STA-2 will remain in the stabilization phase of operation until STA-1E and STA-3/4 begin flow-through operations. Presently STA-1E is still in the construction phase and is not expected to begin flow-through operations until 2005, subject to vegetation grow-in and soil phosphorus stabilization.

STA-2 TOTAL PHOSPHORUS

Under the design objectives of the EFA, STA-2 is achieving its interim discharge goal of less than 50 ppb for TP. Although the hydraulic loading to STA-2 was higher than the design criteria, the TP loading to the system was less than the design amount. During WY2004, the STA received 24.3 mt of TP, equal to a nutrient loading rate of 0.90 g/m². During WY2004, STA-2 received approximately 0.8 mt of TP from Lake Okeechobee. STA-2 removed approximately 19.2 mt of TP during WY2004. Monthly discharge concentrations were considerably lower than inflow concentrations. For example, from May 2002–April 2004, STA-2 reduced discharge loads of TP by 79 percent. Summaries of monthly TP loads and flow-weighted mean TP concentrations are presented in **Figures 4-13** and **4-14**, respectively. The annual flow-weighted mean outflow concentration was 14 ppb, an 81-percent reduction from the inflow concentration of 77 ppb. For informational purposes, the annual geometric mean discharge TP concentration for STA-2 was 15 ppb for WY2004. If an outflow concentration of less than 50 ppb in accordance with the EFA permit for STA-2 had been achieved, then Cells 2 and 3 would have passed the stabilization phase if not for the requirement that STA-2 should remain in the stabilization phase until STA-1E and STA-3/4 begin full flow-through operation. The 12-month moving average TP concentration from STA-2 decreased from 18 ppb to 14 ppb during the course of WY2004 (**Figure 4-15**).

STA-2 OTHER WATER QUALITY PARAMETERS

The monitoring data for non-phosphorus parameters at STA-2 during this reporting period are presented in Appendix 4-5 of the 2005 SFER – Volume I, and are summarized in **Table 4-7**. Compliance with the EFA permit is determined based on the following three part assessments:

1. If the annual average outflow concentration does not cause or contribute to violations of applicable Class III water quality standards, then STA-2 shall be deemed in compliance.
2. If the annual average concentration at the outflow causes or contributes to violations of applicable Class III water quality standards, but it does not exceed or is equal to the annual average concentration at the inflow stations, then STA-2 shall be deemed in compliance.
3. If the annual average concentration at the outflow causes or contributes to violations of applicable Class III water quality standards, and it also exceeds the annual average concentration at the inflow station, then STA-2 shall be deemed out of compliance.

Except for specific conductivity, discharges from STA-2 were determined to be in compliance with the permit by satisfying criterion one above for all non-phosphorus and non-DO parameters with applicable numeric state water standards. Additional requirements for DO are listed in Administrative Order AO-006-EV and are discussed below. Mercury monitoring results are discussed in Chapter 2B, and also in Appendix 4-7 of the 2005 SFER – Volume I.

The District has included the following documentation to satisfy the remaining monitoring requirements of the EFA permit:

- The District has performed all sampling and analysis under the latest FDEP-approved CompQAP No. 870166G (June 1999).
- A signed copy of this statement is provided in Appendix 4-2 of the 2005 SFER – Volume I.

