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CHAPTER 3

SPECIFIC CONDUCTANCE IN THE EVERGLADES AGRICULTURAL AREA

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CHAPTER 3

Specific Conductance in the Everglades Agricultural Area

Data Update 2003

INTRODUCTION

In April of 1994 the Florida state legislature passed “The Everglades Forever Act” (EFA) which mandated: 1) the construction of six STAs encompassing 16,188 ha; 2) Everglades water supply and hydroperiod improvement and restoration; 3) an EAA research and monitoring program; 4) evaluation of water quality standards; 5) research and implementation of BMPs in the EAA; and 6) monitoring and control of exotic species (Florida Statute Section 373.4592, 1994). The research and implementation of BMPs component of the EFA required the South Florida Water Management District (SFWMD) “to conduct research in cooperation with the EAA landowners to identify water quality parameters that are not being significantly improved either by the STAs or the BMPs, and to identify further BMP strategies needed to address these parameters” (Florida Statute Section 373.4592, 1994).

In 1997 the SFWMD revised the Everglades Regulatory Program, Chapter 40E-63 in accordance with the EFA, to include a research/monitoring program to address concerns regarding particulate phosphorus (P), specific conductance, and concentrations of the pesticides Ametryn and Atrazine found in surface waters of the EAA. The UF/IFAS project began to monitor particulate P and specific conductance at three farm sites in early 1997. In 1998, ten project sites were equipped to monitor particulate P and specific conductance.

The objectives of this research are as stated by Chapter 40E-63, Part III: “the farm-scale research shall be expanded to include monitoring for specific conductance at all points where total P is currently being monitored. The expanded research program shall include the development, testing, and implementation of BMPs to address reduction of specific conductance.

A final report was issued about specific conductance in the EAA in March 2004 with data covering the period from 1997 to 2002 (Daroub et al., 2004). This current report will give an update of specific conductance data at the three currently monitoring farms in the EAA for the period of January 1 to December 31, 2003.

MATERIALS AND METHODS

Specific Conductance Monitoring Program in the EAA

A monitoring program was established in January 1997 to measure specific conductance in the EAA in accordance with Chapter 40E-63. Hydrolab DataSonde® (series 3, 4, 4a) multi-parameter water quality data loggers were used to measure and record specific conductance in situ. The DataSonde® units were also equipped to measure temperature, pH, dissolved oxygen, oxidation-reduction potential, depth, and turbidity. The DataSonde® units were calibrated according to instrument specifications and programmed for a six-day run (programmed to record a measurement every hour). The units were transported to the site canals and deployed at a depth of one meter beneath the canal water surface. After the DataSonde®’s programmed run ended, it was retrieved from the field. A freshly calibrated and programmed unit was then placed in the canal. A DataSonde® unit, which completed its six-day deployment, was brought back into the laboratory where the data were downloaded to a computer and stored in electronic format. A post-run assessment for drift of the instrument’s sensors was subsequently conducted. The instruments were then cleaned, maintained, and re-calibrated in the laboratory and returned to the field for deployment during the subsequent monitoring cycle. All field and laboratory activities strictly followed relevant Standard Operating Procedures and the National Environmental Laboratory Accreditation Program (NELAP) approved quality manual (Chen, 2001). Quality control criteria regarding sensor drift and biofouling were as follows: pH $< \pm 0.2$ at pH=7.0 check; specific conductance < ± 0.1 mS/cm at 1.413 mS/cm (0.01 M KCl); percent oxygen saturation < ± 7.0% at 100 % air saturation; redox < ± 20 mv of a pH 7.0 and quinhydrone solution; and turbidity < ± 8.0 NTU at 80 NTU check.

Site Descriptions and Farm Management Practices

In 2003, specific conductance was monitored at three farms (four discharge structures), UF9200A and UF9206A&B (since 1997), and UF9209A (since1998) in the EAA (Figure 3.1). All data used in this report are found in files on the accompanying CD. Following is a short description of each farm with the farm management practices employed.

UF9200A

Site UF9200A is a 1280-acre sugarcane farm located in the S-5A Sub-basin in the northern EAA. This farm started P load reduction BMP operations in January 1994. Beginning in early 1997, UF/IFAS began to monitor specific conductance at this farm. Up to December 2003, the project had acquired 84 months of specific conductance data on this farm.

The grower focused on reducing the amount of irrigation water being let into the farm. In the past this grower tended to irrigate frequently in his attempt to micro-manage water table levels. This micro-management led to increased drainage pumping and often involved pumps being switched directly from the irrigation to the drainage mode. The grower monitored farm drainage more closely, allowing at least one inch of rain to accumulate prior to pumping initiation. At the end of the drainage event, the grower allowed evapotranspiration to rid fields of at least one inch of water that would otherwise have been pumped off-farm. This was accomplished by turning the pumps off earlier and letting water tables redistribute.

UF9206A&B

Site UF9206A&B is a 1754-acre mixed-crop farm located in the S-5A Sub-basin in the eastern EAA. The farm started P load reduction BMP operations in May 1994. The UF/IFAS began monitoring specific conductance in early 1997 on this farm. Up to December 2003, the project had acquired approximately 84 months of specific conductance data at this farm.

The grower installed a sophisticated hydraulic system with culverts, risers, and pumps placed strategically throughout the farm. The grower has partitioned the farm into multiple hydraulic units. Water can be moved from any production block into one of the other hydraulic units for temporary storage, irrigation, or drainage. Rice was also grown on the land during the summer season. This greatly reduces the need for off-farm pumping for much of the wet season. During minor to moderate rainfall events in the wet season, sugarcane field and sod field drainage waters can be diverted to adjacent rice fields instead of being pumped directly off-farm. Virtually every field ditch has an operable riser and board structure allowing for maximum water control, uniform drainage, and the utilization of the longest paths for routing water to the main pump stations.

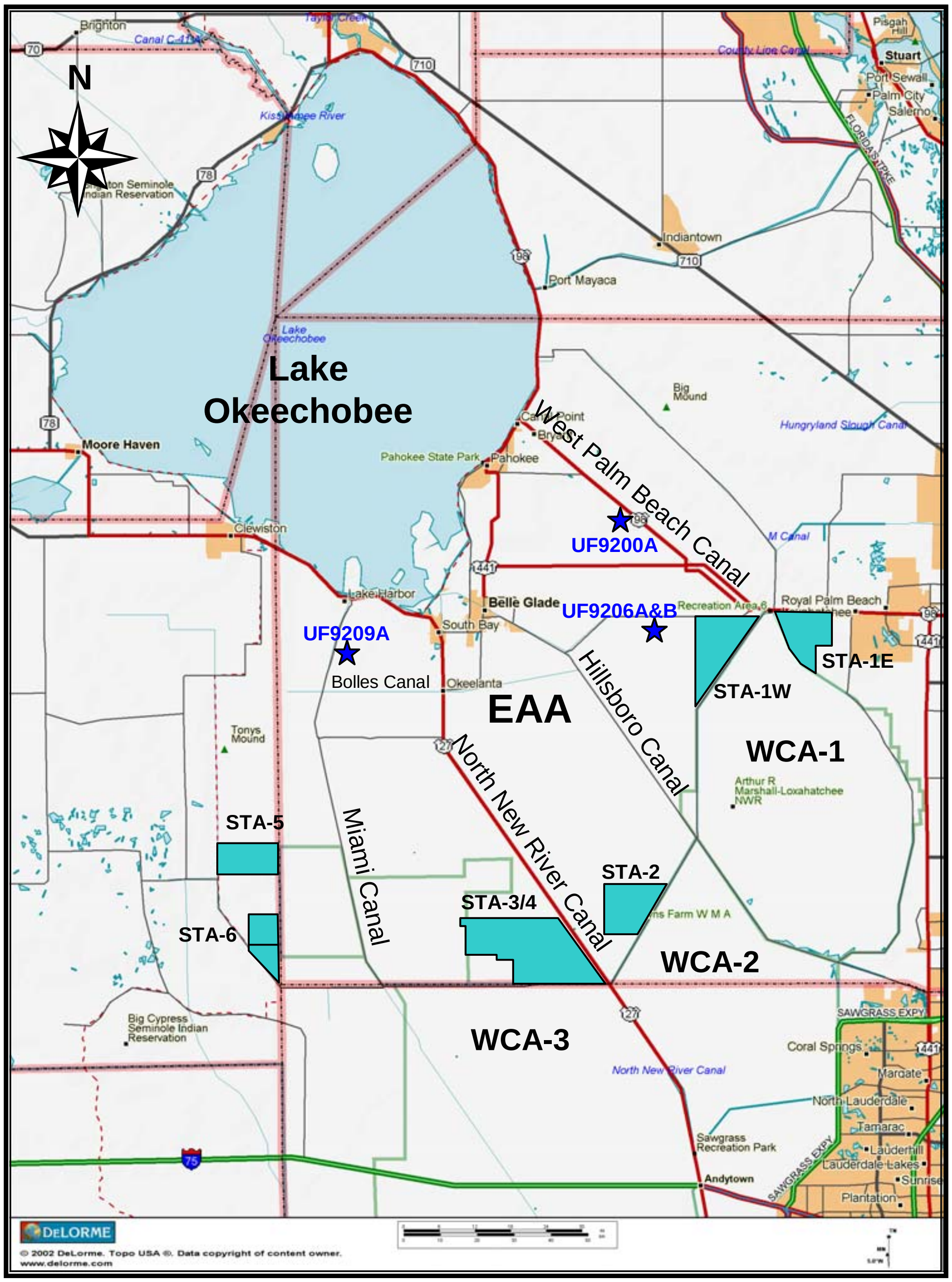
UF9209A

Site UF9209A is a 3072-acre sugarcane monoculture farm located in the S-8 Sub-basin in the western EAA. The farm began P load reduction BMP operations in May 1994. Monitoring of specific conductance started in January 1998. Up to December 2003, the project had acquired 73 months of specific conductance data on this farm. The grower adopted enhanced pump operation strategy. The program uses established upper and lower main canal stages (measured at the main pump station and at the geographic farm center) that serve as criteria for pump operations. An internal booster pump was installed approximately two-thirds of the way down the length of the main farm canal to block the farm into two hydraulic units.

Statistical Data Analysis

Histogram analyses and goodness-of-fit tests were conducted to check the distribution patterns of specific conductance and other parameters measured (Gilbert, 1987). Summary statistics were conducted using UNIVARIATE and ANOVA procedures to assess significant differences between different parameters (SAS Institute, 1982).

Figure 3.1. Specific Conductance Monitoring Sites (UF9200A, UF9206A&B, UF9209A) in 2003.



RESULTS

General Characteristics of Specific Conductance in the EAA

Summary statistics of specific conductance in canal water at the four pump structures in the EAA based on hourly data in 2003 are presented in Table 3.1. Specific conductance varied from 0.15 to 2.37 mS/cm at UF 9200A, averaging 0.93 mS/cm, as the same level as that at UF9209A, which varied from 0.42 to 1.36 mS/cm. The greatest mean specific conductance was observed at UF9206B (1.71 mS/cm). The second greatest mean specific conductance was observed at UF9206A (1.48 mS/cm) (Table 3.1). Specific conductance at both UF9206A and UF9206B continue to show averages above 1.275 mS/cm, as we have reported in our earlier report (Daroub et al., 2004). Historical data showed shallow ground water quality plays a major role in the elevated specific conductance at the two pump structures.

