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Water Budget Analysis for Stormwater Treatment Area 5

(Water Year 2003-2004; May 1, 2003 to April 30, 2004)

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EXECUTIVE SUMMARY

This report presents a water budget for Stormwater Treatment Area (STA) 5. It covers from May 1, 2003 to April 30, 2004. The report augments the previous water budget report for STA-5 published in May 2004. Improvements in the rating curves for the G342 and G344 structures were made in June 2003 and were used for this analysis. In this report, the water year runs from May to April to coincide with periods used in the *South Florida Environmental Report* published annually by the South Florida Water Management District.

STA-5 is located along the western boundary of the Everglades Agricultural Area (EAA) adjacent to the L-2 canal, west of the northwestern corner of the Rotenberger Wildlife Management Area. It has a total effective treatment area of 4,118 acres. Initial flooding occurred January 1999 through October 1999. The Florida Department of Environmental Protection (FDEP) issued an emergency order to the South Florida Water Management District (SFWMD) authorizing discharges from STA-5 for a 14-day period in October 1999 in response to flood flows caused by Hurricane Irene. STA-5 began routine flow-through operations in June 2000.

In water year 2003-2004 (WY 2003-2004; May 2003 to April 2004), a total of 152,984 ac-ft of water entered STA-5 through the gated culverts at G342A-D. It constituted 76 percent of the total inflow to the STA's treatment cells and was 195.28 percent of the expected annual inflow volume at G342A-D (78,340 ac-ft). During the same period, rainfall accounted for 15,634 ac-ft or 8 percent of the total inflow. Flow from seepage canal pumps at G349A and G350A contributed 29,339 ac-ft of flow, which was 15 percent of the total inflow that year. This included 1499 ac-ft of water that came from the Miami Canal using pumps at G349B and G350B. A temporary pump (G 507_P) provided 3,065 ac-ft from the Miami canal to Cell 1B. This cell needed to remain hydrated because it uses submerged aquatic vegetation for phosphorus uptake. During this period, 136,466 ac-ft of water were discharged from the STA at G344A–D (69 percent of the total outflow). Evapotranspiration accounted for an additional 17,557 ac-ft of water leaving the STA (9 percent of the total outflow). Estimated seepage out of STA-5 accounted for 23 percent of the total outflow from the STA or 45,777 ac-ft. Water budget errors other than those inherent in the above estimates were less than 1 percent for WY 2003-2004.

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INTRODUCTION

This report presents a water budget for Stormwater Treatment Area (STA) 5. It covers the period of operation from May 1, 2003 through April 30, 2004. The report is based upon daily water budgets for the treatment cells in STA-5. Daily results were aggregated to develop monthly and annual water budgets for water year 2004, (WY 2003-2004). In this report, the water year runs from May 1, 2003 to April 30, 2004. This coincides with the period used in the South Florida Environmental Report and previous Everglades Consolidated Reports (SFWMD, 2004). The daily water budget accounted for inflow, outflow, rainfall, evapotranspiration, seepage and error.

STA-5 is located along the western boundary of the Everglades Agricultural Area (EAA), adjacent to the L-2 canal, west of the northwestern corner of the Rotenberger Wildlife Management Area. STA-5 and its location relative to major canals and roadways are shown in **Figure 1**.

This section of the report presents background and describes hydro-meteorological monitoring at STA-5. It is followed by sections describing the operation of STA-5 and the sources of data used for the report. The actual water budget analyses are presented, followed by a summary and recommendations.

Background

STA-5's principal purpose is to reduce the phosphorous load in runoff from the C-139 basin to the north and west of STA-5. Prior to construction, the land now occupied by the STA was used for agricultural purposes.

Construction of STA-5 was completed in December 1998. Initial flooding occurred in January 1999 through October 1999. On October 15, 1999, due to conditions caused by Hurricane Irene, the Florida Department of Environmental Protection (FDEP) issued an emergency order to the South Florida Water Management District authorizing discharges from STA-5 for a 14-day period until October 29, 1999.

FDEP issued an Everglades Forever Act (EFA) permit for STA-5 on February 29, 2000. The issuance of the National Pollution Discharge Elimination System (NPDES) permit was delayed due to objections by the Friends of the Everglades, an environmental interest group. However, authorization for interim operations of STA-5 under the terms and conditions of the NPDES permit was recommended by the Division of Administrative Hearings and granted by FDEP on March 20, 2000. After satisfying the Friends of the Everglades' concerns, the NPDES permit was issued on May 24, 2001.

The southern flow-way of STA-5 (Cells 2A and 2B) began routine flow-through operations in June 2000. The northern flow-way of STA-5 (Cells 1A and 1B) began routine flow-through operations in August 2000.

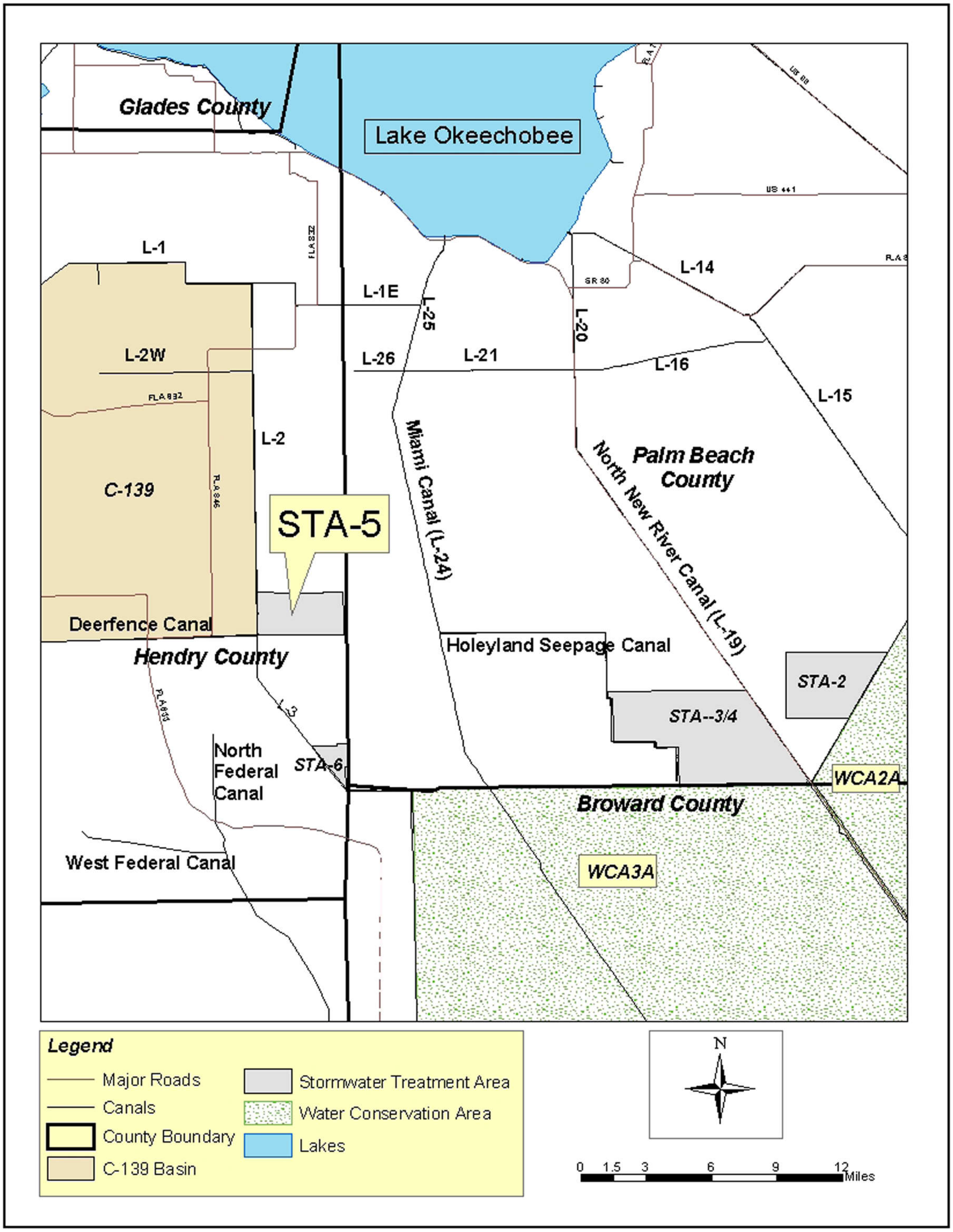

Figure 1. STA-5 location map.

The water budget at STA-5 is comprised of the following hydrologic/hydraulic components:

- Inflow through pumps and gated structures
- Outflow through gated structures
- Rainfall
- Evapotranspiration
- Seepage
- Change in storage
- Water budget error

Each component makes up an important part of the water budget for STA-5. The budget is developed for varying time periods ranging from 1 day to 1 year using the following equation:

$$\frac{\Delta S}{\Delta t} = I - O + R - ET \pm G + \varepsilon \qquad (1)$$

Where	ΔS	=	change in storage over the time period
	Δt	=	time period
	I	=	average inflow over the time period
	O	=	average outflow over the time period
	R	=	rainfall over the time period
	ET	=	evapotranspiration over the time period
	G	=	levee and deep seepage over the time period
	ε	=	water budget error over the time period

In Equation 1, all terms have the same units, acre-feet per unit time (day, month or year). Rainfall and evapotranspiration values (in inches or millimeters) have been converted to feet and multiplied by the effective surface area in acres, (e.g., 839 acres for Cell 1A) to get a volume of rainfall or evapotranspiration for a selected time period.

A full year of daily average stage, flow, rainfall and evapotranspiration data were used in this report. The data were analyzed using Equation 1 on a daily, monthly and annual basis.

Site Description

STA-5 is comprised of four treatment cells that have a total effective treatment area of 4118 acres. The cells are divided into two flow ways running from west to east. The northern flow way consists of Cells 1A and 1B; the southern flow way, Cells 2A and 2B (**Figure 2**). The cells are bermed wetlands with gated culverts and weir structures that control inflow, outflow and stage (water level) within the cells. Vegetation in the cells varies. It includes primrose willow, cattail, smartweed, mixed grasses and submerged aquatic vegetation (Environmental Research Institute, 2001). **Figure 2** shows a schematic of the cells and control structures. **Table A-1** in Appendix A contains a summary of site properties used in the water budget calculations for STA-5.

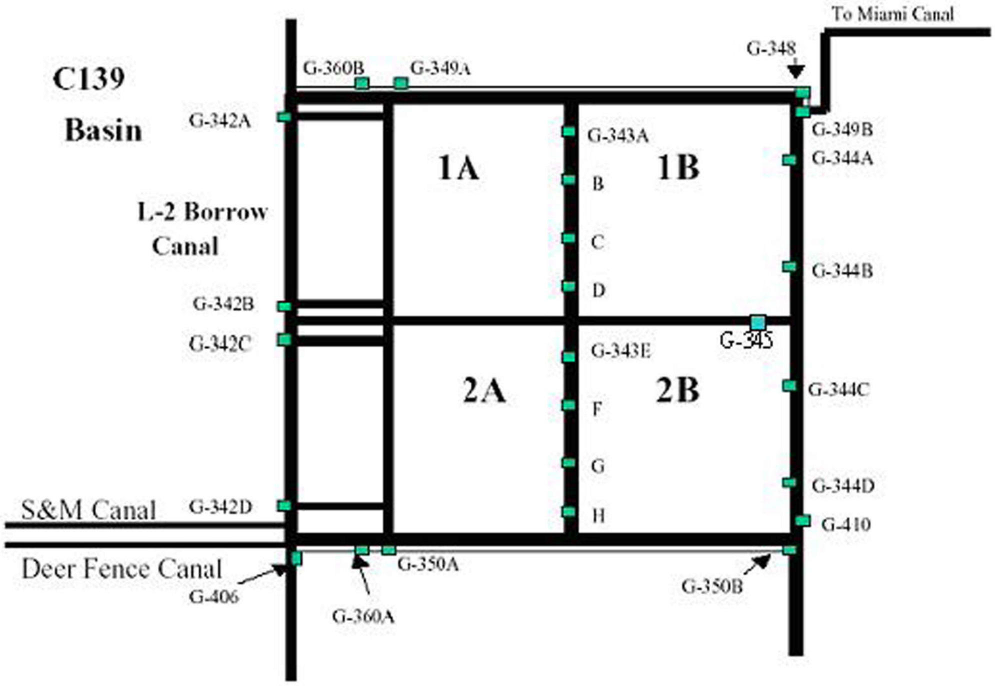

Figure 2. Schematic diagram of STA-5 (not to scale).