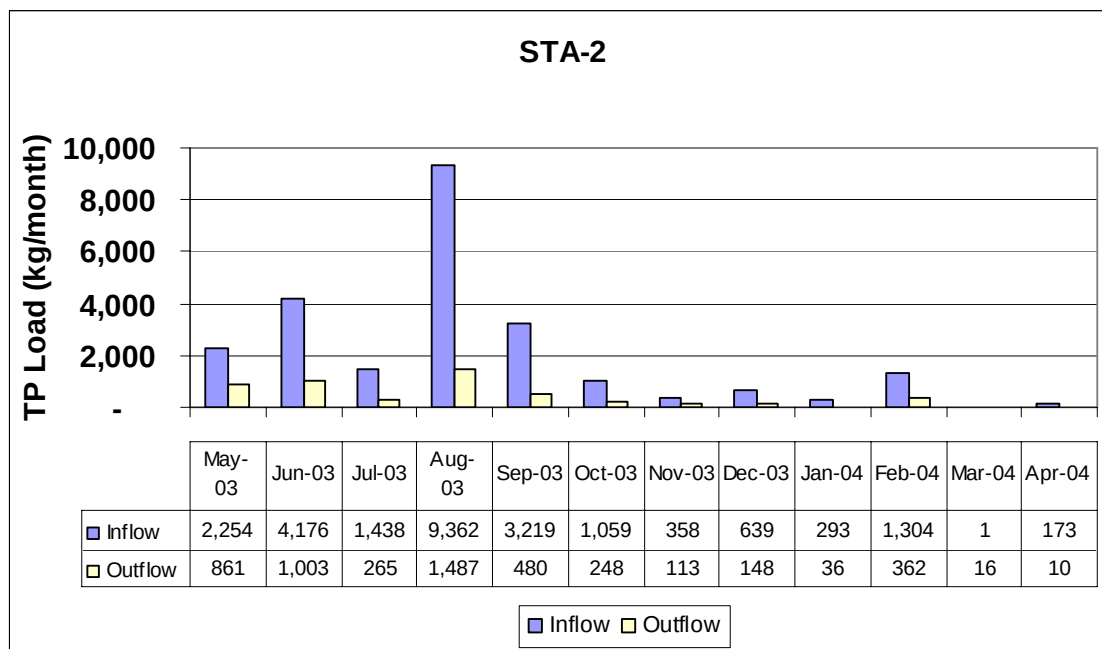


Figure 4-13. Summary of WY2004 TP loads for STA-2.

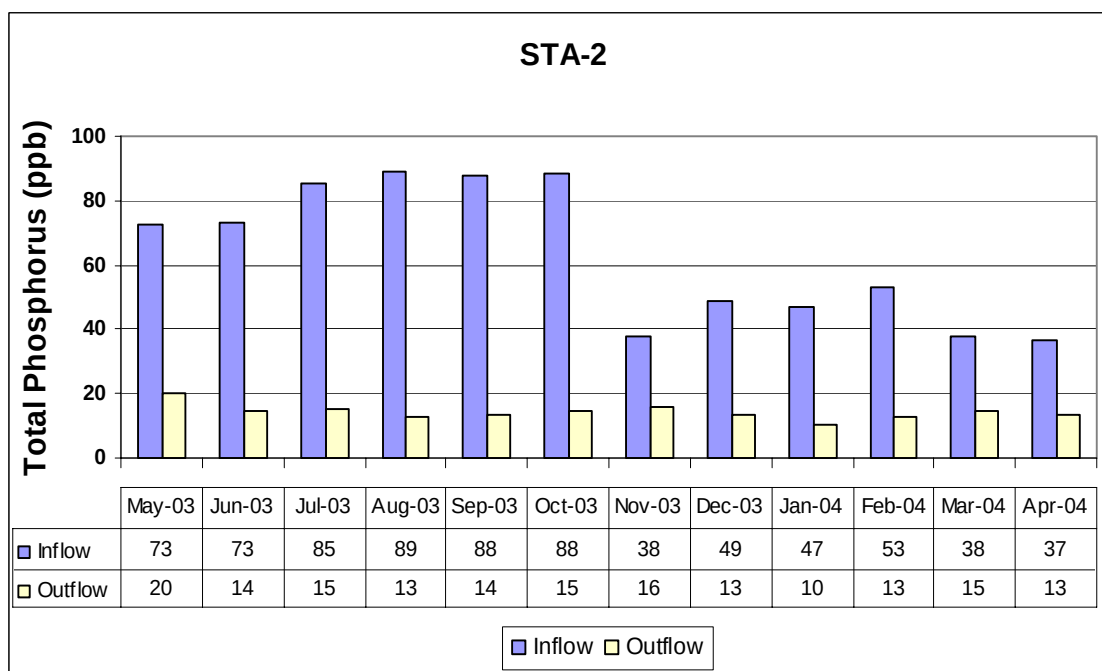


Figure 4-14. Summary of WY2004 TP concentrations for STA-2.

