Adams Bayou Special Study - Subwatershed 1.03

Sabine River Authority of Texas

August 31, 1999

Prepared in Cooperation with the Texas Natural Resource Conservation Commission

Under the Authorization of the Texas Clean Rivers Act.

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Introduction

Subwatershed 1.03 includes Adams Bayou and covers 51 square miles in the coastal area of the Basin. The lower portion of Adams Bayou is designated as Segment 0508 in the Texas Surface Water Quality Standards (TSWQS) and is tidally influenced.

The Sabine River Authority (SRA) 1996 Assessment of Water Quality identified the Adams Bayou Subwatershed as an area of concern due to poor water quality. Water quality concerns or possible concerns in this Subwatershed include dissolved oxygen, ammonia nitrogen, fecal coliform, and ambient toxicity. The problems in Subwatershed 1.03 appear to be due to the impacts from the large human population in the drainage area and the combined influence from point and nonpoint sources on a tidal waterbody with limited assimilative capacity. Tidal waterbodies typically have limited assimilative capacity, because of low flows and high dissolved solids. These conditions are made worse by the Subwatershed's high turbidity due to a heavy clay substrate and a large amount of detritus from the deciduous trees common in the area.

Background

The City of Orange is located almost entirely within this Subwatershed. The total population for the Subwatershed is approximately 21,500 with about 9,000 housing units. The 19 permitted discharges include five domestic, seven industrial, and seven stormwater. There are also four solid waste sites in this Subwatershed.

Water quality tests have been conducted on Adams Bayou every year since 1969. Five sites had been monitored by 1996, but only two sites were sampled for more than two years. Ambient Toxicity (AT) tests were also conducted in this Subwatershed beginning in 1993. The AT tests conducted in 1993 showed possible toxicity problems as demonstrated by the sublethal and lethal effects show in the tests. Monitoring was expanded to additional sites in an attempt to locate the source of the problem. After three years, no persistent toxicity has been indicated. Less than 10% of the 48 tests have shown lethal effects and only 17% of the tests showed sublethal effects. The sublethal effects may have been the result of natural conditions in tidally influenced areas. Tidally influenced waterbodies can be naturally high in sulfates that can affect the organisms used in the tests.

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Due to the extensive use of this waterbody for contact recreation, an intensive study was conducted on the Adams Bayou Subwatershed to identify the sources of water quality impairments. Monitoring included frequent sampling to document both point and non-point sources of fecal coliform, ammonia, and oxygen depleting materials. Sampling was also conducted to substantiate non-compliance with TSWQS.

Study Design

The Adams Bayou Subwatershed was sampled quarterly for biochemical oxygen demand (BOD), total organic carbon (TOC), chemical oxygen demand (COD), nutrients, field parameters, and fecal coliform. All parameters were sampled on the first sampling day of the quarterly program. In order to verify noncompliance with TSWQS, fecal coliform and field parameters were sampled again once per week for a total of five consecutive weeks. To determine which bacteria of the fecal coliform group were present, a differentiation was performed using verification media. Minimum dissolved oxygen measurements were taken within two hours of sunrise during warm weather to verify noncompliance with TSWQS at selected sites.

To help determine whether the fecal coliform concentrations found in Adams Bayou were due to human or animal populations, additional analyses for fecal streptococcus were performed on the samples. Contaminations from animal sources can be indicated by a high number of fecal streptococci as compared to fecal coliform. This analysis must be interpreted with caution since many factors can influence the survival rate of both fecal coliform and fecal streptococci. While the test may show a false negative for animal fecal contamination, it is not likely to produce a false positive. This information can be quite useful when attempting to determine the source of contamination.

Sampling was conducted during rainfall events to get information on runoff as well as information on efficiency of WWTP during significant rainfall events. The sampling was conducted during or just after significant rainfall events following a period of dry weather.

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Salinity was measured from the surface to the bottom to determine the extent of saltwater intrusion. The field measurements were taken at three sites in Adams Bayou.

Samples were collected from Adams Bayou at FM1006 (AB2) for ambient toxicity. Additional biomonitoring was conducted for permitted discharges where toxicity tests had not been previously performed.

Flow was measured at selected sites, primarily at small tributaries to Adams Bayou. Flows were measured as close to the sampling event as possible.

A comparison of the Adams Bayou data was made to data collected in Black Bayou, Subwatershed 1.01. Black Bayou is a tidally influenced waterbody with geological characteristics similar to Adams Bayou. Major differences from Adams Bayou are the lack of permitted discharges and a very sparse population in the Black Bayou watershed. The low level of human activities in the Black Bayou Subwatershed should indicate what the water quality conditions in Adams Bayou would be if it was not impacted by human activities.