STA OPERATION

The STA's treatment cells receive runoff from the C-139 basin via the L-2 canal north of the Deer Fence Canal. Under normal operating conditions, the by-pass structure in the L-2 canal south of the STA, G406, is closed. The gates at G406 are opened when the water level in the L-2 canal exceeds 16.0 ft NGVD.

In the STA water flows west to east by gravity, into distribution ditches located east of the G342A, B, C and D gated culverts in Cells 1A and 2A (**Figure 2**). Two pumps at G349A and two at G350A re-circulate water from the seepage canals located along the northern and southern borders of the STA into Cells 1A and 2A, respectively. Eight intermediate combination weir/culvert structures, G343A through H, pass flow from Cells 1A and 2A to Cells 1B and 2B. Culverts at G345 located near G344B and G344C between Cells 1B and 2B, provide the ability to transfer water between the northern and southern flow ways in the eastern treatment cells.

Water is discharged to the east through structures G344A, B, C and D. Water from the STA flows in a canal to the Miami Canal, five miles to the east. Water discharged from STA-5 is also used to restore hydropatterns in the Rotenberger Wildlife Management Area using pumps located at structure G410 near the southeastern corner of STA-5.

STA-5 is currently operated under an interim operations plan (SFWMD, 2000b). The interim plan accommodates additional flow to STA-5 that will eventually be directed to STA-6, Section 2 once that section of STA-6 is constructed. A full description of STA-5, its design and operation are provided in the revised STA-5 Operation Plan (SFWMD, 2000b).

Monitoring

Three parameters were monitored at STA-5: rainfall, stage (water surface elevation) and gate openings and are discussed below. The station locations are shown in **Figure 2**. Flow is computed using calibrated rating equations. The calibration is based on in-channel flow measurements using acoustic Doppler devices. Evapotranspiration was estimated for STA-5 based on data from a nearby monitoring station. **Tables A-2** through **A-5** in Appendix A list the stations where daily average stage, flow, rainfall and evapotranspiration data were recorded together with database (DB) key numbers and station descriptions. Seepage in each cell was estimated using an equation that relates differences in water surface elevations along a length of levee to the amount of water gained or lost due to seepage and is also discussed below. Estimated seepage is not recorded in DBHYDRO, the South Florida Water Management District's corporate database.

Rainfall

Daily rainfall data for STA-5 was collected at G343B_R. The data were compared to rainfall values at seven nearby rain gage locations outside the STA to check for data errors. Missing values were filled based upon the best available information, usually from nearby rain gages. The data were loaded into a preferred DB key every month. A final QA/QC check of the data was completed on a quarterly basis. The preferred DB key provided a high-quality, continuous record of daily rainfall amounts. **Table B-1** Appendix B lists the daily rainfall amounts recorded at G343B_R.

Stage and Gate Openings

Stage and gate opening data were monitored on an instantaneous basis. Both were recorded using two methods. The first method samples the state of the stage and gate openings every 15 minutes, stores data on-site in solid-state, CR10 data loggers and transmits the data periodically to a District database. The second method transmits stage and gate opening data immediately to a District database via telemetry whenever there is a change in state. Daily mean stage values and gate openings used in this study were based on the second method that provided telemetered data.

The instantaneous stage data were used to compute instantaneous flows at the inlet and outlet structures at STA-5. A headwater stage, a tailwater stage and a gate opening are needed to compute flow at each structure. Instantaneous stage data were also averaged and recorded as daily average stage in DBHYDRO. Each treatment cell has several structures associated with it. As a result, more than one stage value was available to compute average daily stage within each of the treatment cells. The daily stage at each of the recording gages within a cell was arithmetically averaged to generate a daily mean stage for the entire cell.

Flow

Daily average flow rates were determined using two methods, culvert equations and pump performance equations. At pump stations G349A, G350A, G349B, G350B and G507, average daily flow was computed instantaneously using motor speed and headwater and tailwater elevation data. The daily average flow at these stations was recorded in DBHYDRO and reviewed on a monthly basis for accuracy and missing data.

Daily average flow at the gated culverts in STA-5 (G342A, B, C and D, G344A, B, C and D and G406) were based on flow values that were calculated using instantaneous headwater stage, tailwater stage and gate openings. A complete record of daily average flow was loaded monthly to a preferred DB key in DBHYDRO. A final QA/QC check of the flow data in the preferred DB keys was performed on a quarterly basis.

Evapotranspiration

Evapotranspiration (ET) is the loss of water to the atmosphere by vaporization (evaporation) at the surface of a water body and/or by respiration of living organisms including vegetation (transpiration). The evapotranspiration data used in this report were derived from ET data for STA-1W that is based on a predictive equation (Abtew, 1996). These data for ET were considered to be of the highest quality available. Table C-1 in Appendix C list the daily ET values used.

Seepage

No direct measurement of seepage was made at STA-5 during the period of this study. In this analysis, seepage was computed as:

$$G = 1.983 K_{sp} L \Delta H \tag{2}$$

where	G	=	levee (horizontal) and deep (vertical) seepage (ac-ft/d)
	K_{sp}	=	coefficient of seepage (cfs/mi/ft)
	L	=	length along the seepage boundary (mi)
	ΔH	=	hydraulic head difference between the cell stage and the water level along the cell's boundary (ft)
	1.938	=	constant to convert from cfs to ac-ft/d

The value of K_{sp} was adjusted to minimize the sum of the squared daily water budget error in the period of study (one year). Unique seepage coefficient values have used for each treatment cell in this report instead of one value for the whole STA-5.

In general, there is a net loss of water from the STA due to higher water surface elevations maintained in the treatment cells as compared to the L-2 canal, the discharge canal and the seepage canals located along the northern and southern boundaries of the STA.

WATER BUDGET

Methodology

In this analysis, STA-5 was divided into two hydrologic units: 1) the northern flow way consisting of Cells 1A and 1B; and 2) the southern flow way consisting of Cells 2A and 2B. A water budget analysis was performed on each of the units on a daily, monthly and annual basis using Equation 1. A daily, monthly and annual water budget was also completed for the entire STA using data from both flow ways. Terms in equation 1 were converted to acre-feet (ac-ft) per unit time (day, month or year, depending upon the period being used for the water budget calculations). The discussion of the results in the following section of the report focuses on the annual water budgets.

Results

Rainfall and Evapotranspiration

Rainfall data for STA-5 are presented in Appendix B. Evapotranspiration (ET) data can be found in Appendix C. **Table 1** presents the annual rainfall summary for WY 2003-2004. The amount of rainfall for WY 2003-2004 was 45.54 in. (85 percent of expected rainfall based on the historic record for the Everglades Agricultural Area). **Figure 3** shows the monthly rainfall surplus or deficit based on the sum of rainfall less estimated ET at STA-5. In 8 of 12 months, ET exceeded rainfall. During the WY 2003-2004 ET exceeded rainfall by a total of 5.6 in.

Table 1. Rainfall Amounts WY 2003-2004 (in.).

Water Year	Rainfall Amount (in.)	Percent of Expected Rainfall
WY 2003-2004	45.54	85

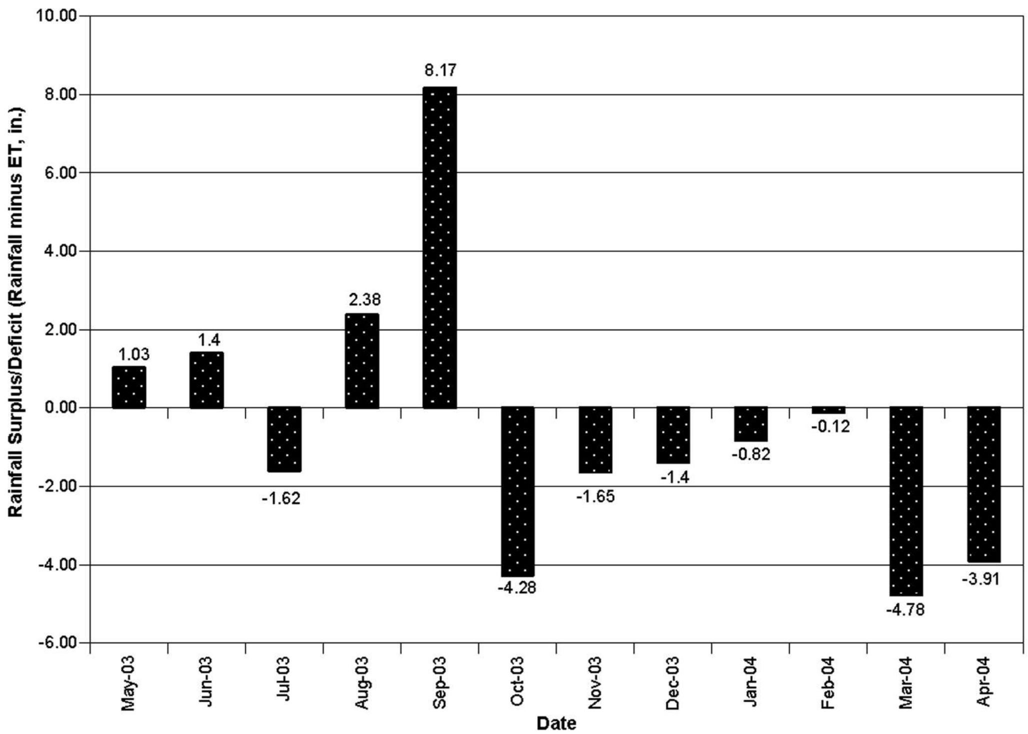

Figure 3. Monthly Rainfall less estimated Evapotranspiration at STA-5.

Northern Flow Way – Cells 1A and 1B

Table 2 and **Figure 4** present the annual water budget summary for the northern flow way at STA 5. The properties (width, length and surface area) of the elements that make up the northern flow way are listed in **Table A-1** in Appendix A. **Table 2** also shows the error summary information for the analysis based on the daily water budgets for the year. A similar table is shown in the corresponding section for the other hydrologic units at STA-5 (**Tables 5** and **9**). Inflow was measured at G342A and B, G349A and G507_P; outflow at G344A and B.

Error in the water budget was less than 2 percent. These errors are less than that of the previous report due in part to the use of a coefficient of seepage that was unique for each flow way. The seepage coefficient used for Cells 1A and 1B was 0.85 cfs/mi/ft. The previous report (Parrish and Huebner, 2004) used a seepage coefficient of 2.20 cfs/mi/ft for all cells. Monthly water budget residuals were used as a check on using adjustments to the seepage coefficient to minimize SSE. Daily water budget residuals are shown in **Figure 5**.