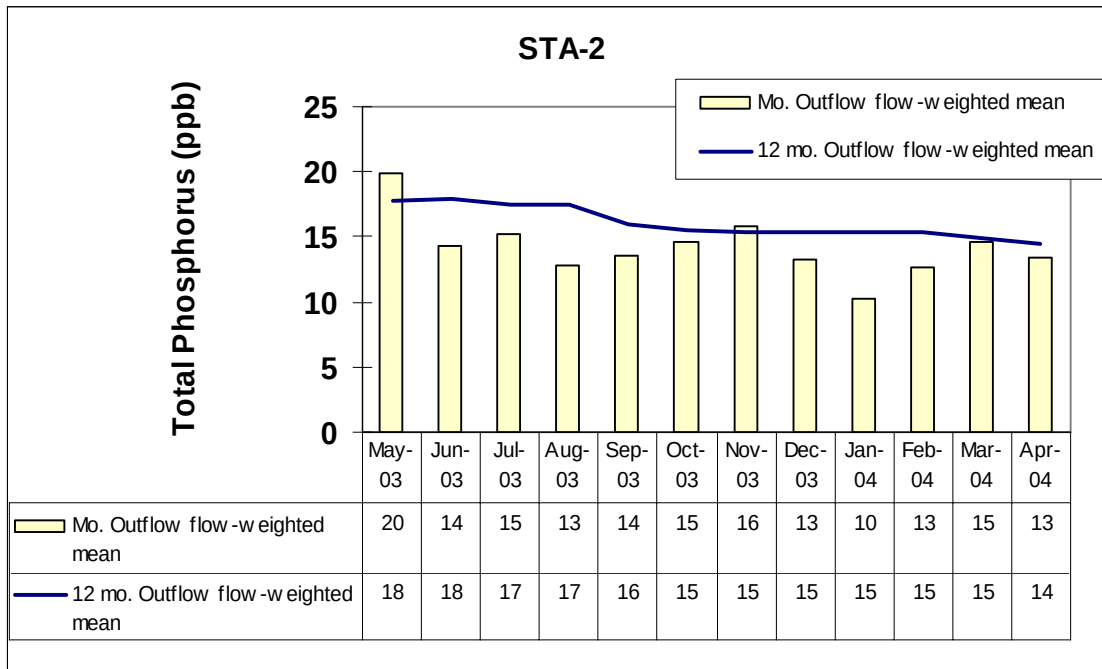


Figure 4-15. Comparison of monthly to 12-month moving average TP concentrations for WY2004 for STA-2 outflow.

Table 4-7. Summary of annual arithmetic averages and flow-weighted means for water quality parameters (other than TP) monitored in STA-2. Note that monitoring for the pesticides ametryn and atrazine is not required under the routine permit. For the purpose of these comparisons, flow-weighted means are calculated as the quotient of the cumulative product of the mean daily flow and the sample concentration divided by the corresponding cumulative daily flows.

Parameter	Arithmetic Means			Flow-Weighted Means			
	Inflow		Outflow	Total Inflow		Total Outflow	
	S6	G328	G335	n	Conc.	n	Conc.
Temperature (°C)	25.1	25.1	25.1	-NA-	-NA-	-NA-	-NA-
Dissolved Oxygen (mg/L)	3.1	4.3	4.6	-NA-	-NA-	-NA-	-NA-
Specific Conductivity (µmhos/cm)	1,305	1,557	1,261	-NA-	-NA-	-NA-	-NA-
pH	7.4	7.5	7.5	-NA-	-NA-	-NA-	-NA-
Turbidity (NTU)	3.8	3.1	1.2	-NA-	-NA-	-NA-	-NA-
Total Dissolved Solids (mg/L)	848	966	823	18 (52)	890	26 (26)	794
Unionized Ammonia (mg/L)	0.0061	0.0087	0.0032	18 (52)	0.0084	26 (26)	0.0013
Orthophosphate as P (mg/L)	0.034	0.012	0.006	32 (104)	0.068	52 (52)	0.007
Total Dissolved Phosphorus (mg/L)	0.041	0.015	0.007	31 (91)	0.073	43 (43)	0.008
Sulfate (mg/L)	82.0	54.4	69.2	18 (52)	102.5	26 (26)	77.4
Alkalinity (mg/L)	324	368	305	18 (52)	341	26 (26)	293
Dissolved Chloride (mg/L)	181	263	185	18 (52)	171	26 (26)	163
Total Nitrogen (mg/L)	3.09	2.68	2.34	18 (52)	4.14	26 (26)	2.34
Total Dissolved Nitrogen (mg/L)	2.98	2.57	2.29	18 (52)	3.94	26 (26)	2.29
Nitrate + Nitrite (mg/L)	0.542	0.378	0.107	18 (52)	1.051	26 (26)	0.185