Monthly averages of specific conductance in 2003 at the three farms (four discharge structures) are presented in Table 3.2. Monthly variations in mean specific conductance at the four pump structures were significantly different ($p=0.05$), decreasing in the following order (in mS/cm): October (1.47), September (1.46) > July (1.40) > August (1.36) > June (1.29) > November (1.23) > December (1.13) > March (1.10) > February (1.04) > January (1.01) > April (0.97) > May (0.97). This is consistent with the overall monthly trend of specific conductance in canal water of EAA farms during 1997-2002 (Daroub et al., 2004).

Summary statistics of specific conductance in canal water at the four pump structures in 2003 averages are presented in Appendix 3.A (daily average) and 3.B (monthly average). Daily averages of specific conductance at each pump structures are presented in Figure 3.2 (UF9200A), Figure 3.3 (UF9206A), Figure 3.4 (UF9206B), and Figure 3.5 (UF9209A). UF9206B has some gaps in specific conductance data due to low canal levels occasionally so a measurement could not be taken (Figure 3.4).

Table 3.1. Summary Statistics of Specific Conductance (mS/cm) in Canal Water at Four Pump Structures in the EAA in 2003

Site	N	Range	Median	Minimum	Maximum	Lower 90% CL for Mean	Upper 90% CL for Mean	Std Dev	Mean	Significant
		…………………..….……..………………….mS/cm……………………..……………………..								
UF9200A	6832	2.22	0.90	0.15	2.37	0.92	0.93	0.45	0.93	C
UF9206A	6678	1.75	1.58	0.34	2.09	1.48	1.49	0.38	1.48	B
UF9206B	4068	2.12	1.79	0.44	2.56	1.70	1.72	0.31	1.71	A
UF9209A	7088	0.94	1.00	0.42	1.36	0.92	0.93	0.23	0.93	C

.

Table 3.2. Monthly Variation in Mean Specific Conductance (mS/cm) of Canal Water at Four Pump Structures in the EAA in 2003

Month	N	Range	Median	Minimum	Maximum	Lower 90% CL for Mean	Upper 90% CL for Mean	Std Dev	Mean	Significant
		………………..…………..……………………….mS/cm………………….…..………………………..								
Jan-03	1682	2.110	1.020	0.450	2.560	0.990	1.030	0.470	1.010	I
Feb-03	2148	1.520	0.990	0.460	1.980	1.030	1.060	0.450	1.040	H
Mar-03	2096	1.520	1.010	0.440	1.960	1.090	1.110	0.400	1.100	G
Apr-03	1910	1.550	0.970	0.420	1.970	0.950	0.980	0.470	0.970	J
May-03	2168	1.680	0.800	0.340	2.020	0.910	0.950	0.500	0.930	K
Jun-03	2367	1.610	1.190	0.630	2.230	1.270	1.300	0.360	1.290	D
Jul-03	2390	1.700	1.470	0.370	2.070	1.390	1.410	0.340	1.400	B
Aug-03	1773	2.000	1.250	0.330	2.330	1.350	1.380	0.330	1.360	C
Sep-03	1942	1.570	1.560	0.520	2.090	1.450	1.480	0.340	1.460	A
Oct-03	2364	1.980	1.760	0.390	2.370	1.450	1.490	0.520	1.470	A
Nov-03	2018	1.930	1.300	0.180	2.110	1.210	1.250	0.520	1.230	E
Dec-03	1808	2.240	0.970	0.150	2.390	1.110	1.150	0.540	1.130	F

Figure 3.2. Daily Average of Specific Conductance in EAA Farm Canal at UF9200A in 2003

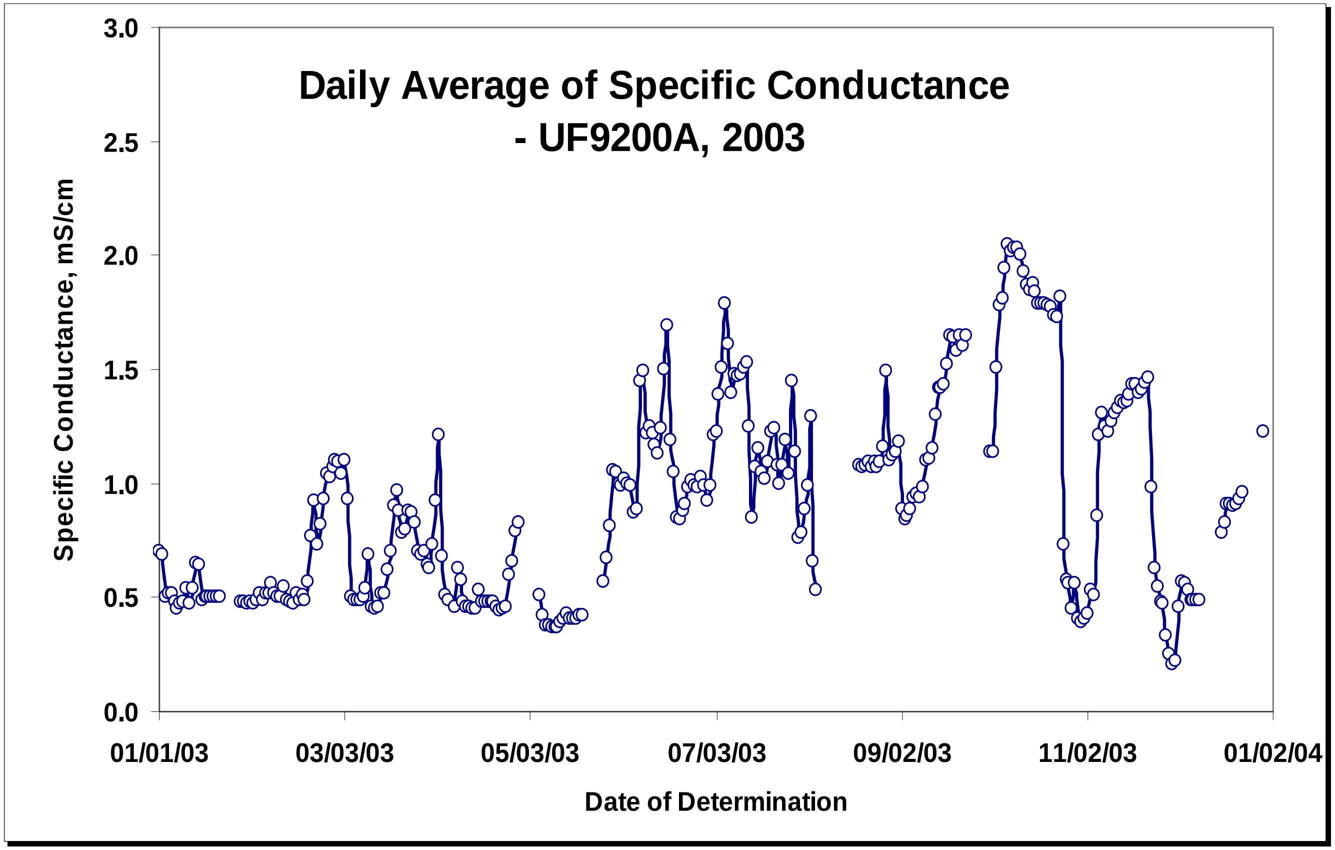


Figure 3.3. Daily Average of Specific Conductance in EAA Farm Canal at UF9206A in 2003

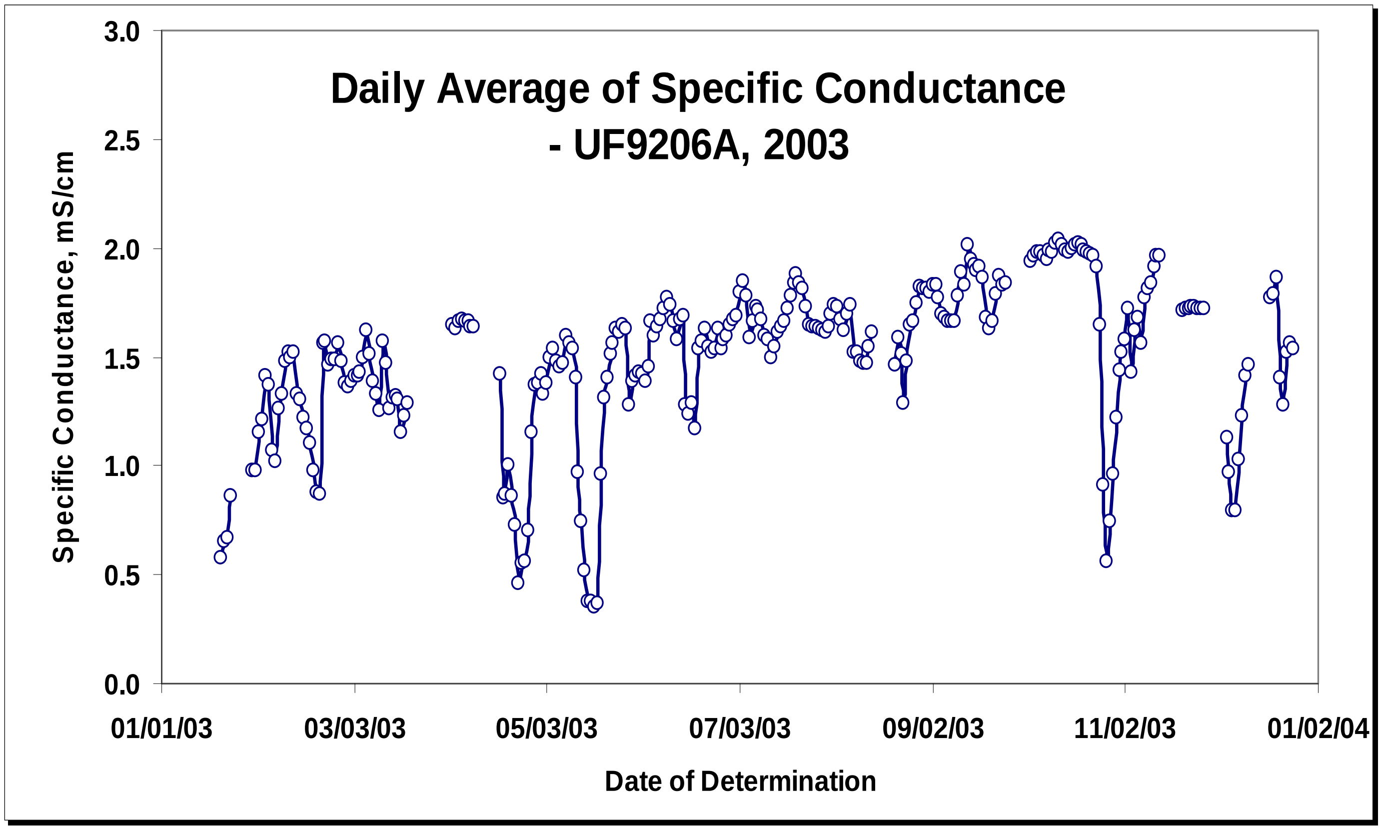


Figure 3.4. Daily Average of Specific Conductance in EAA Farm Canal at UF9206B in 2003