Table 2. Annual Water Budget Summary for Cells 1A and 1B

5/2003 - 4/2004				STA 5 Water Budget - Cell 1			
Inflow		**ac-ft**	**percent**	**Outflow**	**ac-ft**	**percent**	
G342A & B		95,050	78.63%	G344A & B	98,643	82.33%	
+G349A_P		14,945	12.36%	Seepage	10,395	8.68%	
+G507_P		3,065	2.54%	ET	8,778	7.33%	
Rain		7,817	6.47%	Error	2,005	1.67%	
Total		120,877	100%	Total	119,821	100%	
Change in storage		-1,056					
Residual Analysis				**Count**	**1" error**	**2" error**	**3" error**
Sum	2,005	Avg. Err.	5.48	#>	3	1	0
Max	796	St.Dev.	132	#<	4	2	1
Min	-1,113	Avg Ab Err	0.45	Total	7	3	1
		St. Dev.	0.63	Percent	1%	0%	0%
SSE	6,417,712	Sum Abs Err	166.11				

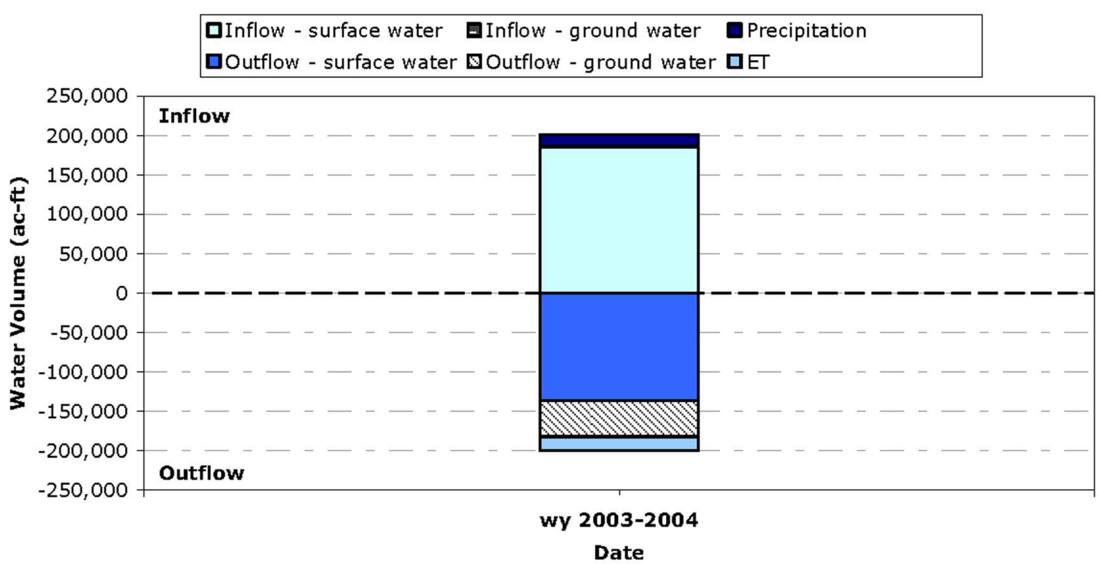

Figure 4. Cell 1 Annual Water Budget Summary, WY 2003-2004

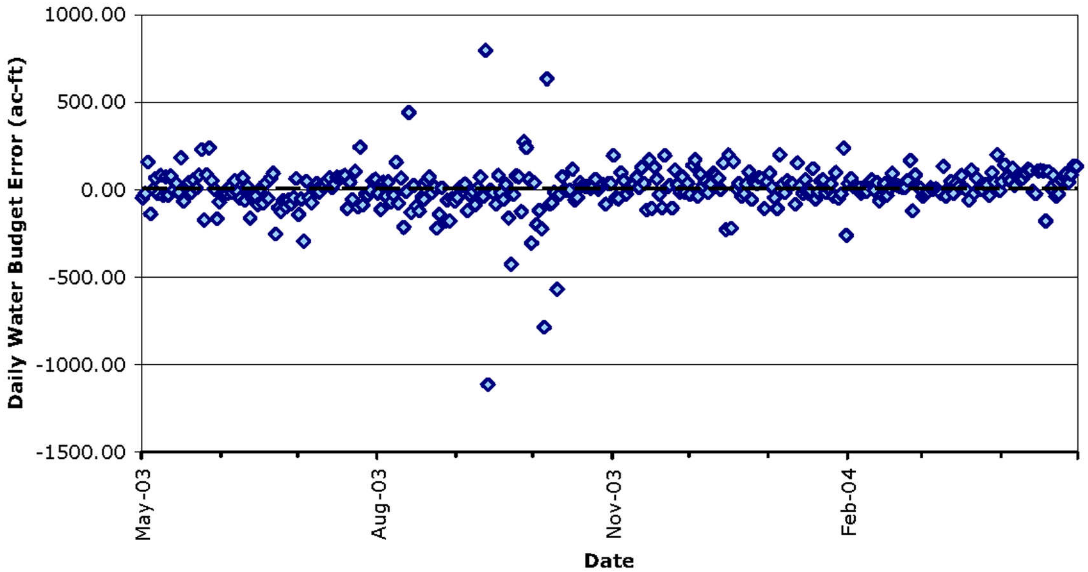

Figure 5. Water Budget Residuals for Cells 1A and 1B.

Seepage in the northern flow way constituted 8.7 percent of the water budget for WY 2003-2004. **Figure 6** shows the estimated seepage for Cells 1A and 1B over the period of the study. **Table 3** summarizes inflow and outflow at culverts and pumps in the northern flow way for WY 2003-2004. **Figure 7** displays the water levels in the northern flow way cells versus surrounding canals and cells. For the year examined, seepage out of the northern flow way was greater than seepage in. In general, the direction of seepage flow was into the treatment cells from the L-2 canal and Cells 2A and 2B and out of the treatment cells toward the seepage canal along the STA's northern boundary and the discharge canal along the eastern boundary. Inflow, outflow and stage for Cells 1A and 1B are shown in **Figure 8**. Approximately 96 percent of the flow leaving the northern flow way at G344A and B entered the STA at G342A and B for WY 2003-2004. **Table 4** presents the results of the monthly water budget analysis for Cells 1A and 1B.

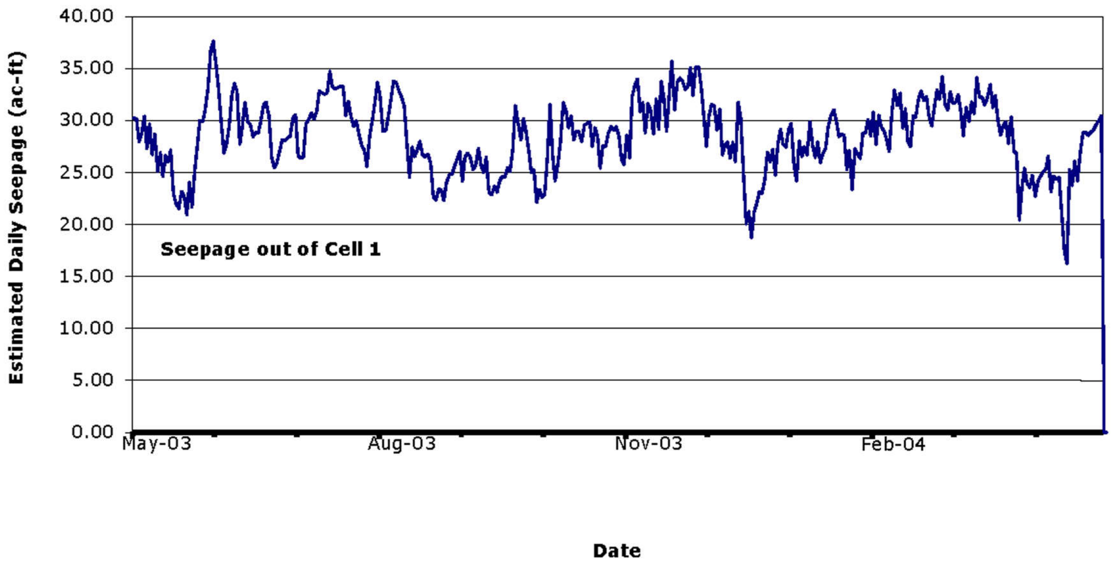

Figure 6. Estimated Daily Seepage for Cells 1A and 1B.

Table 3. Inflow and Outflow at Structures - Northern Flow Way

Water Year	Inflow (ac-ft)	Outflow (ac-ft)	Outflow as a percentage of Inflow
WY2003-2004	113,060	98,643	87

Note: Inflow calculated at G342A, G342B, G349A and G507_P Outflow calculated at G344A and G344B

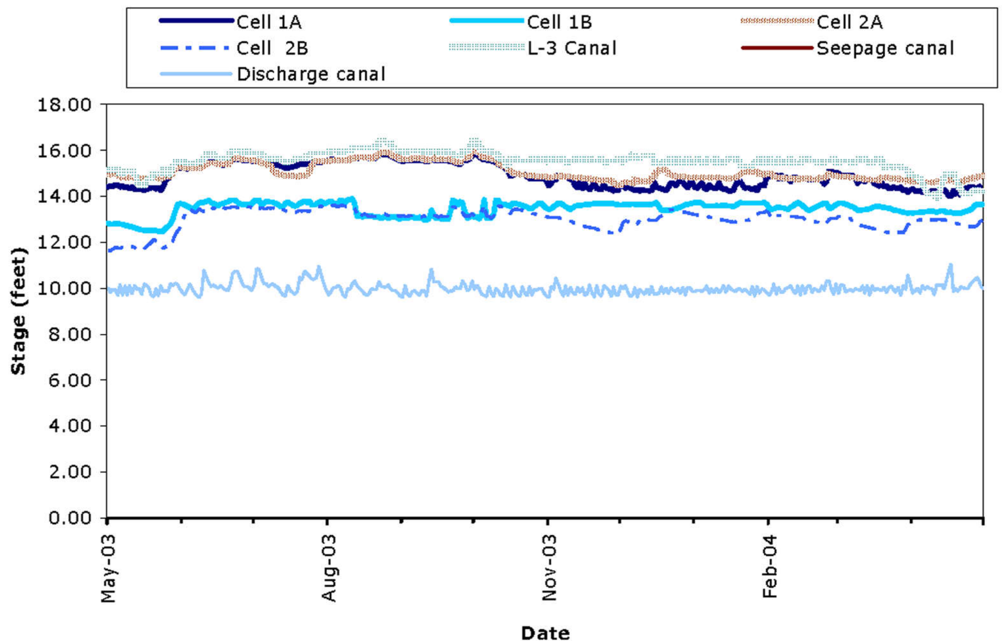

Figure 7. Cells 1A and 1B Stage versus Surrounding Areas.

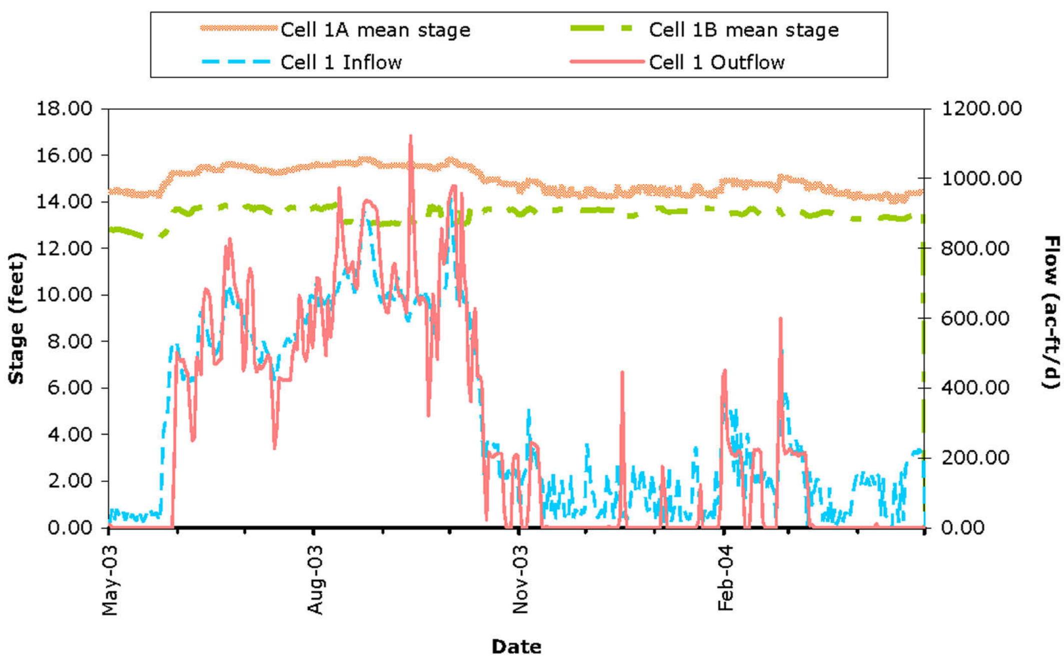

Figure 8. Inflow, Outflow and Stage for Cells 1A and 1B.