-NA- : Not Applicable

n: number of samples with flow (total number of samples)

STA-2 DISSOLVED OXYGEN MONITORING

Introduction

STA-2 Administrative Order No. AO-006-EV in Exhibit C of the EFA STA-2 Permit (Permit No. 0126704, September 29, 2000) specifies the same DO monitoring requirements as those for STA-1W. The District developed the following plan to comply with the DO requirements of the Administrative Orders for STA-2. Under the plan, DO concentrations are measured quarterly with Hydrolab™, DataSonde®, or MiniSonde® probes at 30-minute intervals for four consecutive days at the following locations:

- At the inflow side of the S-6 pump station
- At the inflow side of the G-328 pump station
- At sites along the N, C, S, and Z transects in the northwest section of WCA-2A, located downstream of culverts distributing flow from discharge pump station G-335

Sampling Dates

Diel oxygen measurement dates and sites associated with STA-2 for WY2004 are provided in **Table 4-8**.

Table 4-8. Deployment dates for diel oxygen measurement at STA-2 structures and associated downstream marsh sites.

Event Dates		Structures			Sites Monitored in Water Conservation Area 2
Start	End	Inflow		Outflow	
06/02/2003	06/06/2003	----	----	----	C.25, N.25, N1, N4
08/25/2003	08/28/2003	S6	G328	G335	-----
10/20/2003	10/25/2003	----	----	----	C.25, C1, N.25, N1, N4, S4
12/15/2003	12/18/2003	S6	G328	G335	-----

Note: See Appendix 4-4, Table 3 for statistical summaries by event and diel parameter.

Comparison of Dissolved Oxygen in STA-2 Discharges with Dissolved Oxygen at Downstream WCA-2A Sites

Direct comparisons of DO in STA-2 discharges with DO at downstream marsh sites in WCA-2A (**Figure 4-16**) cannot be made for WY2004 because Hydrolab™ deployment dates differed. However, to satisfy permit requirements, summary statistics for STA-2 discharges and WCA-2A marsh transect sites are presented in **Table 4-9**. Notched box and whisker plots for the sites are presented in **Figure 4-17**. The complete data sets collected at all sites during WY2004 are found in Appendix 4-6 of the 2005 SFER – Volume I.

The data indicate that diel DO concentrations in G-335 discharges were statistically greater than DO concentrations at all of the marsh transect sites. DO at site N.25 was significantly greater than at the other marsh sites.

STA-2 ENHANCEMENTS

Enhancements to STA-2 (**Figure 4-18**) include construction of interior levees and associated water control structures in each of the three treatment cells, as well as conversion of emergent vegetation to SAV in the new downstream cells and construction of a 1,813-acre treatment cell.