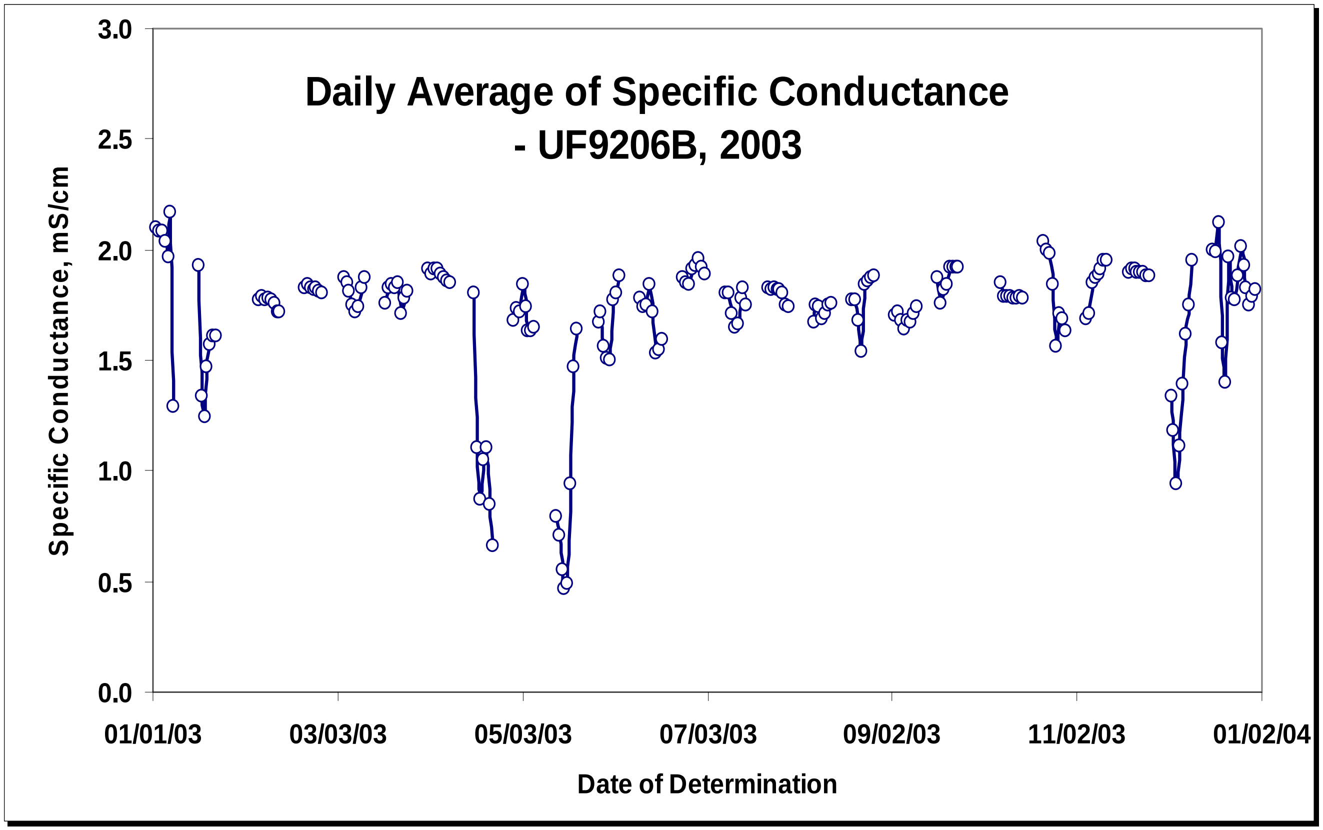
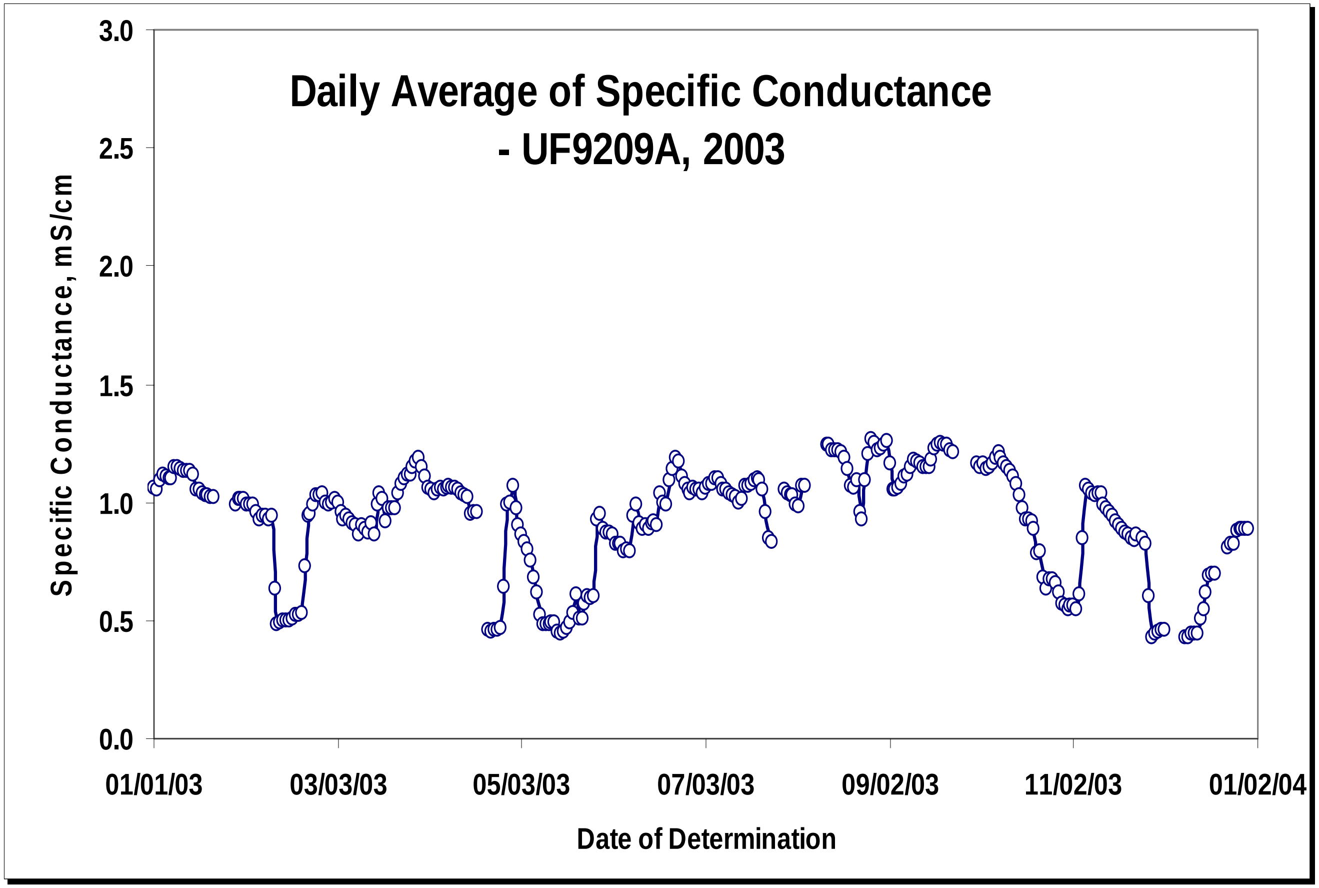


Figure 3.5. Daily Average of Specific Conductance in EAA Farm Canal at UF9209A in 2003



Hourly averages of specific conductance in canal water at four pump structures in the EAA in 2003 are presented at Appendix 3.C. Overall variations in mean specific conductance of the 24 hours' data within a day at each pump structure in the EAA is presented in Table 3.3. No significant differences were found in the mean specific conductance at different recording time during a day (Table 3.3).

Potential Sources of Specific Conductance in the EAA

The March 2004 specific conductance report had outlined a picture for potential sources of specific conductance in canal waters in the EAA: specific conductance is strongly influenced by the composition of the shallow ground water and the irrigation water, the effect of fertilizer application is negligible and that of drainage pumping is variable and site specific for the ten farms monitored (Daroub et al., 2004). In this report, effects of ambient conditions, irrigation, and drainage pumping on specific conductance at three representative farms (four pumping structures UF9200A, UF9206A&B, and UF9209A) were analyzed to determine if there were specific management practices that affect specific conductance (Table 3.4).

Drainage pumping had no significant effect on specific conductance, while irrigation reduced the overall specific conductance at the four pumping structures (Table 3.4). Specific conductance was significantly lower during irrigation than during drainage pumping, or ambient conditions at UF9206A&B and UF9209A. This is consistent with results in our previous report that the addition of irrigation water decreased specific conductance in EAA farm canals (Daroub et al., 2004). Our study also indicated that sites that have received irrigation water directly from low specific conductance district canals (Miami, and West Palm Beach canals) had lower specific conductance. Sites that received irrigation water from district canals with relatively higher specific conductance (Ocean and Hillsboro canals) had relatively higher specific conductance (Daroub et al., 2004).

To illustrate the effects of drainage pumping on specific conductance at the three farms (four structures), graphs of rainfall, specific conductance observations and cumulative drainage volume over time were plotted (Figure 3.6 – Figure 3.9). The drainage event chosen for structure UF9200A occurred in November 2003 (Figure 3.6). Drainage pumping was initiated after rainfall occurred on the 5th and 6th of November. As drainage volume decreased, specific conductance increased.

The drainage event chosen for structure UF9206A occurred in March 2003 (Figure 3.7). Drainage pumping was initiated after a rainfall of approximately 1.6 inch had occurred on the 13th of March and again on the 16th of March. Specific conductance did not change much during the first pumping event while decreased slightly as the drainage volume increased, once pumping ceased specific conductance at UF9206A returned to pre-pumping level (Figure 3.7).

The drainage event chosen for structure UF9206B also occurred in March 2003 (Figure 3.8). Drainage pumping was initiated after a heavy rainfall of approximately 3.1 inch had occurred within four hours on the 27th of March. Specific conductance prior to drainage initiation was ~ 1.75 mS/cm. As drainage pumping proceeded, specific conductance decreased, probably due to dilution effect from the rainfall. Once pumping ceased, however, specific conductance at UF9206B returned to pre-pumping level (Figure 3.8).

The drainage events chosen for structure UF9209A occurred in June 2003 (Figure 3.9). Drainage pumping was initiated after a rainfall of approximately one inch had occurred on the 20th of June. Specific conductance prior to drainage initiation was ~ 1.00 mS/cm. As drainage volume decreased, specific conductance increased slightly (Figure 3.9).