Table 4. Monthly Water Budget for Cells 1A and 1B.

Month-Year	Inflow surface water	Outflow surface water	Change in storage	Rain	ET	Seepage	Error	Daily Average Error
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	in
May - 2003	3802.973	702.681	1754.328	1048.769	871.522	846.334	676.877	0.127
Jun - 2003	16420.899	16633.281	229.009	1065.939	825.945	887.711	-1089.108	-0.212
Jul - 2003	16635.137	15301.536	59.731	636.838	915.623	943.964	51.121	0.010
Aug - 2003	22297.875	23702.257	-835.592	1141.470	732.741	857.083	-1017.144	-0.191
Sep - 2003	19670.331	20770.578	410.431	2104.420	702.325	778.066	-886.649	-0.172
Oct - 2003	12129.986	12209.100	-556.240	3.437	737.727	867.728	-1124.891	-0.211
Nov - 2003	3162.755	1226.364	-194.579	262.612	545.774	950.060	897.747	0.174
Dec - 2003	2923.499	567.452	362.366	281.525	521.494	829.536	924.175	0.174
Jan - 2004	2597.013	910.726	162.087	437.710	578.663	855.884	527.364	0.099
Feb - 2004	6354.394	4760.256	156.364	595.631	616.376	879.069	537.959	0.112
Mar - 2004	3182.130	1848.383	-1081.382	18.881	839.800	941.321	652.889	0.123
Apr - 2004	3882.873	10.733	589.543	219.710	890.151	757.799	1854.358	0.360
Total–WY04	113,060	98,643	1,056	7,817	8,778	10,395	2,005	0.033

Note: Negative storage values indicate decreasing stage over the month. No signs are shown for other values, except error. To compute the water budget error, flow into the cell was taken as positive and flow out of a cell was taken as negative.

Southern Flow Way – Cells 2A and 2B

Table 5 and **Figure 9** shows the WY 2003-2004 water budget for the southern flow way, comprised of Cells 2A and 2B. Inflow was measured at G342C and D and G350A; outflow at G344C and D. As a percentage of the budget, error was less than 4 percent for WY 2003-2004. These errors are less than that of the previous report due in part to the coefficient of seepage. The seepage coefficient for the Cells 2A and 2B was 3.45 cfs/mi/ft. Monthly water budget residuals were used as a check on using adjustments to the seepage coefficient to minimize SSE.

Table 5. Annual Water Budget Summary Cells 2A and 2B.

5/2003 - 4/2004			**STA 5 Water Budget - Cell 2**				
Inflow	**ac-ft**	**percent**		**Outflow**	**ac-ft**	**percent**	
G342C & D	57,935	72.29%		G344C & D	37,822	44.34%	
+G350A_P	14,394	17.96%		Seepage	35,382	41.48%	
				ET	8,778	10.29%	
Rain	7,817	9.75%					
				Error	3,314	3.89%	
Total	80,146	100%		**Total**	85,296	100%	
Change in storage	-1,478						
Residual Analysis				**Count**	**1" error**	**2" error**	**3" error**
Sum	7,817	Avg. Err.	-9.06	#>	6	1	0
Max	958	St.Dev.	144	#<	4	2	0
Min	-744	Avg Ab Err	0.56	Total	10	3	0
		St. Dev.	0.62	Percent	1%	0%	0%
SSE	7,614,815	Sum Abs Err	206				

Figure 10 shows the daily residual error plot for the WY 2003-2004 water budget. **Table 6** shows the annual inflow and outflow at culverts and pumps for the southern flow way for WY2003-2004.

Seepage constituted 44 percent of the water budget for WY 2003-2004. Seepage out of the southern flow way is depicted in **Figure 11**. In general, seepage from the southern flow way flows into the northern flow way, the seepage canal along the southern boundary of the cells and the discharge canal along the eastern boundary of the STA. Based on water elevation differences, it appears that some water seeped into the southern flow way from the L-2 canal and the northern flow way. Stage in the cells and in surrounding areas is presented in **Figure 7**. **Figure 13** shows the inflow, outflow and stage in Cells 2A and 2B for study period.

The monthly water budget is shown in **Table 7**. The monthly error in ac-ft/month and the daily average error in inches are given in the right two columns of the table. All average daily errors based on the monthly water budget are less than 1.0 in.

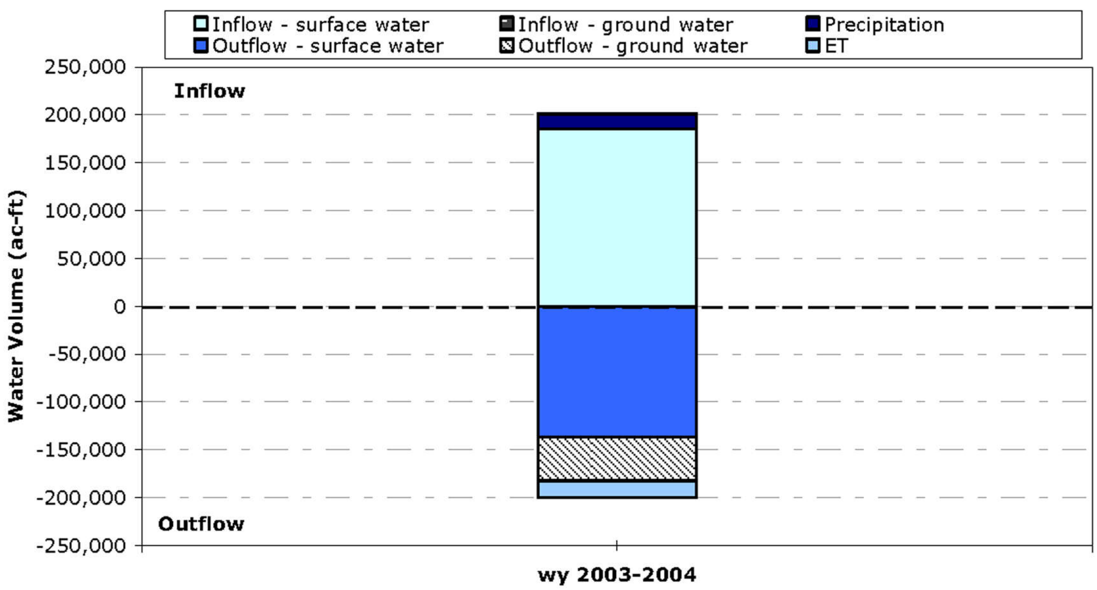

Figure 9. Cell 2 Annual Water Budget Summary, WY 2003-2004

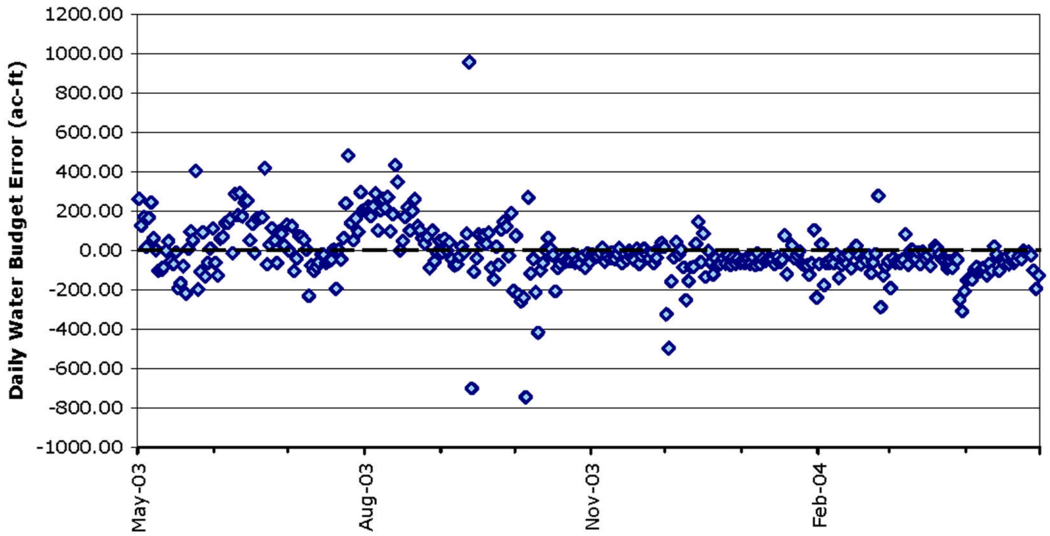

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Figure 10. Water Budget Residuals for Cells 2A and 2B.

Table 6. Inflow and Outflow at Structures - Southern Flow Way .

Water Year	Inflow (ac-ft)	Outflow (ac-ft)	Outflow as a percentage of Inflow
WY 2003-2004	72,329	37,822	52

Note: Inflow calculated at G342C, G342D and G350A. Outflow calculated at G344C and G344D.

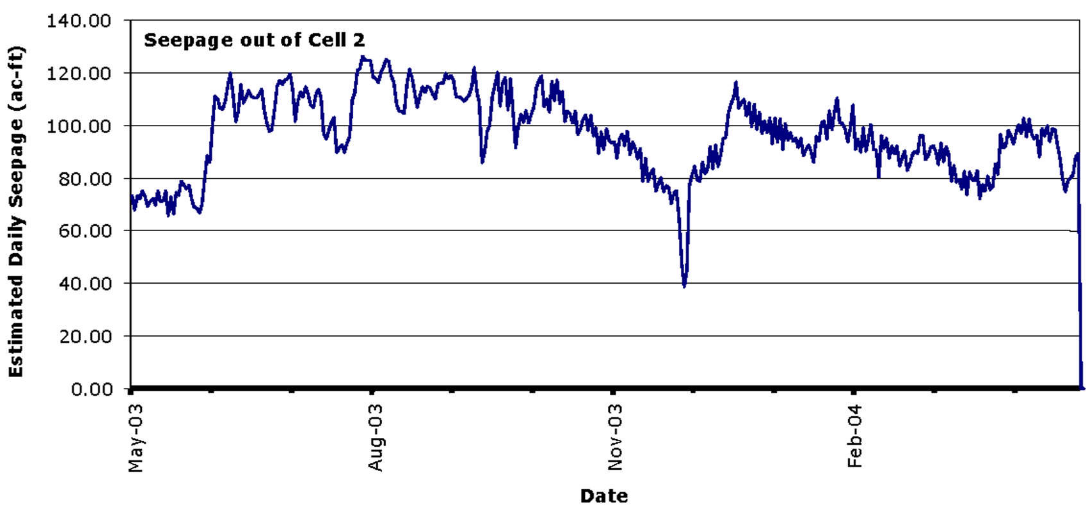

Figure 11. Estimated Daily Seepage Cells 2A and 2B.