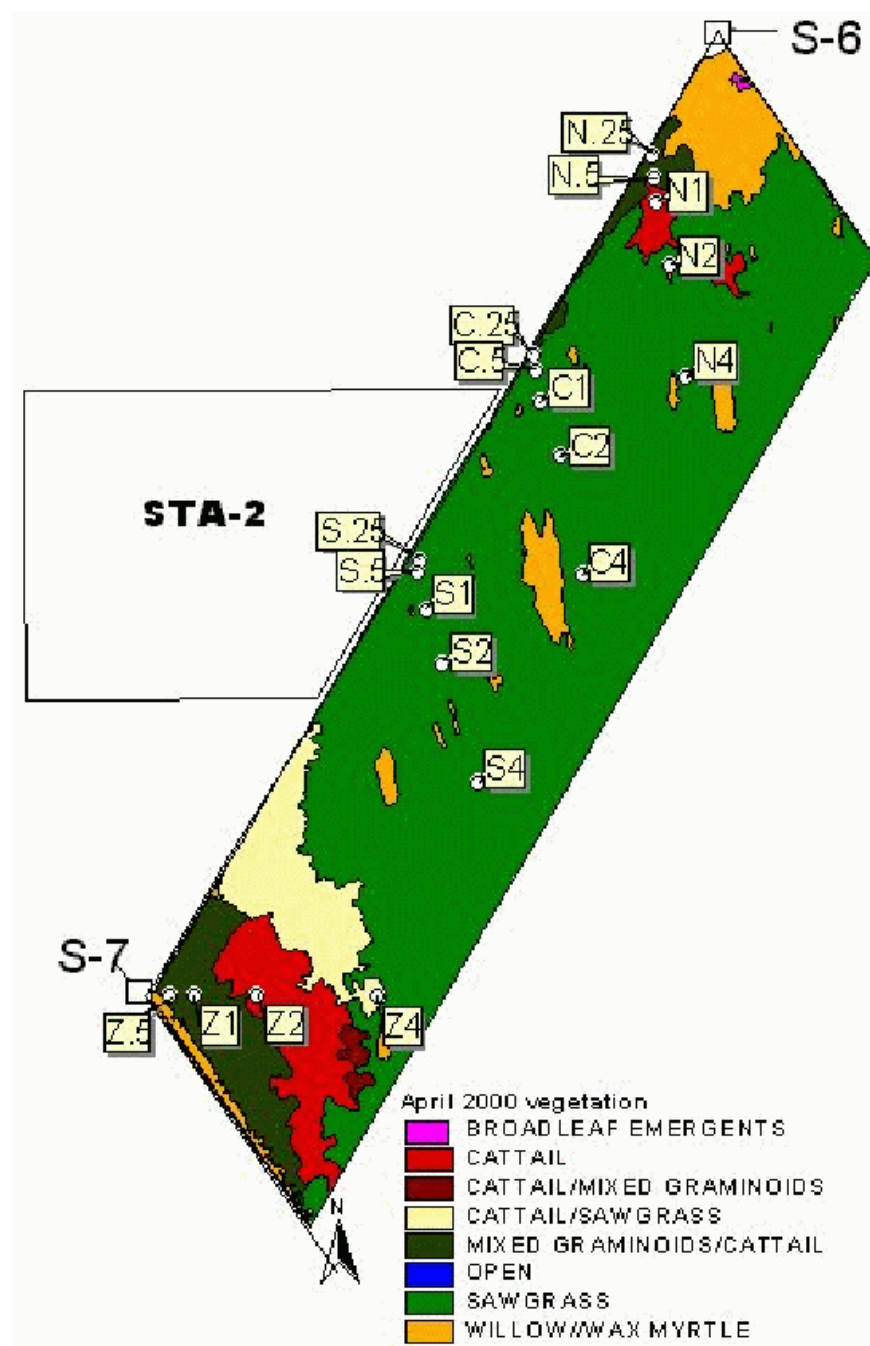


Figure 4-16. DO monitoring sites in WCA-2.