This again illustrates very clearly the conclusions we previously had, that effect of drainage pumping on specific conductance is variable and site specific.

Table 3.3. Hourly Variation of Mean Specific Conductance (mS/cm) in Canal Water at Four Pump Structures in the EAA in 2003

Time	N	Range	Median	Minimum	Maximum	Lower 90% CL for Mean	Upper 90% CL for Mean	Std Dev	Mean	Significant
		………………….…….……..…………….mS/cm…………………….….…………………..								
0:00	1072	1.98	1.14	0.20	2.18	1.18	1.23	0.48	1.21	A
1:00	1073	1.93	1.14	0.19	2.12	1.18	1.23	0.48	1.21	A
2:00	1071	1.87	1.15	0.21	2.08	1.19	1.23	0.48	1.21	A
3:00	1072	1.91	1.14	0.20	2.11	1.18	1.23	0.48	1.21	A
4:00	1070	2.07	1.14	0.21	2.28	1.18	1.23	0.48	1.21	A
5:00	1070	2.14	1.14	0.19	2.33	1.18	1.23	0.48	1.21	A
6:00	1070	2.15	1.14	0.17	2.32	1.18	1.23	0.48	1.21	A
7:00	1070	2.14	1.14	0.17	2.31	1.18	1.23	0.48	1.21	A
8:00	1070	2.00	1.14	0.17	2.17	1.18	1.23	0.48	1.20	A
9:00	916	1.95	1.14	0.17	2.12	1.17	1.23	0.48	1.20	A
10:00	918	2.15	1.14	0.18	2.33	1.17	1.23	0.48	1.20	A
11:00	919	2.16	1.13	0.18	2.34	1.17	1.22	0.48	1.20	A
12:00	920	2.20	1.13	0.16	2.36	1.18	1.23	0.48	1.20	A
13:00	922	2.22	1.13	0.15	2.37	1.18	1.23	0.48	1.20	A
14:00	927	2.24	1.13	0.15	2.39	1.17	1.23	0.48	1.20	A
15:00	926	2.07	1.13	0.20	2.27	1.18	1.23	0.48	1.20	A
16:00	1065	2.12	1.14	0.21	2.33	1.18	1.23	0.48	1.21	A
17:00	1068	2.09	1.14	0.22	2.30	1.19	1.23	0.48	1.21	A
18:00	1072	2.27	1.14	0.18	2.45	1.19	1.23	0.49	1.21	A
19:00	1075	2.36	1.14	0.20	2.56	1.19	1.23	0.48	1.21	A
20:00	1075	2.34	1.14	0.19	2.53	1.19	1.23	0.48	1.21	A
21:00	1076	2.19	1.14	0.19	2.38	1.19	1.23	0.48	1.21	A
22:00	1075	2.05	1.14	0.20	2.25	1.19	1.23	0.48	1.21	A
23:00	1074	1.98	1.14	0.19	2.17	1.18	1.23	0.48	1.21	A

Table 3.4. Statistical Summary of the Effects of Ambient Conditions, Pumping, and Irrigation on Mean Specific Conductance (mS/cm) in Canal Water at Four Pump Structures in the EAA in 2003

Wate management practives	No. of Observation	Statistical summary (Specific conductance, mS/cm)						Significance	
		Range	Median	Minimum	Maximum	Std Dev	Mean	Difference	Pr.>F
Site = UF9200A									
Ambient	270	1.83	0.89	0.22	2.05	0.45	0.92	A	0.3087
Pump	68	1.38	0.91	0.46	1.84	0.30	0.97	A	
Irrigation	25	1.66	0.51	0.21	1.87	0.50	0.80	A	
Site = UF9206A									
Ambient	247	1.69	1.63	0.35	2.04	0.33	1.56	A	<0.0001
Pump	69	1.57	1.46	0.37	1.94	0.33	1.43	A	
Irrigation	42	1.61	1.41	0.38	1.99	0.45	1.28	B	
Site = UF9206B									
Ambient	242	1.65	1.81	0.47	2.12	0.22	1.78	A	<0.0001
Pump	81	1.51	1.71	0.49	2.00	0.27	1.65	A	
Irrigation	40	1.62	1.62	0.55	2.17	0.48	1.42	B	
Site = UF9209A									
Ambient	288	0.82	0.99	0.43	1.25	0.23	0.91	A	<0.0001
Pump	60	0.67	1.06	0.60	1.27	0.16	1.02	A	
Irrigation	17	0.69	0.63	0.45	1.14	0.26	0.73	B	
All sites (UF9200A, UF9206A&B, UF9209A)									
Ambient	1047	1.90	1.13	0.22	2.12	0.49	1.21	A	0.05
Pump	278	1.63	1.21	0.37	2.00	0.39	1.25	A	
Irrigation	124	1.96	1.12	0.21	2.17	0.52	1.10	B	

Figure 3.6. Hourly Specific Conductance, Rain, and Flow Plotted against Time at Pump Structure UF9200A

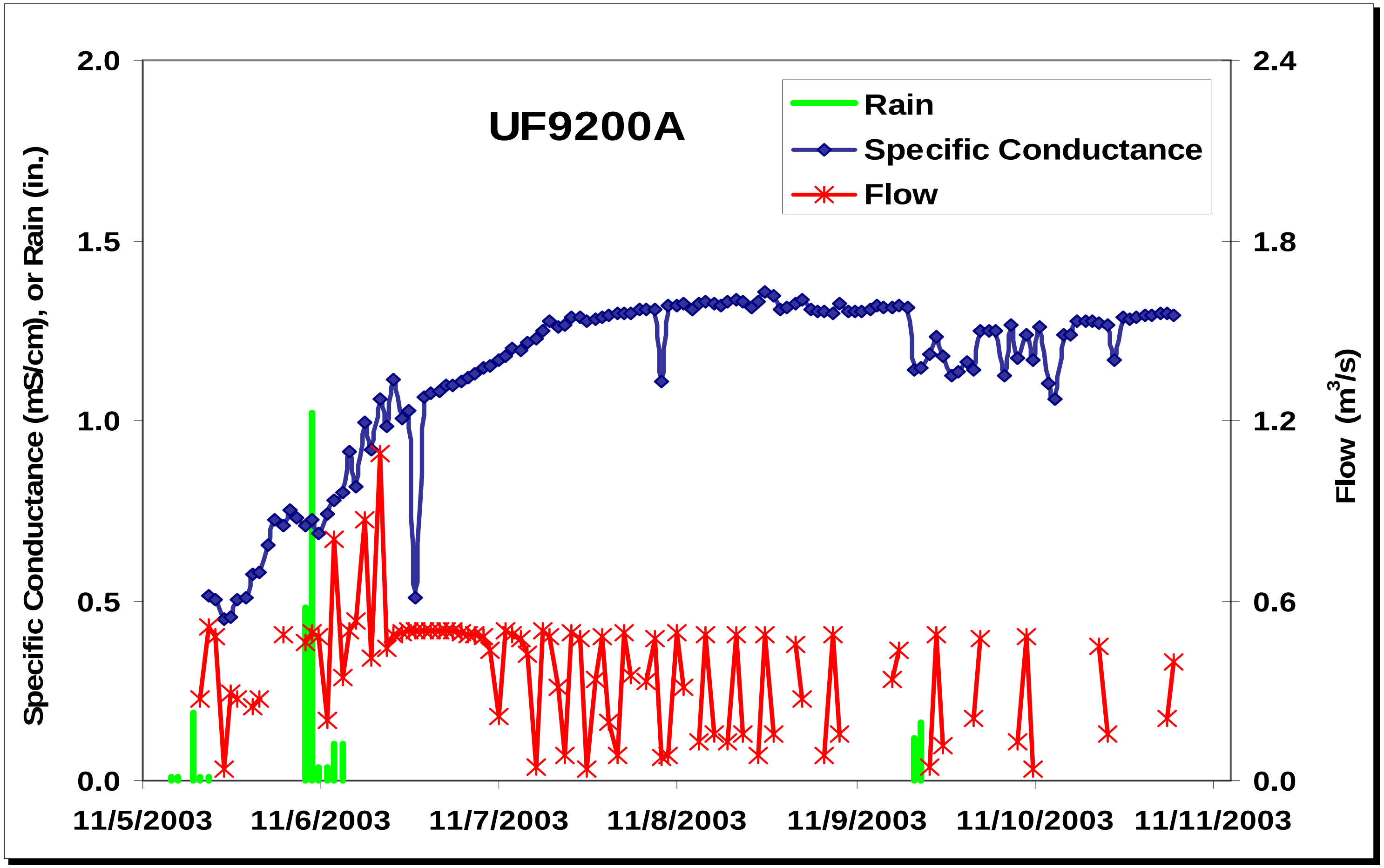


Figure 3.7. Hourly Specific Conductance, Rain, and Flow Plotted against Time at Pump Structure UF9206A