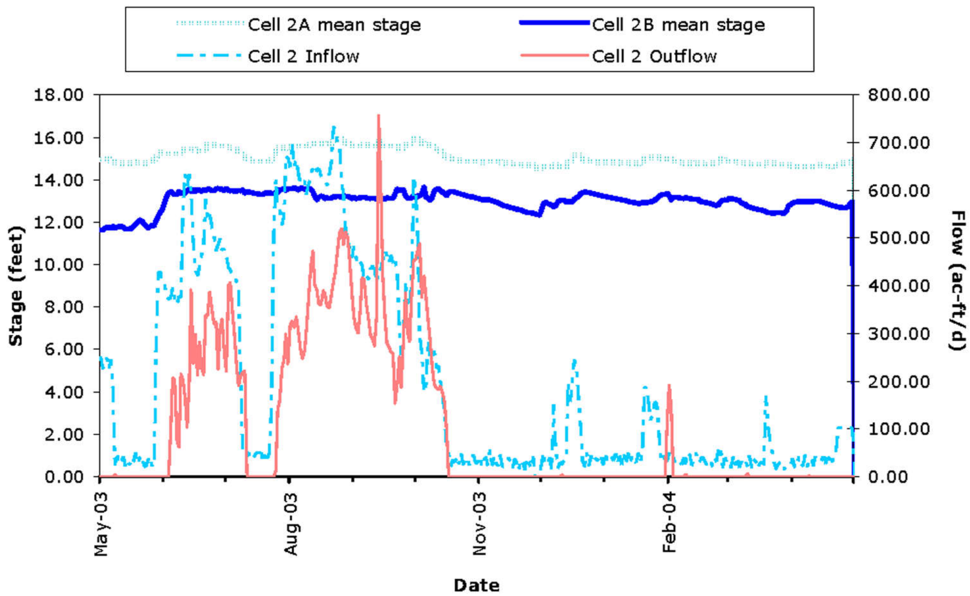

Figure 12. Cells 2A and 2B Inflow, Outflow and Stage.

Table 7. Monthly Water Budget for Cells 2A and 2B.

Month-Year	Inflow surface water	Outflow surface water	Change in storage	Rain	ET	Seepage	Error	Daily Average Error
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	in
May - 2003	3812.498	3.851	1394.751	1048.769	871.522	2272.798	318.346	0.060
Jun - 2003	14272.184	6591.631	1318.271	1065.939	825.945	3295.893	3306.383	0.642
Jul - 2003	8668.139	4061.839	51.316	636.838	915.623	3333.557	942.642	0.177
Aug - 2003	19341.901	12016.475	-489.294	1141.470	732.741	3579.160	4644.288	0.873
Sep - 2003	12757.136	10071.467	389.094	2104.420	702.325	3251.646	447.025	0.087
Oct - 2003	4616.628	4604.987	-1009.824	3.437	737.727	3243.117	-2955.942	-0.556
Nov - 2003	820.724	0.000	-1266.850	262.612	545.774	2446.786	-642.375	-0.125
Dec - 2003	2194.803	3.535	1371.500	281.525	521.494	2917.135	-2337.336	-0.439
Jan - 2004	2077.351	118.870	281.841	437.710	578.663	3007.988	-1472.300	-0.277
Feb - 2004	1055.522	341.442	-449.336	595.631	616.376	2662.670	-1520.001	-0.316
Mar - 2004	1137.141	6.567	-419.195	18.881	839.800	2590.139	-1861.289	-0.350
Apr - 2004	1574.965	1.589	305.634	219.710	890.151	2781.216	-2183.915	-0.424
Total-WY04	72,329	37,822	1,478	7,817	8,778	35,382	-3,314	-0.054

Note: Negative storage values indicate decreasing stage over the month. No signs are shown for other values, except error. To compute the water budget error, flow into the cell was taken as positive and flow out of a cell was taken as negative.

STA-5

Table 8 summarizes the annual inflow and outflow volumes at culverts and pumps at STA-5 for WY 2003-2004. **Table 9** and **Figure 13** shows the summary of the water budget for the entire STA, which includes both flow ways, discussed above. Using a seepage coefficient of 0.85 cfs/mi/ft for Cell 1 A & B and 3.45 cfs/mi/ft for Cell 2 A & B, error for the WY 2003-2004 budget became slightly less than 1 percent. Seepage was about 23 percent of the water budget for WY 2003-2004.

Figure 14 shows the residual in the daily water budgets. The peaks in the residual plot occur during periods of high inflow, indicating that the daily water budget under these conditions does not accurately quantify the hydrologic processes occurring in the STA. **Figure 15** presents the estimated seepage out of STA-5. It does not show a loss of water from the treatment cells. The pumps at G349A and G350A return almost all the flow of this seepage volume (shown in **Table 9**) to Cells 1A and 2A. Inflow, outflow and stage are shown in **Figure 16**.

Table 10 shows the monthly water budget summary. The daily average errors are less than 1.0 in through out the year. **Figure 17** summarizes the inflows and outflows to STA-5. The outflow volume during this one year period at G344A through D was 89 percent of the inflow volume at G342A thought D.

Table 8. Annual Inflow and Outflow at Culverts and Pumps - STA-5.

Water Year	Inflow (ac-ft)	Outflow (ac-ft)	Outflow as a percentage of Inflow
WY 2003-2004	185,389	136,466	74

Note: Inflow calculated at G342A, B, C and D, G349A, G350A and G507_P. Outflow calculated at G344A, B, C and D.

Table 9. Annual Water Budget Summary for STA-5.

5/2003 - 4/2004				STA 5 Water Budget			
Inflow		**ac-ft**	**percent**	**Outflow**	**ac-ft**	**percent**	
G342A-D		152,984	76.10%	G344A-D	136,466	68.75%	
	+G349A_P	14,945	7.43%	Seepage	45,777	23.06%	
	+G350A_P	14,394	7.16%	ET	17,557	8.84%	
	+G507_P	3,065	1.53%				
Rain		15,634	7.78%	**Error**	-1,310	-0.65%	
Total		201,023	100%	**Total**	198,490	100%	
Change in storage		-2,534					
Residual Analysis				**Count**	**1" error**	**2" error**	**3" error**
Sum	1,310	Avg. Err.	-3.58	#>	11	4	1
Max	1,755	St.Dev.	236	#<	15	3	2
Min	-1,814	Avg Ab Err	0.38	Total	26	7	3
		St. Dev.	0.57	Percent	2%	1%	0%
SSE	20,285,894	Sum Abs Err	138				

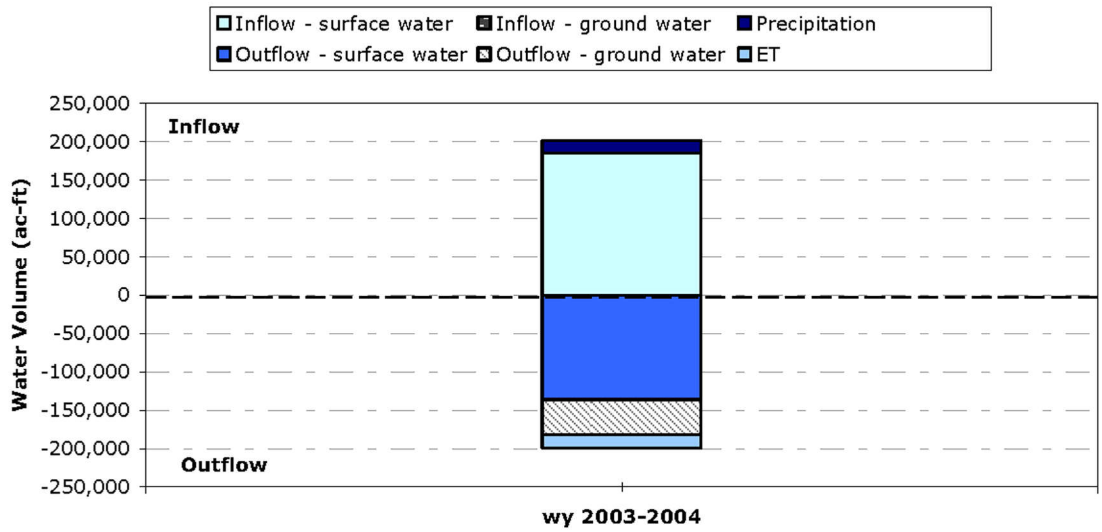

Figure 13. STA-5 Annual Water Budget Summary, WY 2003-2004

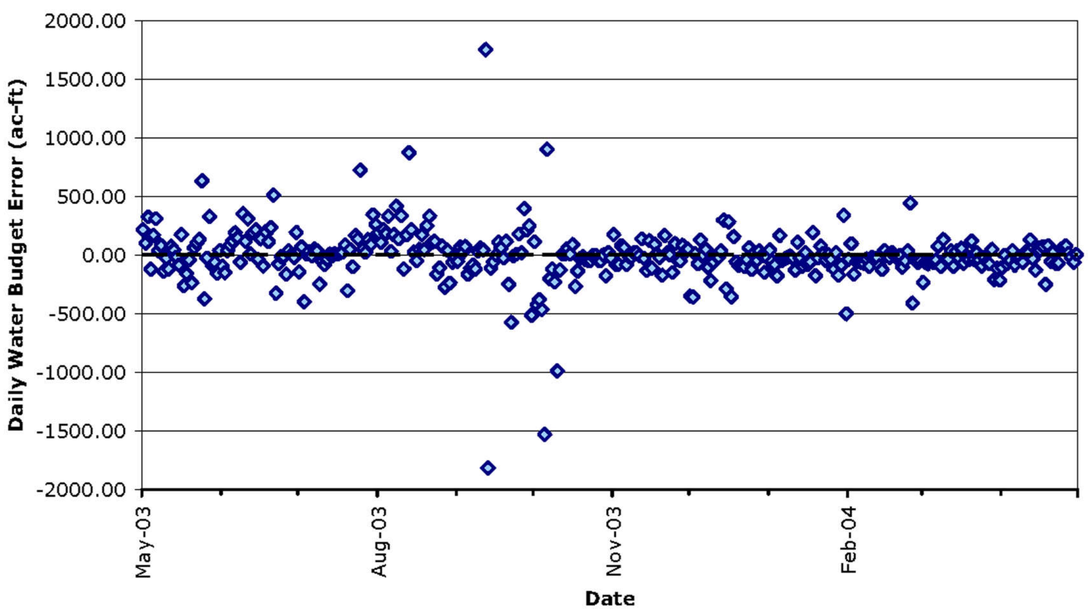

Figure 14. Water Budget Residuals for STA-5.

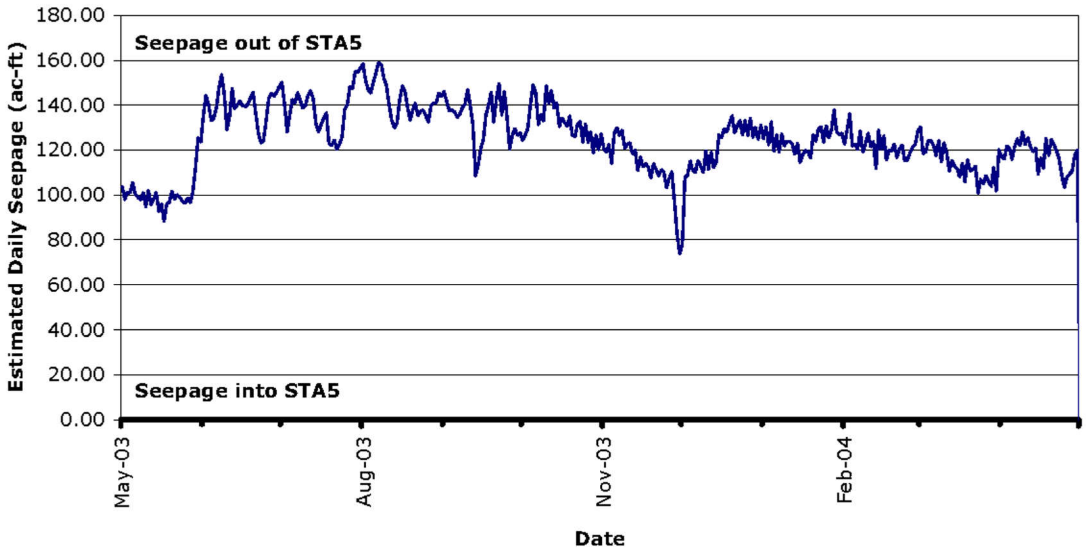

Figure 15. STA-5 Estimated Daily Seepage.