Adams Bayou Sampling Sites

Stream Sites

SRA ID	Description	TNRCC #	Parameter Set
AB9	Adams Bayou at FM 1130	15742	Q, RF, DO
AB8	Adams Bayou at FM 1078	14964	Q, RF, DO
AB7	Adams Bayou at FM 3247	15107	Q, RF, DO
AB5	Adams Bayou at Park Ave.	14990	Q, RF, DO
AB4	Adams Bayou at Green Ave.	16059	Q, RF, DO
AB3	Adams Bayou @ Western Avenue	10442	Q, RF, DO
AB2	Adams Bayou at FM 1006	10441	Q, RF, AT

Tributary Sites

AL8	Adams Bayou Lateral @ Bancroft Rd.	16056	Q, RF, DO
GG	Gum Gully at Halliburton Rd	16049	Q, RF, DO
AL4B	Adams Bayou Lateral @ 31st St.	16039	RF
HG	Hudson Gully	16041	Q, RF, DO
SD1	Storm Drain to Adams Bayou	16061	RF
AL3	Adams Bayou Lateral # 3 @ Dayton Dr.	16054	Q, RF, DO
AL2	Adams Bayou Lateral # 2 @ Flint Rd	16053	Q, RF, DO
AL1	AB Lateral #1 @ FM 2177	16057	Q, RF, DO

Discharge Sites

AW3	City of Pinehurst WWTP	16043	Q, RF
AW2	Orange County WCID 002 WWTP	16044	Q, RF
AW1	A. Schulman Inc. WWTP *	16051	Q, RF
AI2	Equitable Bag Company Inc.		AT
AI1	A. Schulman Inc.		AT

Parameter Set Codes: Q = Quarterly Sampling, RF = Wet Weather Sampling, DO = Diurnal Dissolved Oxygen Sampling, AT = Ambient Toxicity Sampling

* After the initial sampling, A. Schulman Inc. declined to participate in this study.