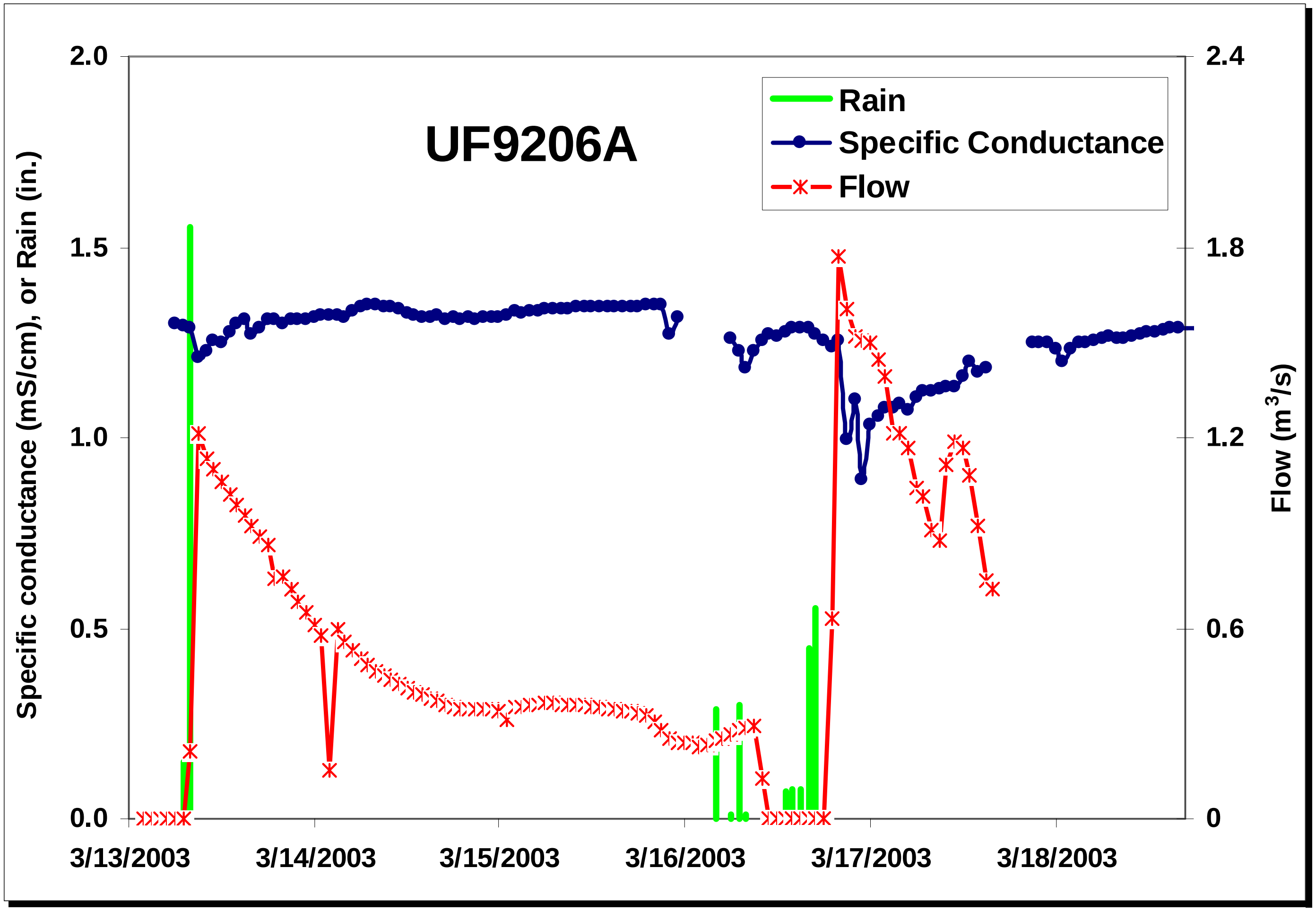


Figure 3.8. Hourly Specific Conductance, Rain, and Flow Plotted against Time at Pump Structure UF9206B

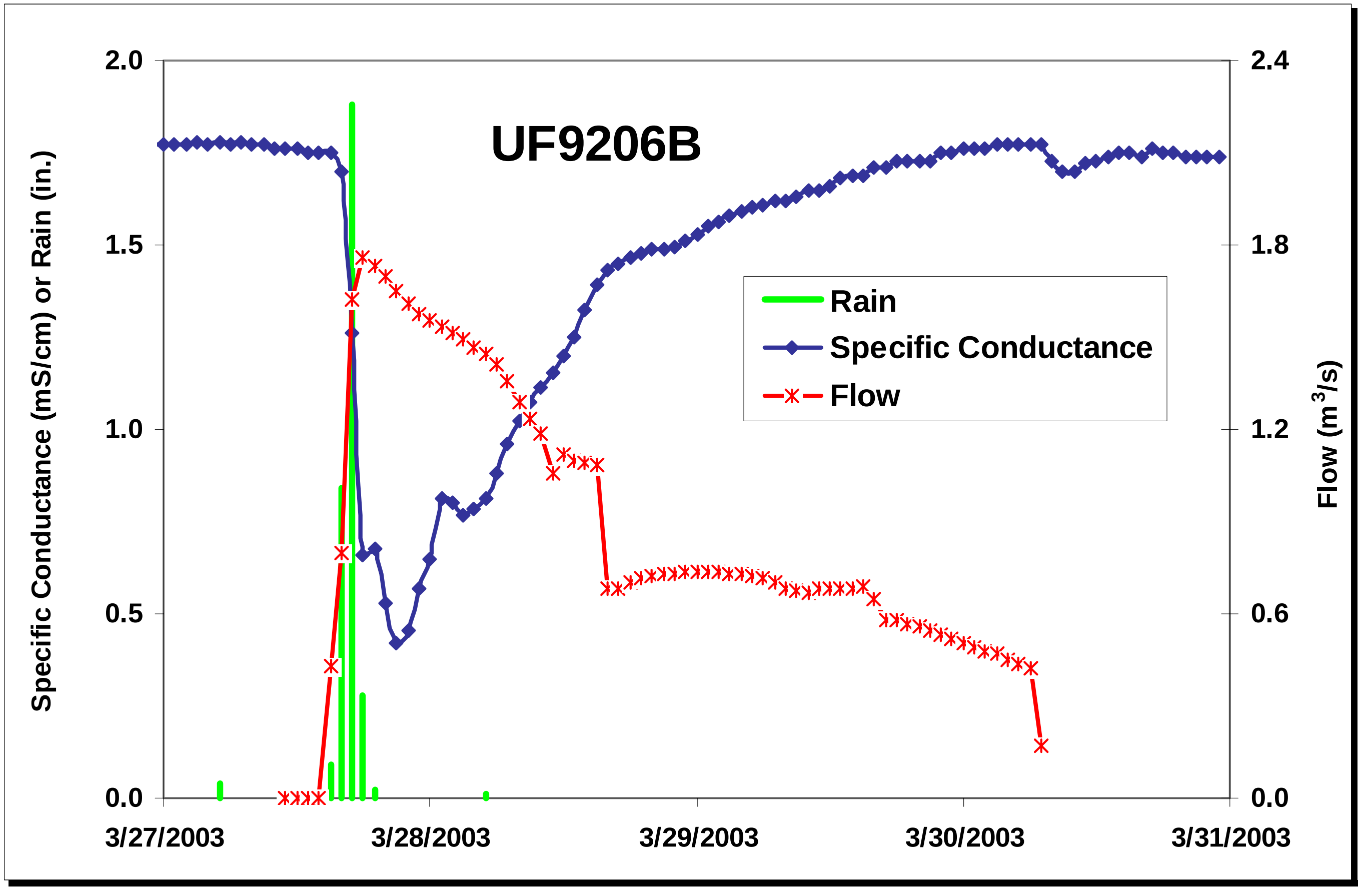
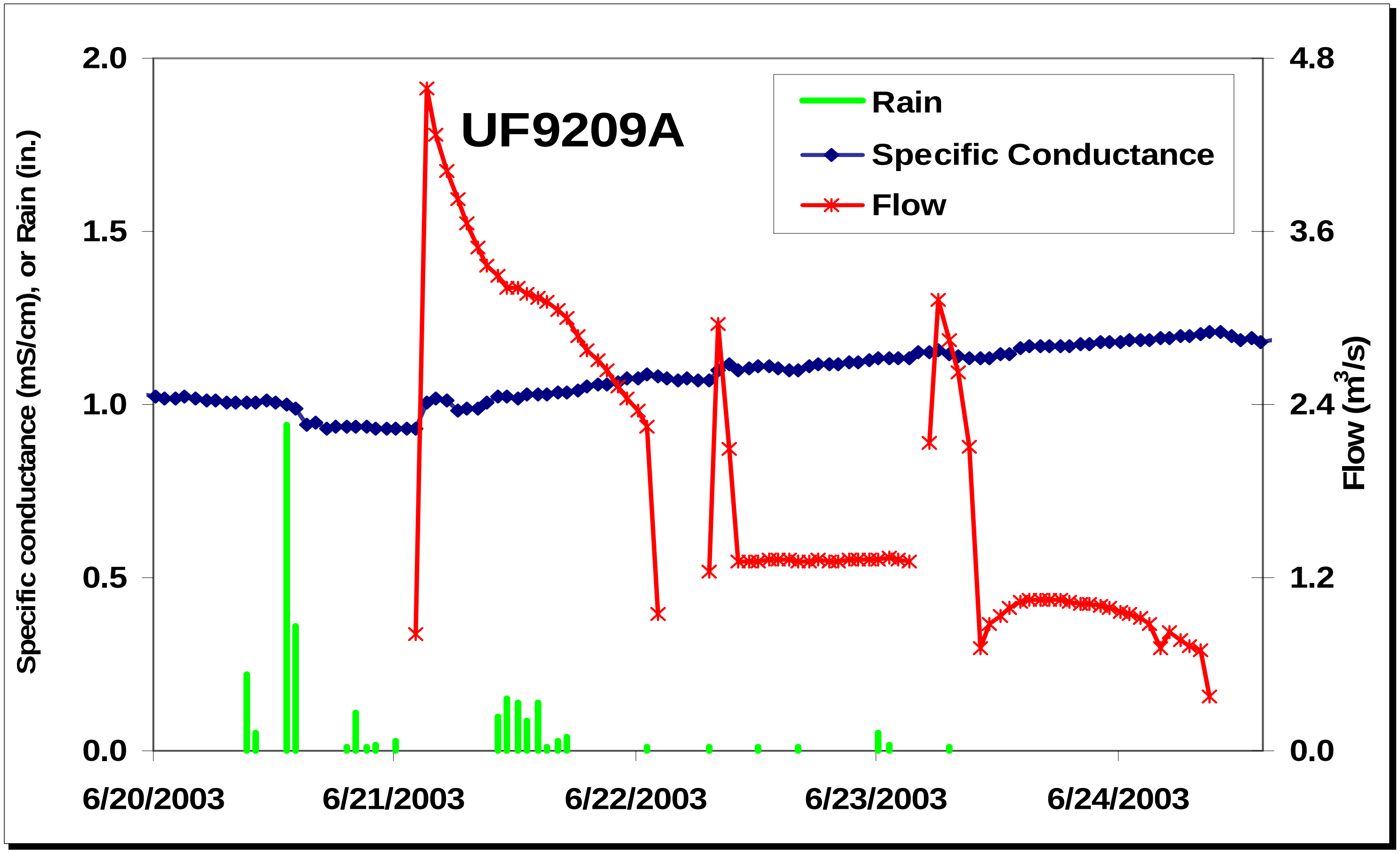


Figure 3.9. Hourly Specific Conductance, Rain, and Flow Plotted against Time at Pump Structure UF9209A



Trends of Specific Conductance in the EAA

Water quality data possess unique characteristics that may exhibit seasonal variation, which may include a seasonal fluctuant, as well as a yearly trend. This variation may be the result of a diversity of conditions, including specific agricultural land use practices, biological activity, or sources of stream flow or sediment (Lietz, 2000).

In the March 2004 specific conductance report, we demonstrated that, in general, there was a monthly trend for the ten monitored EAA farms, however, no site-specific analysis was conducted for these individual farms (Daroub et al., 2004). In this report, monthly trends were plotted with time to visually show the variations of specific conductance for the three currently monitored farms (UF9200A, UF9206A&B, and UF9209A) in 2003 (Figures 3.10 – 3.13). Two pumping structures, UF9200A (Figure 3.10) and UF9206A (Figure 3.11), showed an upward monthly trend from January to November of the year, whereas two pumping structures, UF9206B (Figure 3.12) and UF9209A (Figure 3.13), had no monthly trends.

In the March 2004 specific conductance report, we also demonstrated that there was no significant yearly trend for the three extensively monitored farms (UF9200A, UF9206A&B, and UF9209A) (Daroub et al., 2004). In this report, yearly trends were plotted using monthly average data with time to visually show the variations of specific conductance during the time period of 1997-2003 (Figures 3.14 – 3.17). The figures indicate that specific conductance at all three farms (UF9200A, UF9206A&B, and UF9209A) have no obvious upward or downward trends due to the variability of the data.