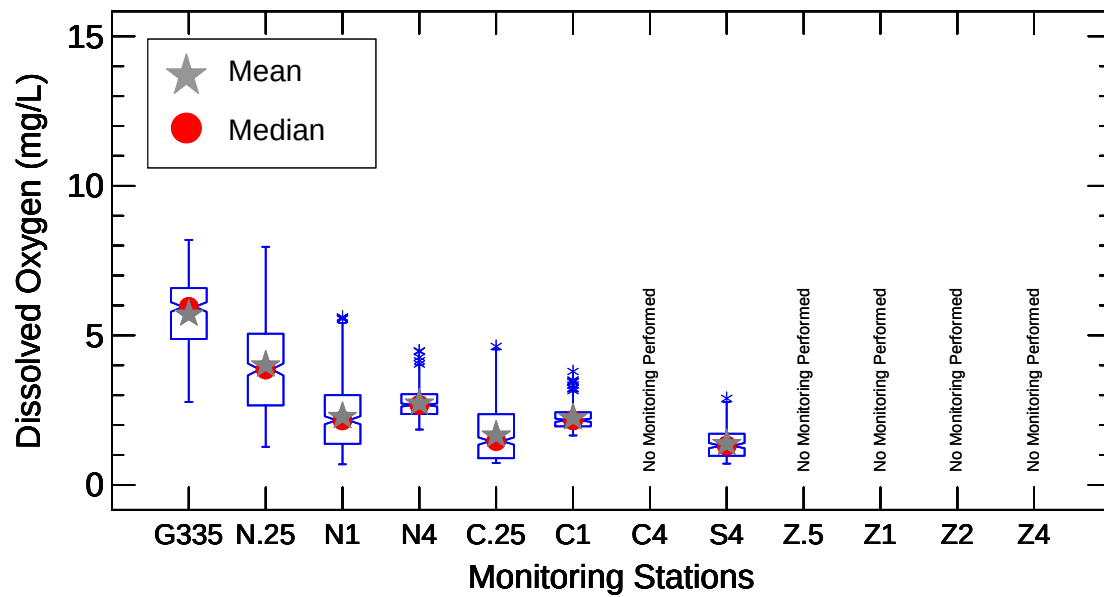


Figure 4-17. Notched-box and whisker plots of diel DO measurements at the STA-2 outflow station (G-335) and along transect sites in WCA-2 during three monitoring periods. The notch on a box plot represents the C.I. about the median, which is represented by the narrowest part of the notch. The top and bottom of the box represent the 75th and 25th percentiles, respectively. The whiskers represent the highest and lowest data values that are within two standard deviations of the median. Values above and below the whiskers are greater than two standard deviations from the median. Notches that do not overlap indicate that the data represented by the boxes being compared are significantly different at 95% C.I.

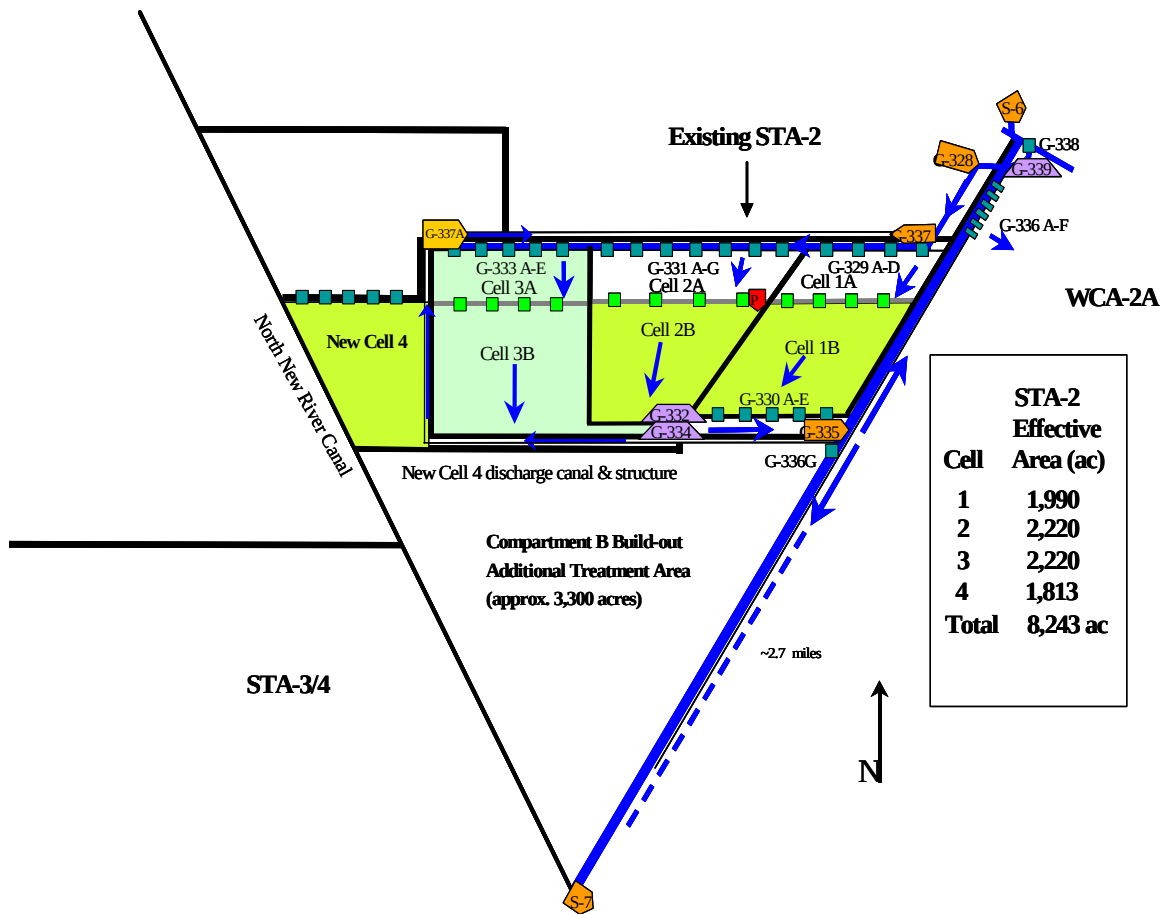


Figure 4-18. STA-2 enhancements.