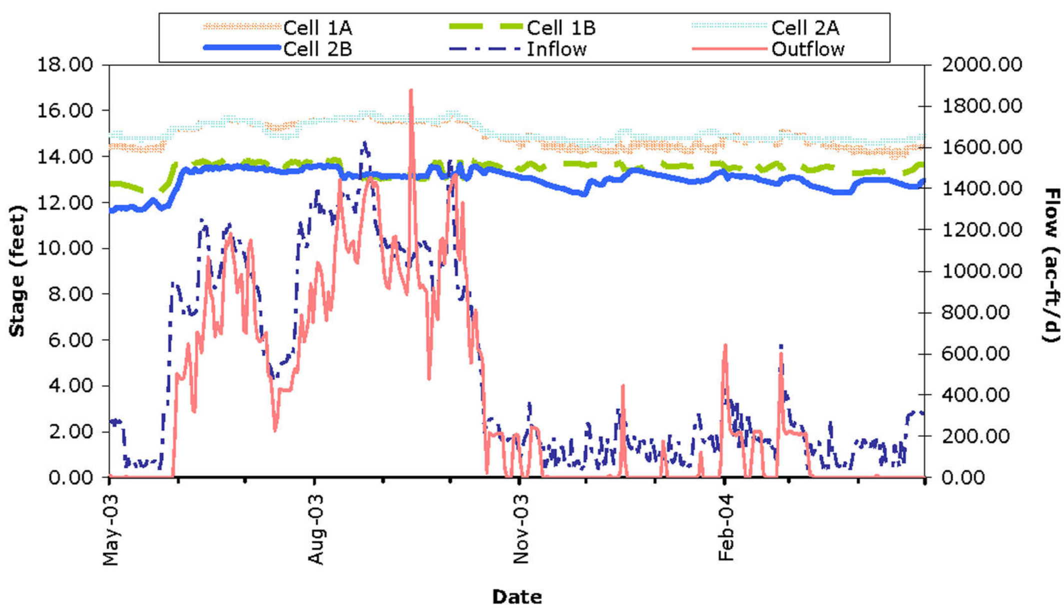

Figure 16. STA-5 Inflow, Outflow and Stage.

Table 10. Monthly Water Budget for STA-5.

Month-Year	Inflow surface water	Outflow surface water	Change in storage	Rain	ET	Seepage	Error	Daily Average Error
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	in
May - 2003	7615.479	706.532	3149.095	2097.570	1743.124	3119.099	995.199	0.094
Jun - 2003	30693.074	23224.896	1547.280	2131.894	1651.890	4183.595	2217.307	0.215
Jul - 2003	25303.293	19363.376	111.055	1273.611	1831.253	4277.521	993.699	0.093
Aug - 2003	41639.784	35718.723	-1324.902	2282.948	1465.499	4436.203	3627.209	0.341
Sep - 2003	32427.435	30842.029	799.517	4208.840	1404.698	4029.720	-439.689	-0.043
Oct - 2003	16746.614	16814.087	-1566.047	6.858	1475.519	4110.837	-4080.923	-0.384
Nov - 2003	3983.495	1226.364	-1461.429	525.248	1091.540	3396.790	255.478	0.025
Dec - 2003	5118.285	570.978	1733.842	563.001	1043.005	3746.712	-1413.250	-0.133
Jan - 2004	4674.316	1029.596	443.928	875.405	1157.359	3863.855	-945.018	-0.089
Feb - 2004	7409.931	5101.698	-292.939	1191.246	1232.769	3541.731	-982.082	-0.102
Mar - 2004	4319.246	1854.949	-1500.552	37.761	1679.575	3531.484	-1208.448	-0.114
Apr - 2004	5457.822	12.314	895.177	439.421	1780.310	3539.007	-329.566	-0.032
Total-WY04	185,389	136,466	2,534	15,634	17,557	45,777	-1,310	-0.011

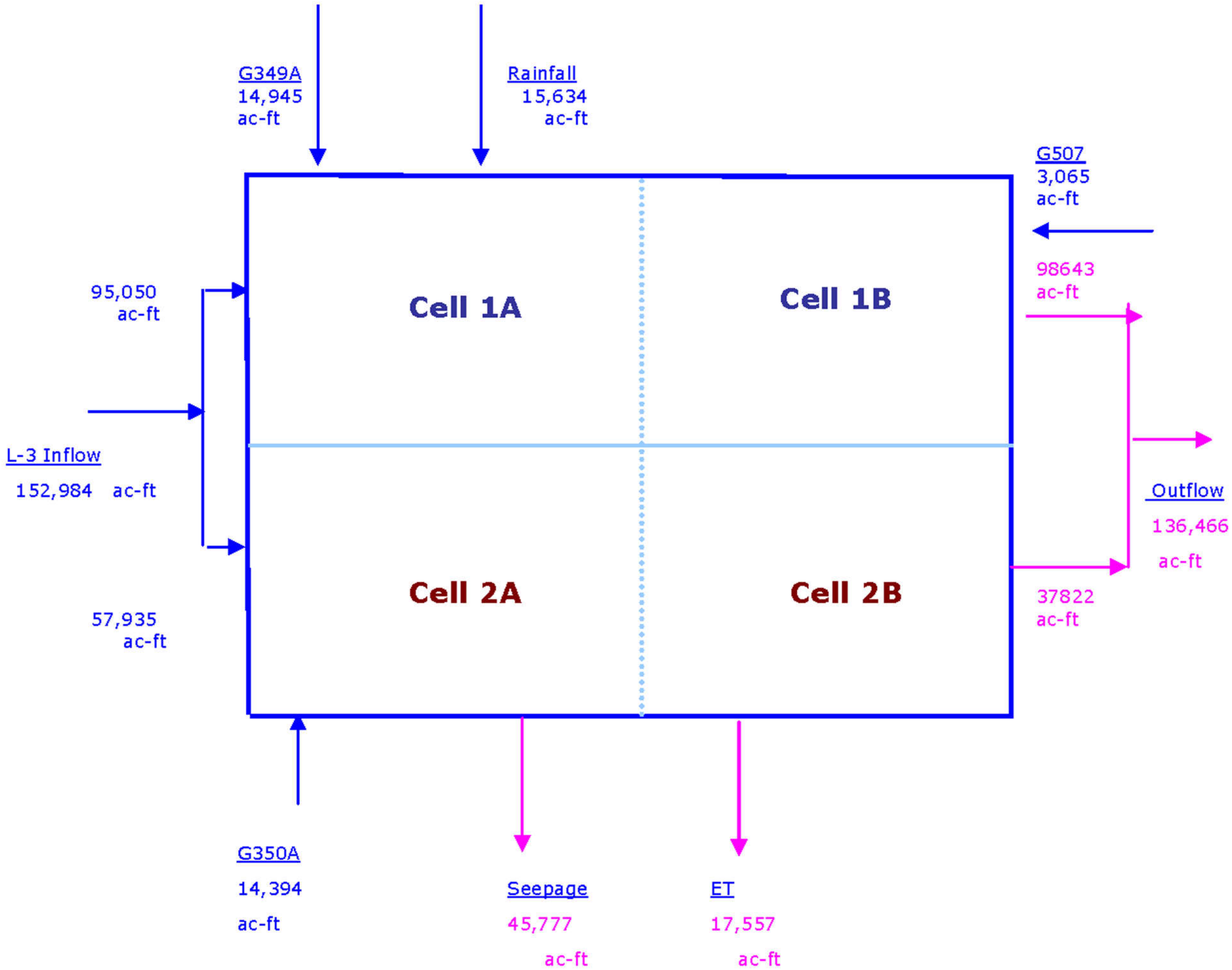

Figure 17. STA-5 Water Budget Volumes WY 2003-2004.

Mean Hydraulic Retention Time

Mean hydraulic retention time (MHRT) is a measure of how long water remains in each cell and estimates the treatment time. Over this period, physical, chemical and biological processes remove particulate and soluble phosphorous and other contaminants. The mean hydraulic retention time (also referred to as mean cell residence time) was determined using equation 3:

$$t = \frac{V}{Q} \qquad (3)$$

where t = mean hydraulic retention time (d)
V = cell volume (ac-ft)
Q = flow rate (ac-ft/d)

MHRT was based upon the average stage during the study period and the average volume of total inflow and total outflow including rainfall, evapotranspiration and seepage which are large percentages of the water budget. **Table 11** shows the MHRT in days for the northern flow way (Cells 1A and 1B) and the southern flow way (Cells 2A and 2B) for wet and dry seasons. MHRT was 7.56 days for the northern flow way and 11.22 days for the southern flow way during the wet season in WY 2003-2004 (June 03 to October 03) During the dry season (November 03 to April 04 and May 03) MHRT was 32.13 days for the northern flow way and 35.05 days for the southern flow way.

Table 11. Mean Hydraulic Retention Time (MHRT).

	Annual		Wet Season		Dry season	
Cell 1A	Average depth (feet)	MHRT (days)	Average depth (feet)	MHRT (days)	Average depth (feet)	MHRT (days)
WY 2003-004	2.10	5.40	2.68	3.64	1.68	12.06
Cell 1B						
WY 2003-2004	1.95	7.28	1.98	3.92	1.92	20.07
Cell 2A						
WY 2003-2004	2.31	8.77	2.68	5.62	2.05	18.53
Cell 2B						
WY 2003-2004	1.50	8.27	1.84	5.60	1.26	16.52

SUMMARY AND DISCUSSION

A total of 152,984 ac-ft of water entered STA-5 from the gated culverts at G342A – D from May 1, 2003 to April 30, 2004. This flow constituted about 76 percent of the total inflow to the STA. Rainfall accounted for 15,634 ac-ft or 8 percent of the total inflow. Flow from seepage canal pumps at G349A and G350A contributed 14,945 ac-ft and 14,394 ac-ft of flow, respectively, which was 7.4 and 7.2 percent of the total inflow to the treatment area during the water year.

During WY 2003-2004, 696 ac-ft of water came from the Miami Canal via pumping at G349B and 803 ac-ft via pumping at G350B. The area around STA-5 received about 85 percent of its expected annual rainfall. The Pollution Prevention Plan (SFWMD, 2000b) cites expected flows into the STA through the G342A – D culverts of 78,340 ac-ft per year or 215 ac-ft per day. During the study period, STA-5 received 418 ac-ft per day or 94 percent more than the expected annual volume of flow through these structures.

During the same period, 136,466 ac-ft of water was discharged from the STA at G344A – D (69 percent of the total outflow). Evapotranspiration accounted for an additional 17,557 ac-ft of water leaving the STA (9 percent of the total outflow). Estimated seepage out of STA-5 accounted for 23 percent of the total outflow from the STA or 45,777 ac-ft. The volume of seepage was based upon head differences between the treatment cells and the water levels in the areas surrounding the STA and an estimated seepage coefficient of 0.85 cfs/ft/mi for Cell 1 and 3.45 cfs/ft/mi for Cell 2. These coefficients were well within the values found in literature concerning the design of STAs and other analyses of seepage potential. Water budget error was less than 1.0 percent for the WY 2003-2004. The daily average error in the monthly water budgets for STA-5 was less than 1.0 in through out the period of study.

Cells 1A and 1B, constituting the northern flow way, received 95,050 ac-ft of water from May 2003 to April 2004 through structures G342A and B. The pumps at G349A provided an additional 14,945 ac-ft of water during the same period. Rain into these cells accounted for 7,817 ac-ft of inflow. The volume of water stored in the cells decreased by 1,056 ac-ft over this period. G344A and B discharged 98,643 ac-ft of water. ET accounted for another 8,778 ac-ft. Seepage out of Cells 1A and 1B was estimated at 10,395 ac-ft using an estimated seepage coefficient of 0.85 cfs/ft/mi and 3.45 cfs/ft/mi. Water budget error was less than 2 percent.