Figure 3.10. Monthly Variation of Specific Conductance in EAA Farm Canal at UF9200A in 2003

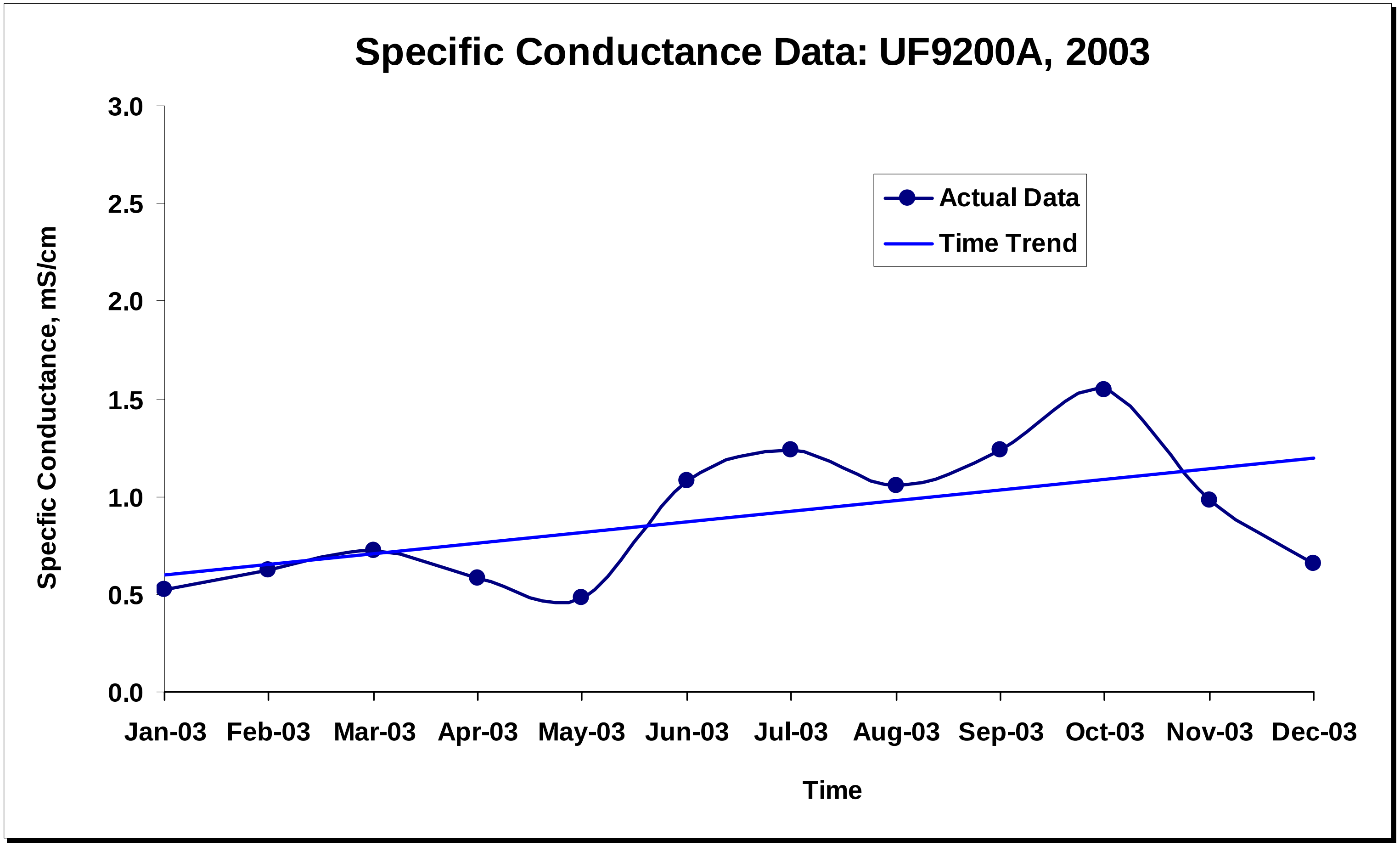


Figure 3.11. Monthly Variation of Specific Conductance in EAA Farm Canal at UF9206A in 2003

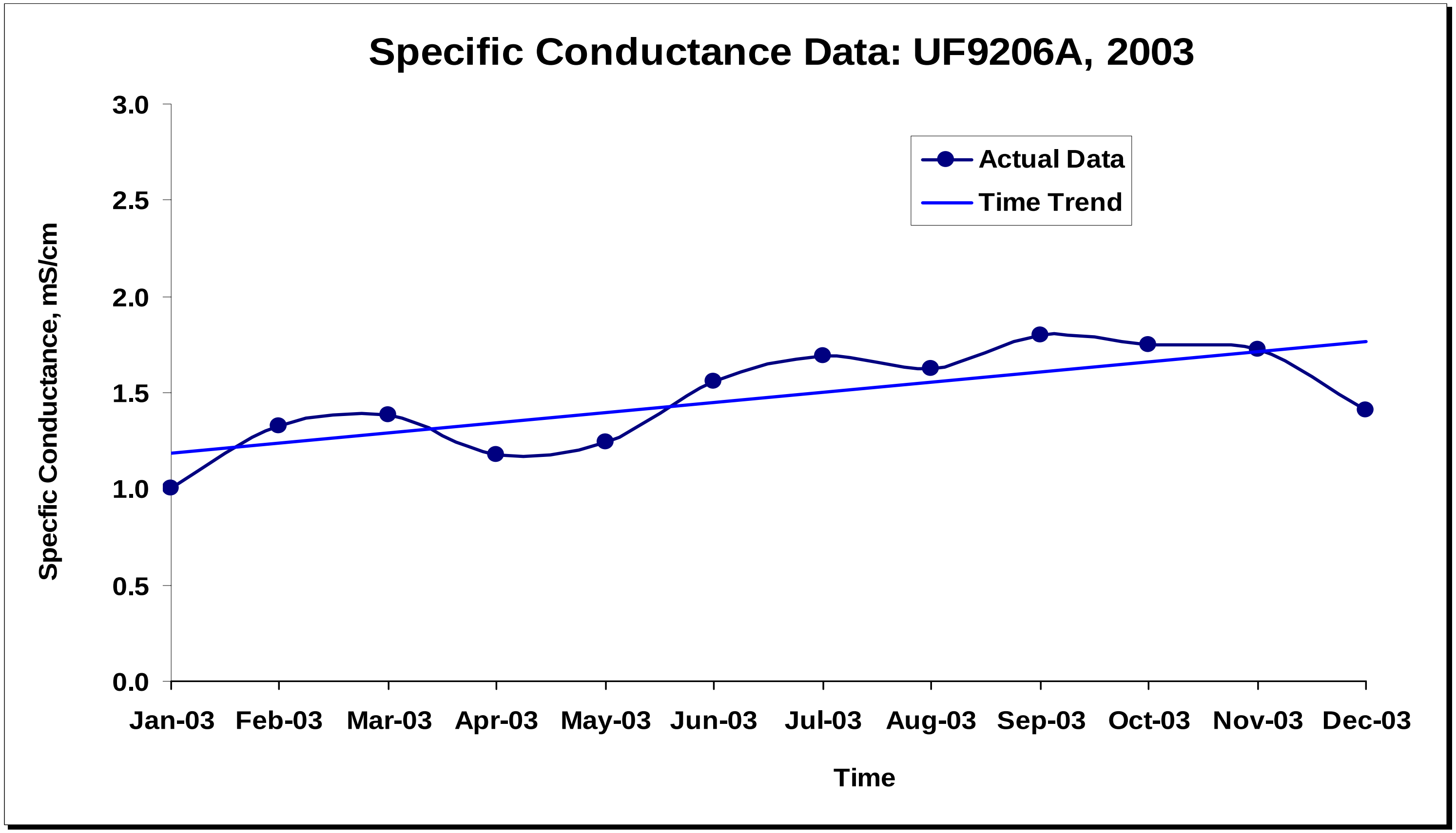


Figure 3.12. Monthly Variation of Specific Conductance in EAA Farm Canal at UF9206B in 2003

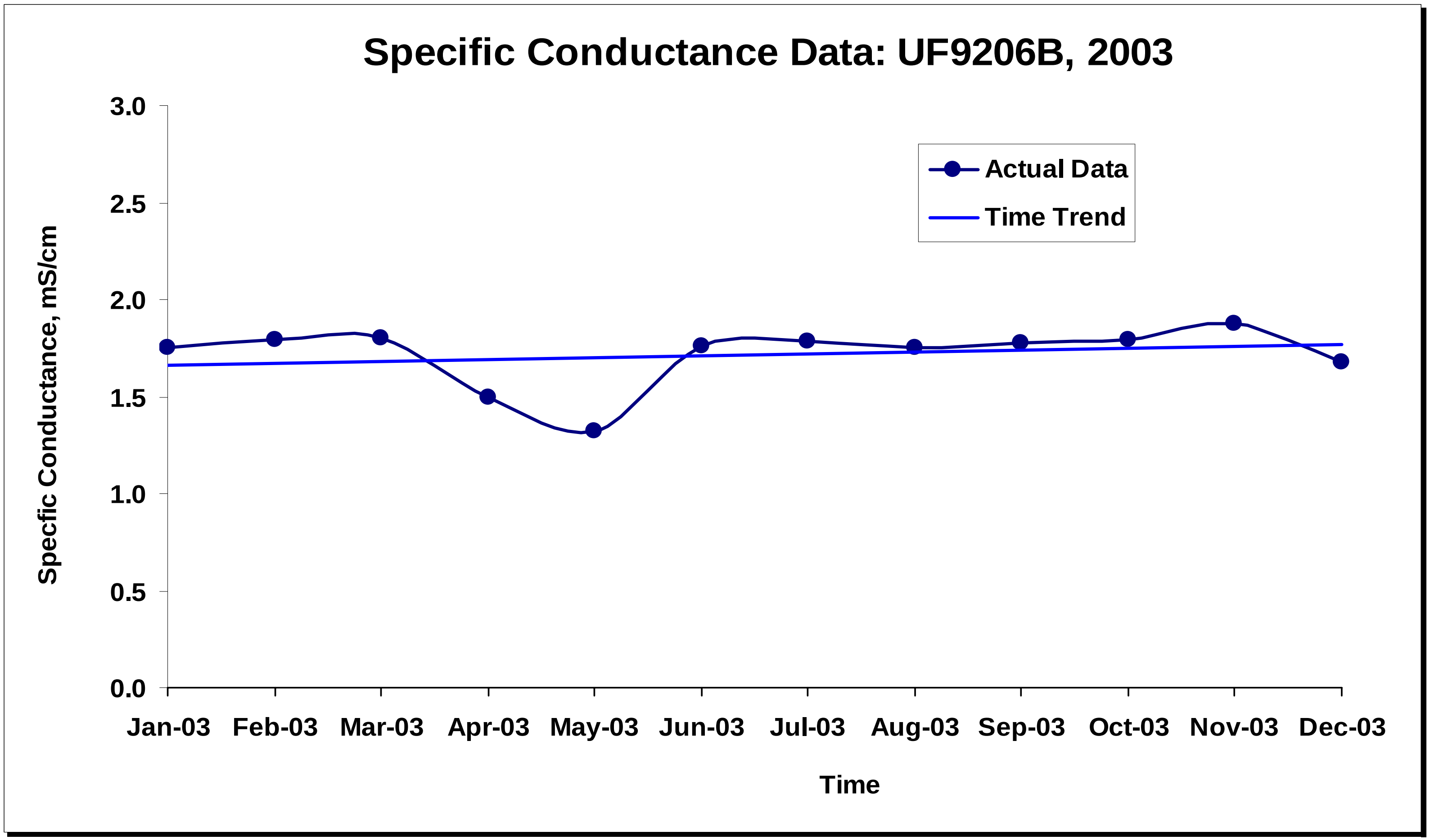


Figure 3.13. Monthly Variation of Specific Conductance in EAA Farm Canal at UF9209A in 2003