Table 4-9. Statistical summary of diel DO at the outflow pump station from STA-2 and marsh stations in WCA-2 during WY2004.

Location	Station	Number of Measurements	Mean	Minimum	Median	Maximum	Standard Deviation
Outflow	G335	278	5.73	2.77	5.95	8.19	1.33
	C.25	360	1.68	0.73	1.47	4.63	0.88
Transect C	C1	181	2.26	1.65	2.16	3.79	0.41
	C4	----	----	----	----	----	----
Transect N	N.25	359	4.03	1.27	3.86	7.96	1.59
	N1	377	2.31	0.69	2.16	5.61	1.14
	N4	377	2.75	1.85	2.67	4.48	0.52
Transect S	S4	181	1.41	0.71	1.31	2.89	0.52
	Z.5	----	----	----	----	----	----
Transect Z	Z1	----	----	----	----	----	----
	Z2	----	----	----	----	----	----
	Z4	----	----	----	----	----	----



APPENDIX 2. DMSTA2 SIMULATION

DMSTA2- Inputs & Outputs			Project: TEN MILE CREEK	
Input Variable	Units	Value	Case Description:	
Design Case Name	-	TMC Constr.	526-acre reservoir with water supply releases discharging to 132	
Input Series Name	-	TMC Input		
Starting Date for Simulation	-	01/01/65		
Ending Date for Simulation	-	12/31/95		
Starting Date for Output	-	01/01/65	Simulation Type: Base Output Variable Mean FWM Outflow C (ppb) 72.3 GM Outflow C (ppb) 62.4 Load Reduction % 76% Bypass Load (%) 6.3%	
Integration Steps Per Day	-	4		
Number of Iterations	-	0		
Output Averaging Interval	days	30		
Inflow Conc Scale Factor	-	1		
Rainfall P Conc	ppb	10		
Atmospheric P Load (Dry)	mg/m2-yr	20		
Cell Number -->			1	2
Cell Label	-	RES	STA-C1	
Vegetation Type	-->	RES_3	EMG_3	
Inflow Fraction	-	1		
Downstream Cell Number	-	2		
Surface Area	km2	2.13	0.53	
Mean Width of Flow Path	km	1.50	0.73	
Number of Tanks in Series	-	1.0	3.0	
Minimum Depth for Releases	cm	30		
Release 1 Series Name		WSUPPLY		
Release 2 Series Name				
Outflow Series Name		TO_STA		
Depth Series Name				
Outflow Control Depth	cm	30.5	30.5	
Outflow Weir Depth	cm	30.5		
Outflow Coefficient - Exponent	-	1.5	3.5	
Outflow Coefficient - Intercept	-	0.3	0.4	
Bypass Depth	cm	335		
Maximum Inflow	hm3/day			
Maximum Outflow	hm3/day			
Inflow Seepage Rate	(cm/d) / cm			
Inflow Seepage Control Elev	cm			
Inflow Seepage Conc	ppb			
Outflow Seepage Rate	(cm/d) / cm	0.00285	0.00682	
Outflow Seepage Control Elev	cm	-100	-100	
Max Outflow Seepage Conc	ppb	20	20	
Seepage Recycle to Cell Number	-			
Seepage Recycle Fraction	-			
Seepage Discharge Fraction	-			
Initial Water Column Conc	ppb	30	30	
Initial P Storage Per Unit Area	mg/m2	500	500	
Initial Water Column Depth	cm	150	30	
C0 = Conc at 0 g/m2 P Storage	ppb	3	3	
C1 = Conc at 1 g/m2 P storage	ppb	150	22	
C2 = Conc at Half-Max Uptake	ppb		300	
K = Net Settling Rate at Steady State	m/yr	5.0	16.8	
Z1 = Saturated Uptake Depth	cm	40	40	
Z2 = Lower Penalty Depth	cm	100	100	
Z3 = Upper Penalty Depth	cm	400	200	