The southern flow way, Cells 2A and 2B, received 57,935 ac-ft of water during the study period through culverts G342C and D. The pumps at G350A discharged 14,394 ac-ft of water into Cell 2A. Rainfall contributed 7,817 ac-ft of water to these cells. Storage in Cells 2A and 2B decreased by 1,478 ac-ft. G344C and D released 37,822 ac-ft of water during the study period. ET accounted for a loss of 8,778 ac-ft and seepage losses were estimated at 35,382 ac-ft using an estimated seepage coefficientsof 0.85 cfs/ft/mi and 3.45 cfs/ft/mi. Water budget error was about 4 percent.

Mean hydraulic residence times during this period were 7.56 (wet season WY 2003-2004) 32.13 (dry season WY 2003-2004) days for the northern flow way, Cells 1A and 1B and 11.22 (wet season WY 2003-2004) to 35.05 (dry season WY 2003-2004) days for the southern flow way, Cells 2A and 2B. These values compare favorably with the MHRT's observed for STA-1W and the ENR project.

There were a number of problems associated with calculating the water budget for STA-5. The largest source of error may be the values computed for seepage. The seepage and budget residual combined constitute up to 23 percent of the water budget (**Table 9**). The seepage coefficients used in this study were calibrated based on minimizing the sum of the squared daily net water budget error for the entire STA. The seepage coefficients were 0.85 cfs/mi/ft for Cell 1A and 1B and 3.45 cfs/mi/ft for Cell 2A and 2B. The previous report (Parrish and Huebner, 2004) used a seepage coefficient of 2.20 cfs/mi/ft for the entire STA 5. Other errors, such as those associated with flow calculations, may also be incorporated in the seepage estimates. However, implementation of new rating curves for the inflow and outflow structures in July 2003 should have reduced this error

The daily water budget residuals or error for STA-5 were shown in **Figures 5**, **10** and **14** (residuals for Cells 1A and 1B, Cells 2A and 2B and STA-5 as a whole). The residuals increase when flow increases. **Figure 18** shows the residuals for STA-5 plotted with inflow data and seepage data. The largest residuals are observed during high inflow values. These errors are due to changes in storage that are not captured accurately by daily mean stage values. (Parrish and Huebner 2004).

Other possible sources of error in the budget include use of ET values from the ENR located approximately 33 miles to the northeast of STA-5, using average ground elevations for the bottom of the treatment cells and assuming a constant surface area independent of water depth in the cells. However these weaknesses should have had a minor impact on the water budget.

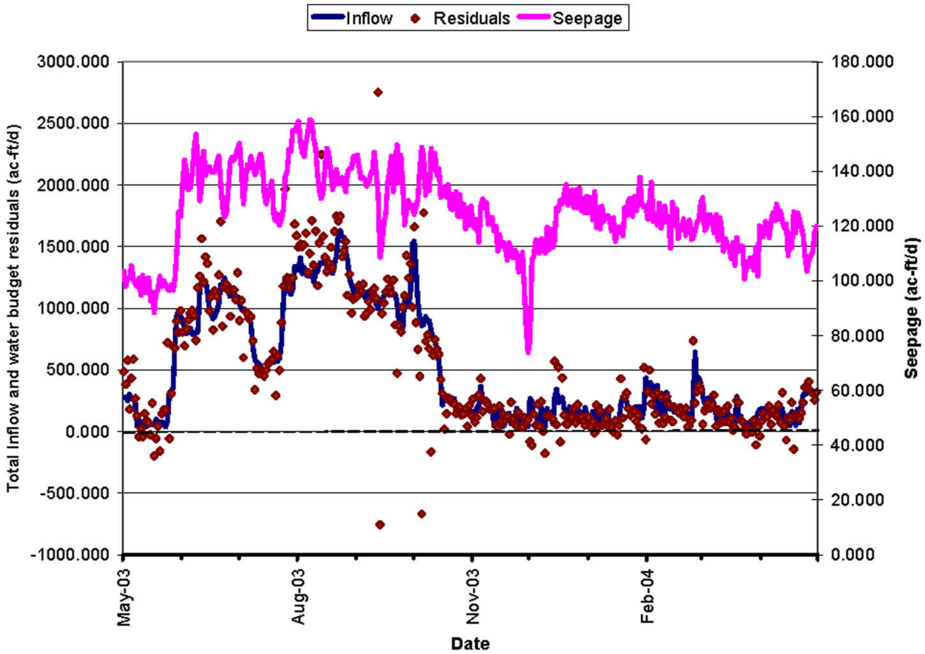

Figure 18. STA-5 Inflow, Seepage and Water Budget Residuals.

RECOMMENDATIONS

Seepage was the largest single quantifiable unknown at the site. Additional study of the groundwater flow regime and the impact of seepage on treatment performance is warranted. Piezometers with water level recorders located outside the boundary of STA-5 would have aided the analysis of seepage for this study especially along the northern and southern boundaries. The ability to calculate seepage into and out of an STA should be a design criterion. Location and installation of observation wells for this purpose should be a design/construction requirement for all STAs.

The design of the gated culverts at STA-5 is susceptible to backflow or reverse flow under certain operating conditions. Although the magnitude of these flows is small relative to flow during major runoff events, backflow into or out of the STA is contrary to the design principles of STAs in general. Back-flow at the G344A through D structures introduces untreated water from the Miami Canal into the finishing Cells 1B and 2B. Likewise, backflow from Cells 1A and 2A at structures G342A through D mixes treated water with untreated water in the L-2 canal. Automating the operation of the gates would minimize the volume of backflow.

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APPENDICES

Appendix A – Site Properties and Monitoring Stations

Table A-1. STA-5 Site Properties

Surface Area		
Cell 1A (Northwest)	**839 ac**	
Cell 1B (Northeast)	**1220 ac**	
Cell 2A (Southwest)	**839 ac**	
Cell 2B (Southeast)	**1220 ac**	
Total	**4118 ac**	
Cells 1A and 2A Bottom Elevation	**~12.75 ft NGVD**	
(Cells 1A and 2A vary in elevation from G342 to G360 from 14.5 to 13.0 ft.; Cells 1A and 2A slope west to east from 13.50 to 11.25 ft.)		
Cells 1B and 2B Bottom Elevation	**~11.50 ft NGVD**	
(Cells 1B and 2B slope west to east from 12.25 to 10.75 ft.)		
Inflow		
Flow at G342A-D, G349A_P, G350A_P and STA-5TP_P		
Outflow		
Flow at G344A-D		
Levee Length		Aspect Ratio
Along Northern Boundary		
Cell 1A	**~ 7,140 ft**	**1.39**
Cell 1B	**~10,380 ft**	**2.03**
Along Southern Boundary		
Cell 2A	**~ 7,140 ft**	**1.39**
Cell 2B	**~10,380 ft**	**2.03**
Along Eastern Boundary		
Cell 1A	**~ 5,120 ft**	
Cell 2A	**~ 5,120 ft**	
Along Western Boundary		
Cell 1B	**~ 5,120 ft**	
Cell 2B	**~ 5,120 ft**	

Table A-2. Stage Monitoring Stations.

DBKEY	Structure	STATION DESCRIPTION
JJ109	G342A_H	STA-5 inflow structure Cell 1A (Headwater)
JJ110	G342A_T	STA-5 inflow structure Cell 1A (Tailwater)
JJ114	G342B_H	STA-5 inflow structure Cell 1A (Headwater)
JJ115	G342B_T	STA-5 inflow structure Cell 1A (Tailwater)
JJ121	G342C_H	STA-5 inflow structure Cell 2A (Headwater)
JJ123	G342C_T	STA-5 inflow structure Cell 2A (Tailwater)
JJ127	G342D_H	STA-5 inflow structure Cell 2A (Headwater)
JJ128	G342D_T	STA-5 inflow structure Cell 2A (Tailwater)
JJ812	G343B_H	STA-5 interior structure between Cell 1A and 1B (Headwater)
JJ813	G343B_T	STA-5 interior structure between Cell 1A and 1B (Tailwater)
JJ815	G343F	STA-5 interior structure between Cell 2A and 2B (Headwater)
JJ816	G343F_T	STA-5 interior structure between Cell 2A and 2B (Tailwater)
JJ133	G344A_H	STA-5 Cell 1B outflow structure (Headwater)
JJ135	G344A_T	STA-5 Cell 1B outflow structure (Tailwater)
JJ138	G344B_H	STA-5 Cell 1B outflow (Headwater)
JJ140	G344B_T	STA-5 Cell 1B outflow (Tailwater)
JJ143	G344C_H	STA-5 Cell 2B outflow (Headwater)
JJ145	G344C_T	STA-5 Cell 2B outflow (Tailwater)
JJ148	G344D_H	STA-5 Cell 2B outflow (Headwater)
JJ150	G344D_T	STA-5 Cell 2B outflow (Tailwater)
JJ156	G349A_H	STA-5 inflow pump (Headwater)
JJ157	G349A_T	STA-5 inflow pump (Tailwater)
JJ802	G349B_H	STA-5 (Headwater)
JJ803	G349B_T	STA-5 (Tailwater)
JJ160	G350A_H	STA-5 inflow pump (Headwater)
JJ161	G350A_T	STA-5 inflow pump (Tailwater)
JJ810	G350B_H	STA-5 south seepage canal pump station (Headwater)
JJ811	G350B_T	STA-5 south seepage canal pump station (Tailwater)

Table A-3. Flow Monitoring Stations.

DBKEY	Structure	STATION DESCRIPTION
J6406	G342A	STA-5 inflow structure cell 1
J6398	G342B	STA-5 inflow structure cell 1
J6407	G342C	STA-5 inflow structure cell 2
J6405	G342D	STA-5 inflow structure cell 2
JJ838	G349A	STA-5 inflow pump cell 1
JJ839	G350A	STA-5 inflow pump cell1
SJ382	G507_P	STA-5C1 temporary pump (between G349B and G344A) for Cell 1
J0719	G344A	STA-5 outflow structure cell 1
J0720	G344B	STA-5 outflow structure cell 1
J0721	G344C	STA-5 outflow structure cell 2
J0722	G344D	STA-5 outflow structure cell 2
JA353	G349B	STA-5 supply pump cell 1
JA352	G350B	STA-5 supply pump cell 2

Table A-4. Rainfall Monitoring Sites.

DBKEY	Structure	STA
JJ837	G343B_R	STA-5 interior structure between Cell 1A and 1B

Table A-5. Evapotranspiration Stations.

DBKEY	Structure	STA
KN810	STA1W	Areal computed parameter for STA 1W project

Appendix B – Rainfall Data

Table B-1. Rainfall at G343B_R (in.) for WY 2003-2004.