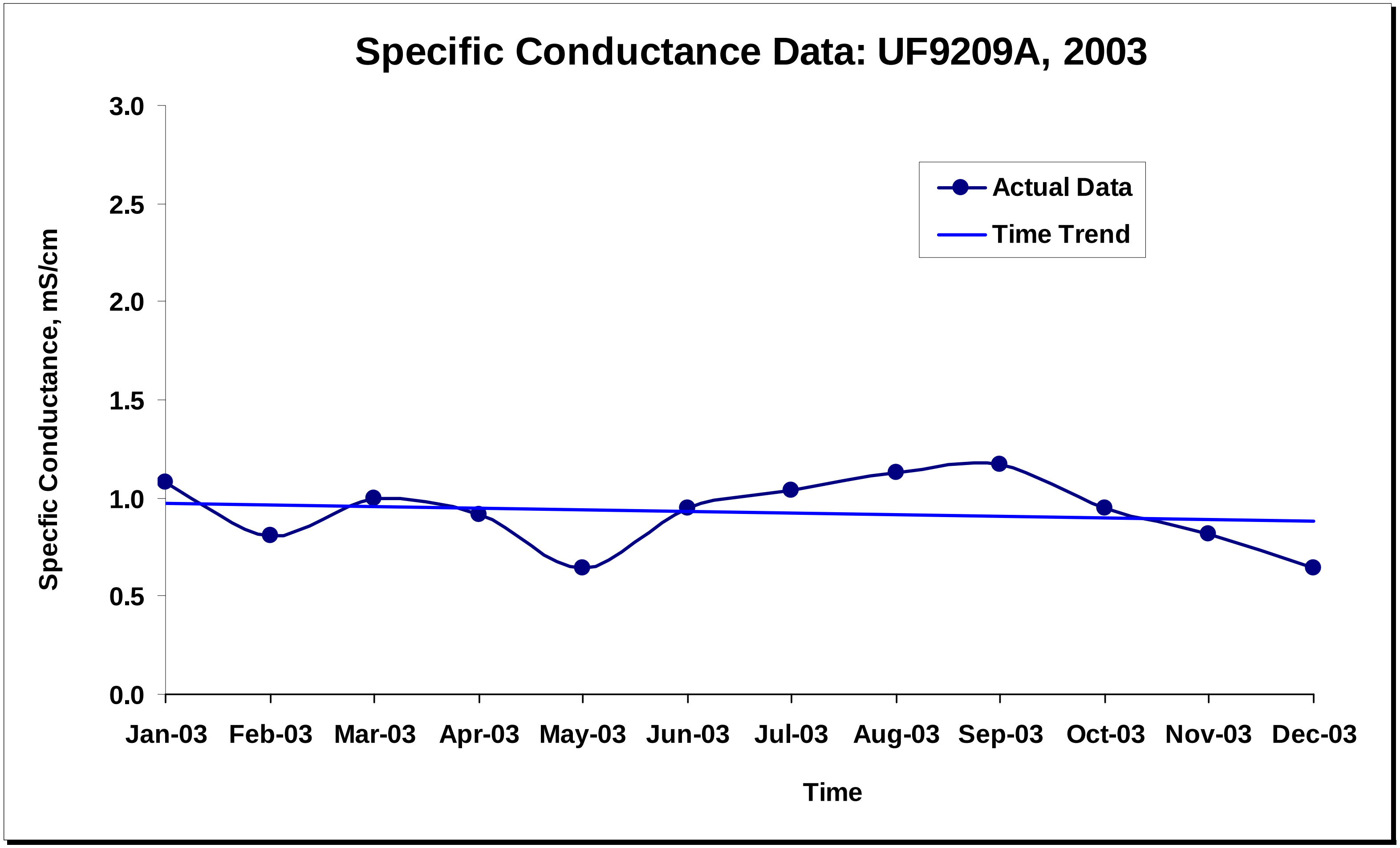


Figure 3.14. Time Trend of Specific Conductance at UF9200A during 1997-2003

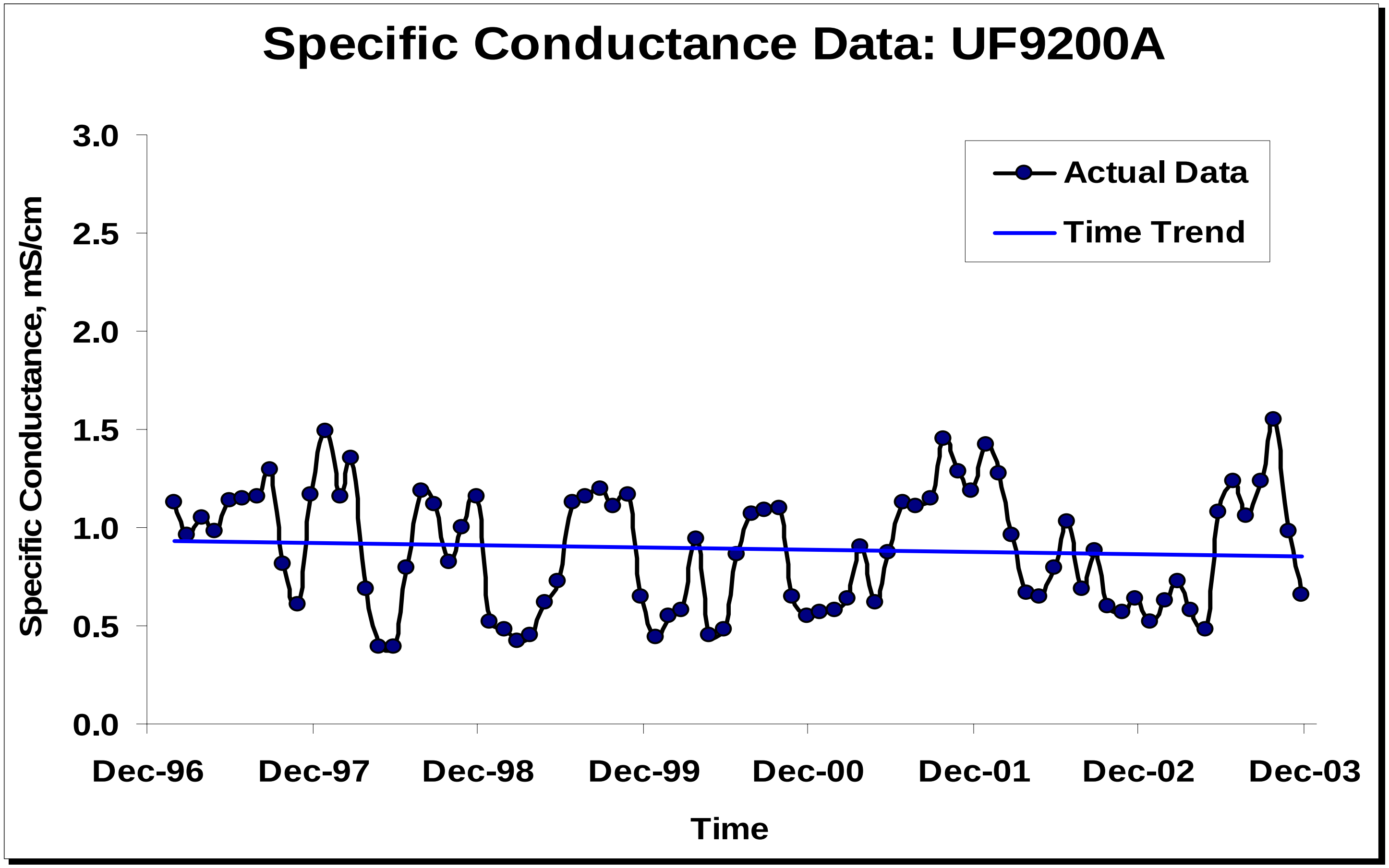


Figure 3.15. Time Trend of Specific Conductance at UF9206A during 1997-2003

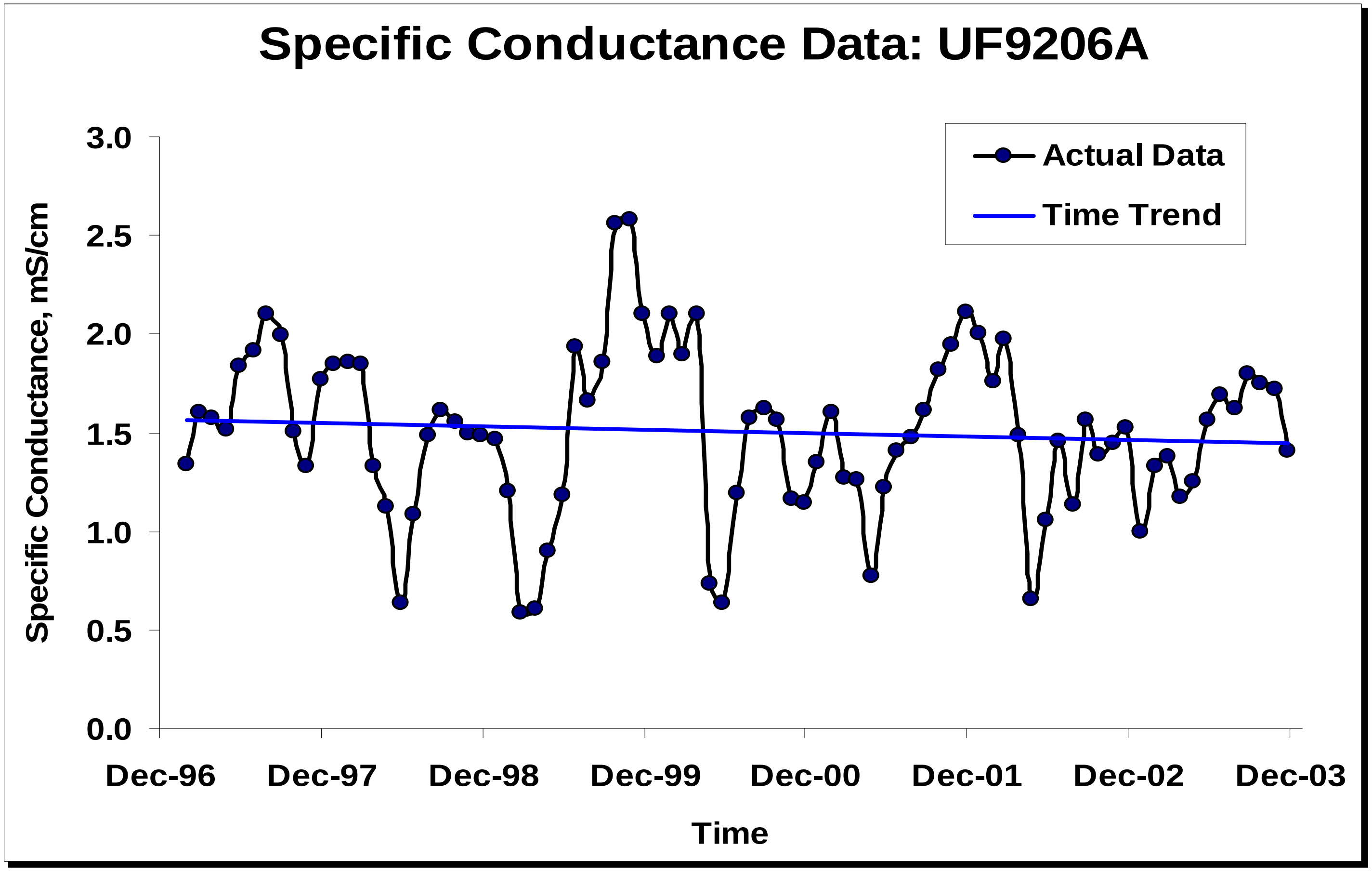


Figure 3.16. Time Trend of Specific Conductance at UF9206B during 1997-2003

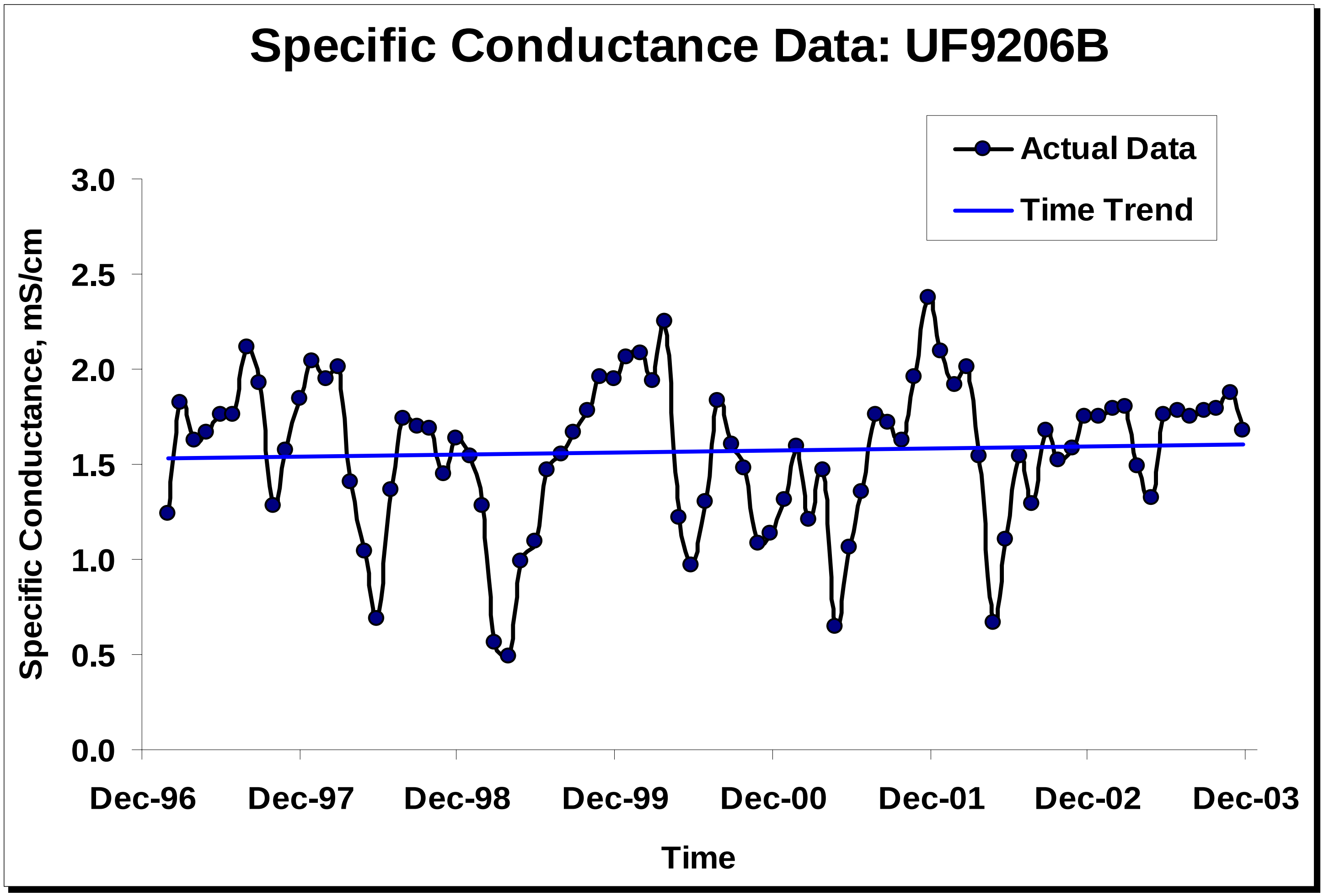
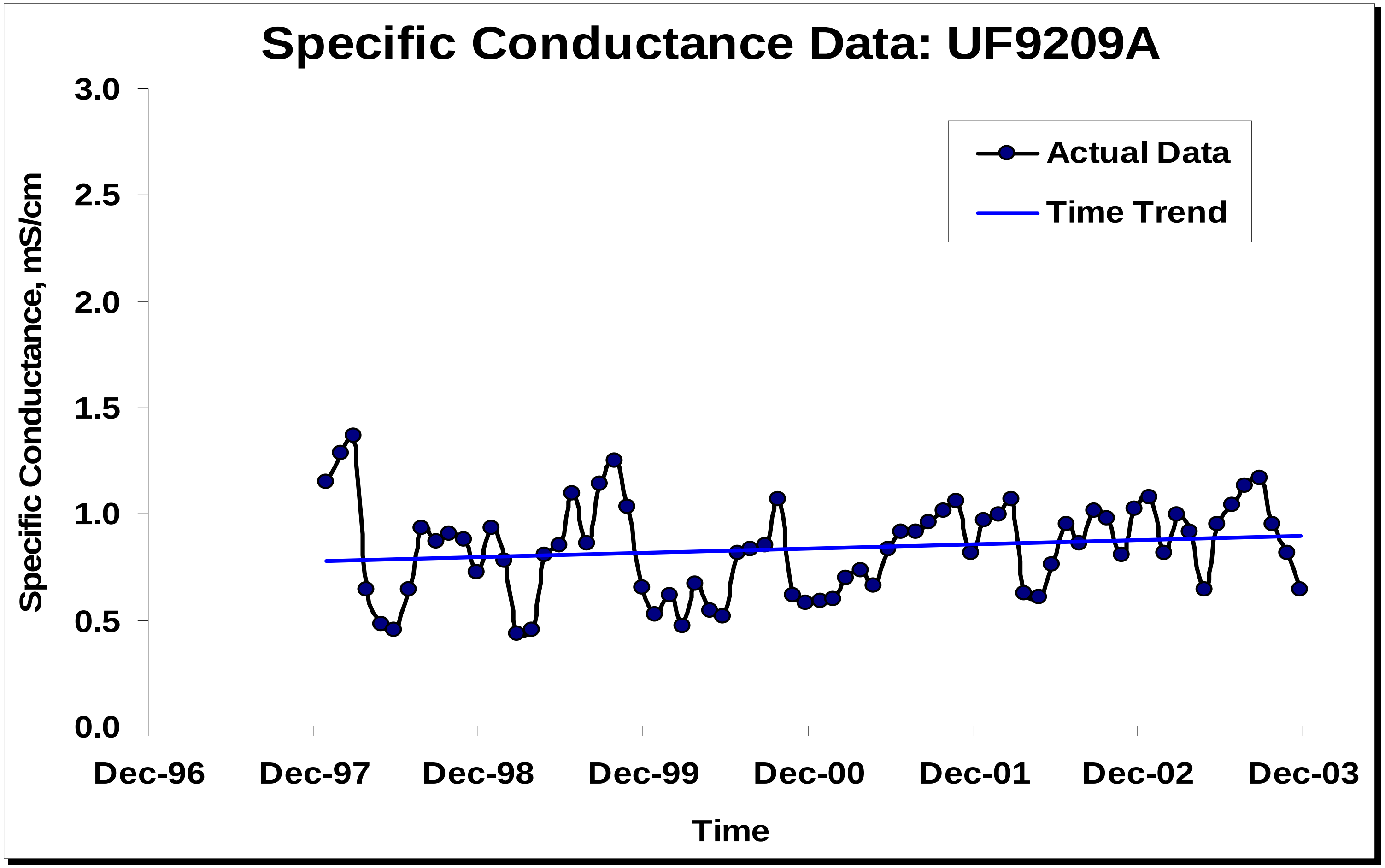


Figure 3.17. Time Trend of Specific Conductance at UF9209A during 1997-2003



CONCLUSIONS

Specific conductance was continuously monitored at three representative farms (UF9200A, UF9206A&B, and UF9209A) in 2003. Results of the specific conductance data in 2003 confirm that specific conductance is not an issue in the majority of the EAA farm canals monitored. Out of the three farms monitored, only one had average specific conductance higher than 1.275 mS/cm. As being addressed in our March 2004 report, the farm with high specific conductance level, UF9206A&B, is in an area of shallow wells that have high salt concentrations. The irrigation water flowing into this farm was also characterized by higher specific conductance (Daroub et al., 2004).

Drainage pumping had no significant effect on specific conductance, while irrigation water reduced specific conductance at three (UF9206A&B and UF9209A) of the four pumping structures. Sites that received irrigation water directly from low specific conductance district canals (Miami, and West Palm Beach canals) had lower mean specific conductance values. Sites that received irrigation water from district canals with relatively higher specific conductance (Ocean and Hillsboro canals) had relatively higher mean specific conductance values (Daroub et al., 2004).

There was a monthly upward trend in specific conductance at two (UF9200A, and UF9206A) of the four pump structures in 2003 (from January to November). However, there was no hourly variation in specific conductance within a day. There was also no obvious upward or downward trend in specific conductance over the entire monitoring period. This implies that the implementation of farm level P load reduction BMPs in the EAA since 1995 have had no effect on specific conductance in canal water at these three farms.

Keeping the BMP definition in mind, it is the conclusion of this study that no further BMPs can be identified by additional research that would provide abatement of specific conductance for farm discharge waters of the EAA. The currently employed P load reduction BMPs had no obvious impact on specific conductance at the three farms, so we conclude that further BMPs that target specific conductance will not be effective or practical. The issue of specific conductance is a geological problem in the EAA and additional farm management practices will have minimal effect on specific conductance.

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