Ten Mile Creek WPA Performance Plan

Output Variables	Units	1	2	3	4	5	6
Execution Time	sec/yr	2.48	3.19				
Run Date	-	11/18/05	11/18/05				
Starting Date for Simulation	-	01/01/65	01/01/65				
Starting Date for Output	-	01/01/65	01/01/65				
Ending Date	-	12/31/95	12/31/95				
Output Duration	days	11322	11322				
Cell Label		RES	STA-C1				
Downstream Cell Label		STA-C1	Outflow				
Network Simulation Name	-	none	none				
Simulation Type	-	Base	Base				
Surface Area	km2	2.13	0.53				
Mean Rainfall	cm/yr	135.2	135.2				
Mean ET	cm/yr	122.8	109.4				
Cell Inflow Volume	hm3/yr	18.7	9.6				
Cell Inflow Load	kg/yr	4575	1704				
Cell Inflow Conc	ppb	245.1	177.6				
Treated Outflow Volume	hm3/yr	9.6	8.1				
Treated Outflow Load	kg/yr	1704	585				
Treated FWM Outflow Conc	ppb	177.6	72.3				
Upper Confidence Limit	ppb	#N/A	#N/A				
Lower Confidence Limit	ppb	#N/A	#N/A				
Total Outflow Volume + Bypass	hm3/yr	14.1	8.1				
Total Outflow Load + Bypass	kg/yr	2544	585				
Total FWM Outflow Conc	ppb	180.5	72.3				
Bypass Load	kg/yr	306	0				
Bypass Load	%	0.1	0.0				
Maximum Inflow	hm3/d	0.27	0.06				
Maximum Outflow	hm3/d	0.06	0.06				
Surface Load Reduction	kg/yr	2870	1119				
Load Trapped in Sediments	kg/yr	1188	479				
Overall Load Reduction	%	51%	66%				
Lower Confidence Limit	%	#N/A	#N/A				
Upper Confidence Limit	%	#N/A	#N/A				
Daily Geometric Mean	ppb	193.1	81.5				
Outflow Geo Mean - Composites	ppb	168.6	62.4				
Upper Confidence Limit	ppb	#N/A	#N/A				
Lower Confidence Limit	ppb	#N/A	#N/A				
Frequency Outflow Conc > 10 ppb	%	100%	100%				
Frequency Outflow Conc > 20 ppb	%	100%	99%				
Frequency Outflow Conc > 50 ppb	%	100%	64%				
Freq Outflow Volume > 10 ppb	%	76%	100%				
95th Percentile Outflow Conc	ppb	203	126				
Mean Biomass P Storage	mg/m2	1067	2817				
Storage Increase / Net Removal	%	0%	0%				
Net Storage Turnover Rate	1/yr	16.2	9.9				
Unit Area P Removal	mg/m2-yr	558	897				
Mean Water Load	cm/d	2.4	4.9				
Max Water Load	cm/d	12.9	12.0				
Mean Depth	cm	175	38				
Minimum Depth	cm	1	1				
Maximum Depth	cm	335	64				
Frequency Depth < 10 cm	%	8.7%	21.7%				
Flow/Width	m2/day	34	36				
HRT Days	days	73.1	7.6				
Mean Velocity	cm/sec	0.02	0.11				
Seepage Outflow / Total Outflow	%	32%	17%				
Release 1 Outflow Volume	hm3/yr	3.318	0.0				
Release 2 Outflow Volume	hm3/yr	0.0	0.0				
95th Percentile Outflow Volume	hm3/d	0.06	0.06				
95th Percentile Outflow Load	kg/d	11.52	4.78				
Simulated / Specified Mean Depth	%	#N/A	#N/A				
Release 1 Demand Met	%	74%	#N/A				
Release 2 Demand Met	%	#N/A	#N/A				
Outflow Demand Met	%	99%	#N/A				
Range Check - Mean Depth	-	-	-				
Range Check - Freq Depth < 10 cm	-	-	2.42				
Range Check - Flow/Width	-	0.50	-				
Range Check - Inflow Conc	-	-	-				
Range Check - Outflow Conc	-	-	-				
Water Balance Error	%	0.00%	0.00%				
Mass Balance Error	%	0.01%	0.06%				
Warning or Error Messages	Cell# 1 RES Flow/Width out of calib. range for RES_3: 34 vs. 68 - 1135 m2/day Bypass occurred around cell 1 Cell# 2 STA-C1 Freq Z < 10 cm out of calib. range for EMG_3: 22 vs. 0 - 9 %						