Day	2003-05	2003-06	2003-07	2003-08	2003-09	2003-10	2003-11	2003-12	2004-01	2004-02	2004-03	2004-04
1	0.10	0.01	0.00	0.30	0.22	0.00	0.02	0.00	0.00	0.27	0.00	0.00
2	0.00	0.00	0.52	0.11	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.00
3	0.94	0.00	0.00	0.04	0.06	0.00	0.49	0.00	0.00	0.00	0.00	0.00
4	0.00	0.10	0.05	0.06	0.70	0.00	0.27	0.01	0.00	0.00	0.00	0.00
5	0.00	0.00	0.03	0.12	0.57	0.00	0.64	0.09	0.00	0.00	0.00	0.00
6	0.00	0.06	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.16	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.24	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	1.23	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	1.31	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
11	0.00	0.21	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.03	0.00	0.07	6.08	0.00	0.00	0.00	0.00	0.00	0.00	0.77
13	0.00	0.15	0.00	0.28	0.07	0.00	0.00	0.00	0.00	0.01	0.00	0.48
14	0.00	0.57	0.03	0.31	0.00	0.01	0.00	0.84	0.00	0.00	0.00	0.00
15	0.00	0.00	0.13	0.02	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
16	0.67	0.15	0.00	0.12	0.00	0.00	0.00	0.51	0.00	0.00	0.10	0.00
17	0.00	0.04	0.00	0.00	0.43	0.00	0.00	0.05	0.00	0.01	0.00	0.00
18	0.00	0.53	0.00	0.05	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0.00
19	0.45	0.12	0.58	0.00	0.01	0.00	0.06	0.00	0.01	0.00	0.00	0.00
20	0.12	0.65	0.01	0.12	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	2.12	0.35	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.06	0.05	0.13	0.62	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
23	0.00	0.03	0.35	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	2.12	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.08	0.00	1.17	0.00	1.24	0.00	0.00	0.00	0.00	2.38	0.01	0.00
26	0.00	0.00	0.00	0.01	0.35	0.00	0.00	0.00	0.00	0.29	0.00	0.00
27	0.89	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.20	0.00	0.00	0.03
28	0.33	0.00	0.00	1.08	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.35	0.00	0.00	0.16	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.05	0.00	0.00	0.01	0.00	0.00	1.12		0.00	0.00
31	0.00		0.05	0.00		0.00		0.00	0.20		0.00	
MAX	*2.12*	*2.12*	*1.17*	*1.31*	*6.08*	*0.01*	*0.64*	*0.84*	*1.12*	*2.38*	*0.10*	*0.77*
MEAN	*0.20*	*0.21*	*0.12*	*0.21*	*0.41*	*0.00*	*0.05*	*0.05*	*0.08*	*0.12*	*0.00*	*0.04*
MIN	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
SUM	*6.11*	*6.21*	*3.71*	*6.65*	*12.26*	*0.02*	*1.53*	*1.64*	*2.55*	*3.47*	*0.11*	*1.28*

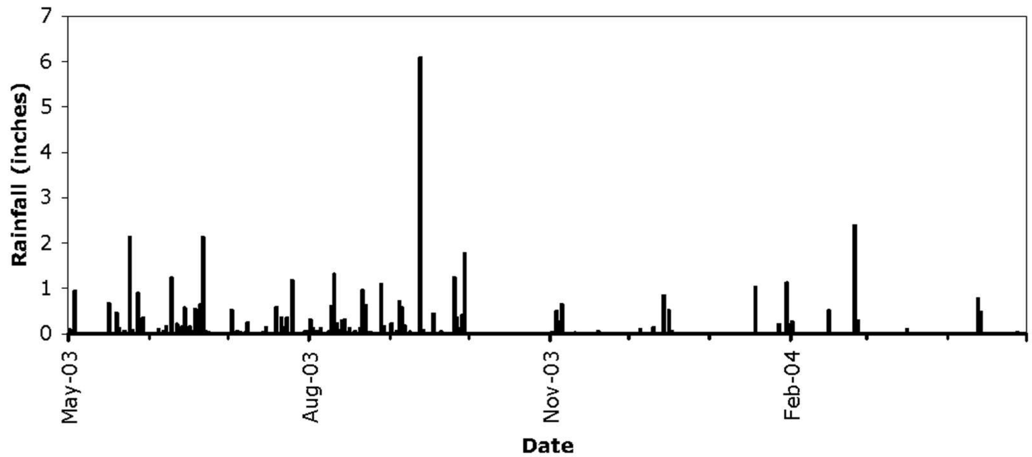

Figure B- 1. Rainfall at G343B_R, WY 2003-2004

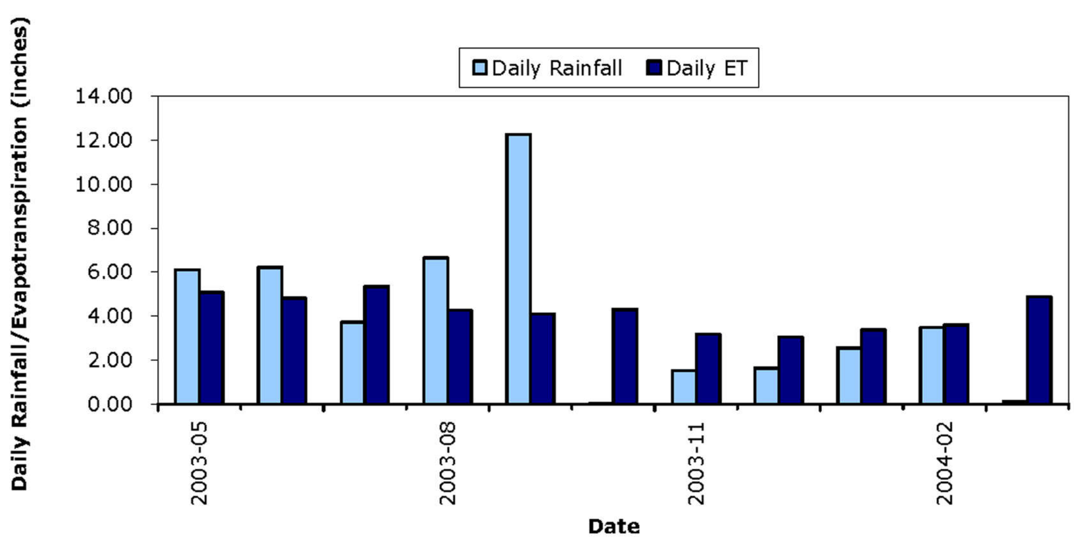

Figure B- 2. Daily Rainfall and ET WY2003-2004.

Appendix C – Evapotranspiration Data

Table C- 1. Evapotranspiration at STA-5 (in.) for WY 2003-2004.

Day	2003-05	2003-06	2003-07	2003-08	2003-09	2003-10	2003-11	2003-12	2004-01	2004-02	2004-03	2004-04
1	0.16	0.16	0.16	0.11	0.11	0.13	0.13	0.11	0.13	0.10	0.13	0.21
2	0.21	0.23	0.16	0.07	0.16	0.13	0.13	0.12	0.10	0.13	0.15	0.22
3	0.20	0.09	0.18	0.14	0.14	0.14	0.13	0.11	0.09	0.15	0.13	0.23
4	0.21	0.14	0.18	0.20	0.13	0.12	0.04	0.10	0.10	0.13	0.16	0.21
5	0.21	0.16	0.12	0.17	0.10	0.18	0.06	0.06	0.10	0.12	0.15	0.22
6	0.13	0.15	0.19	0.14	0.09	0.15	0.07	0.07	0.13	0.13	0.18	0.17
7	0.16	0.14	0.20	0.19	0.15	0.15	0.10	0.13	0.05	0.10	0.16	0.18
8	0.14	0.16	0.18	0.11	0.18	0.13	0.10	0.10	0.12	0.14	0.19	0.20
9	0.17	0.18	0.22	0.15	0.18	0.15	0.10	0.10	0.13	0.13	0.14	0.13
10	0.18	0.24	0.21	0.13	0.17	0.13	0.13	0.04	0.04	0.14	0.19	0.14
11	0.16	0.17	0.23	0.15	0.20	0.12	0.15	0.13	0.13	0.10	0.18	0.18
12	0.18	0.18	0.19	0.18	0.18	0.17	0.11	0.11	0.08	0.15	0.15	0.06
13	0.17	0.23	0.21	0.20	0.12	0.15	0.15	0.11	0.15	0.12	0.17	0.09
14	0.16	0.21	0.18	0.10	0.11	0.11	0.14	0.01	0.15	0.14	0.09	0.21
15	0.19	0.15	0.14	0.15	0.19	0.14	0.13	0.13	0.15	0.06	0.15	0.24
16	0.17	0.15	0.13	0.15	0.18	0.15	0.10	0.07	0.16	0.16	0.08	0.17
17	0.10	0.17	0.16	0.12	0.18	0.09	0.09	0.04	0.10	0.08	0.16	0.17
18	0.13	0.10	0.15	0.12	0.14	0.17	0.14	0.13	0.06	0.18	0.21	0.18
19	0.09	0.13	0.18	0.11	0.14	0.12	0.04	0.12	0.09	0.15	0.19	0.20
20	0.21	0.11	0.21	0.04	0.08	0.14	0.14	0.13	0.14	0.07	0.19	0.21
21	0.19	0.09	0.21	0.12	0.17	0.15	0.10	0.09	0.09	0.13	0.20	0.15
22	0.08	0.13	0.13	0.11	0.15	0.17	0.10	0.07	0.13	0.16	0.19	0.16
23	0.14	0.09	0.18	0.15	0.13	0.16	0.10	0.10	0.15	0.15	0.16	0.19
24	0.17	0.16	0.09	0.12	0.14	0.17	0.12	0.10	0.15	0.15	0.09	0.18
25	0.17	0.22	0.13	0.15	0.11	0.11	0.07	0.10	0.14	0.07	0.11	0.19
26	0.19	0.18	0.12	0.13	0.13	0.15	0.10	0.10	0.10	0.16	0.16	0.14
27	0.12	0.16	0.18	0.14	0.11	0.14	0.10	0.11	0.07	0.09	0.18	0.12
28	0.10	0.13	0.12	0.08	0.11	0.10	0.11	0.11	0.15	0.13	0.21	0.12
29	0.14	0.20	0.22	0.15	0.03	0.16	0.13	0.10	0.13	0.11	0.08	0.14
30	0.22	0.21	0.19	0.18	0.10	0.10	0.09	0.12	0.05		0.16	0.18
31	0.21		0.19	0.21		0.13		0.11	0.01		0.18	
MAX	*0.22*	*0.24*	*0.23*	*0.21*	*0.20*	*0.18*	*0.15*	*0.13*	*0.16*	*0.18*	*0.21*	*0.24*
MEAN	*0.16*	*0.16*	*0.17*	*0.14*	*0.14*	*0.14*	*0.11*	*0.10*	*0.11*	*0.12*	*0.16*	*0.17*
MIN	*0.08*	*0.09*	*0.09*	*0.04*	*0.03*	*0.09*	*0.04*	*0.01*	*0.01*	*0.06*	*0.08*	*0.06*
SUM	*5.08*	*4.81*	*5.33*	*4.27*	*4.09*	*4.30*	*3.18*	*3.04*	*3.37*	*3.59*	*4.89*	*5.19*

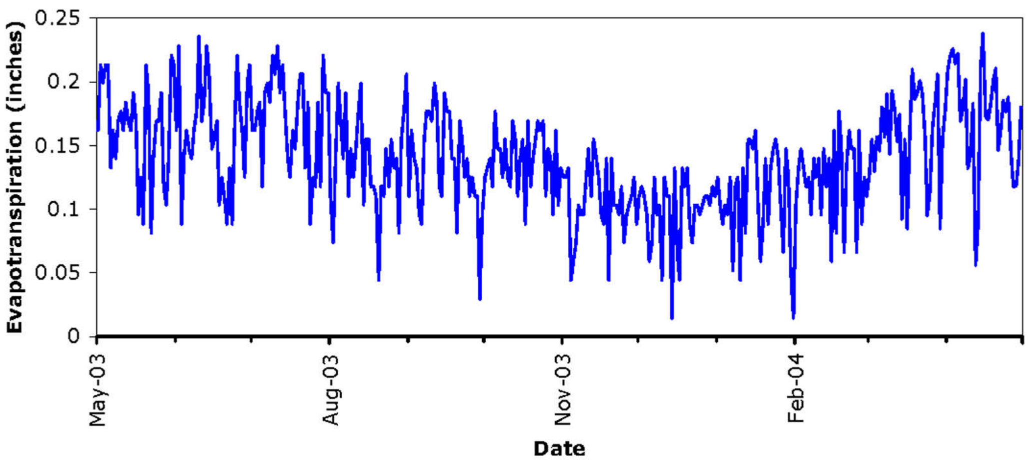

Figure C- 1. STA-5 Daily Evapotranspiration WY 2003-2004