Figure 1. Sample Locations in the Adams Bayou Watershed

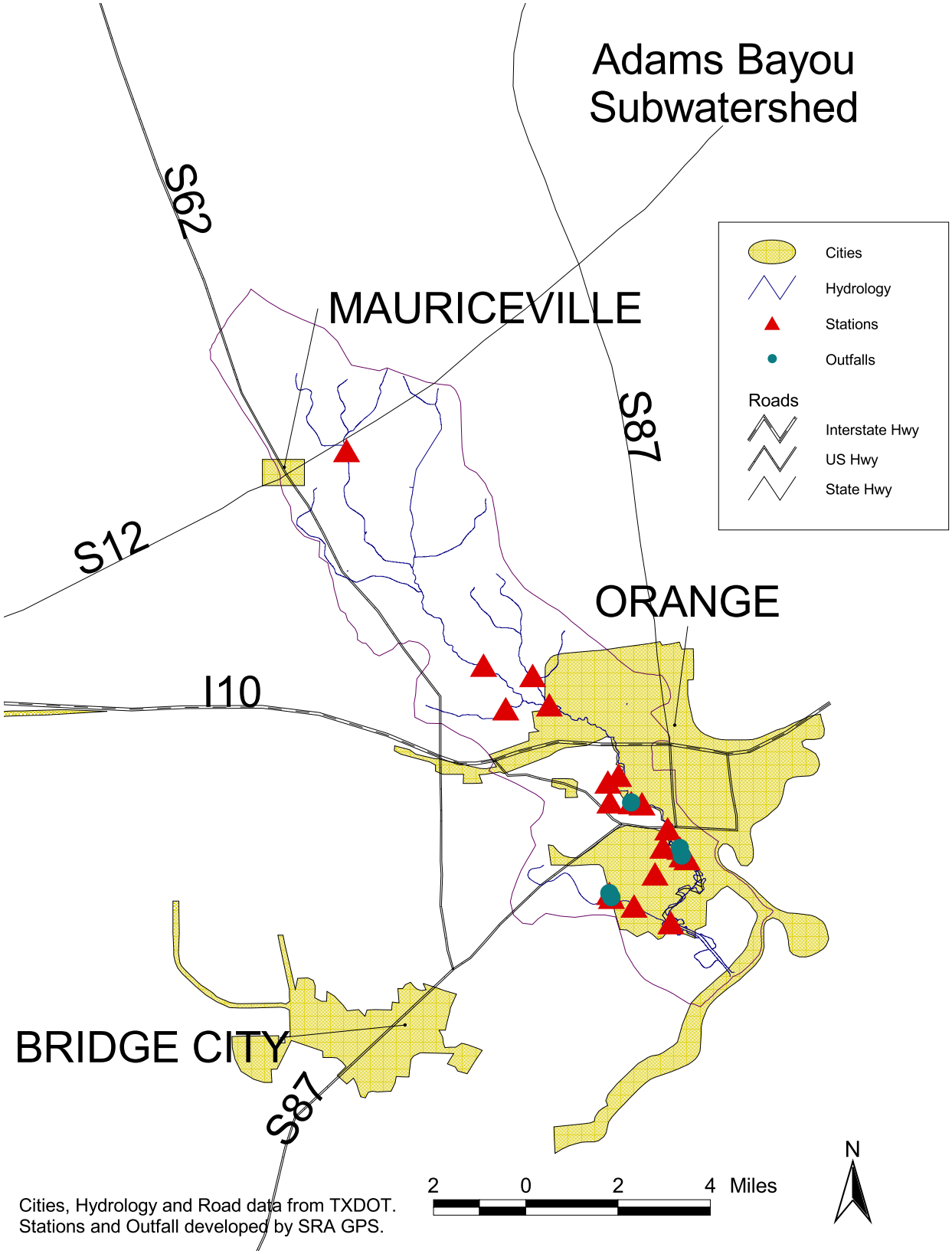


Figure 2. Land Use in the Adams Bayou Watershed

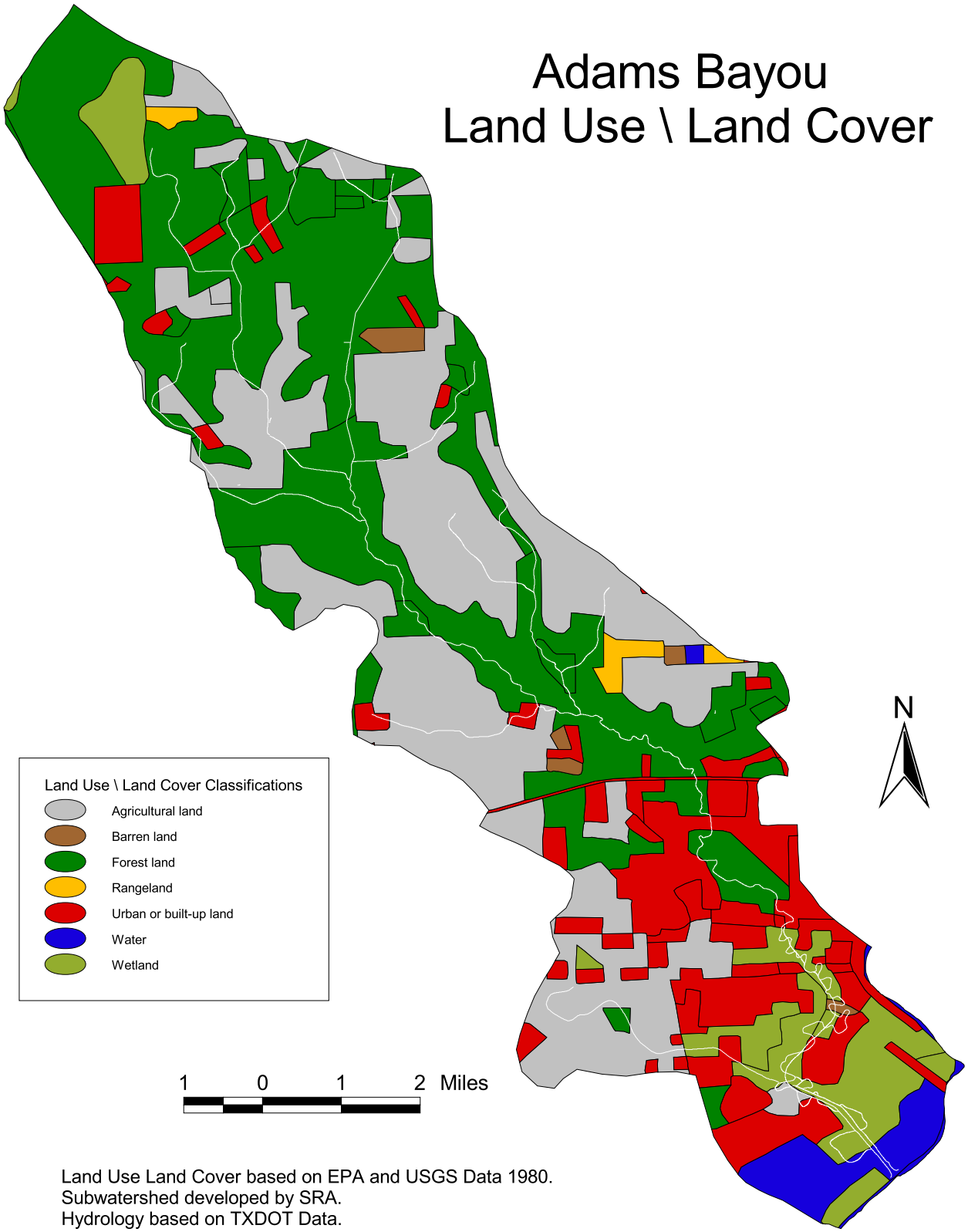
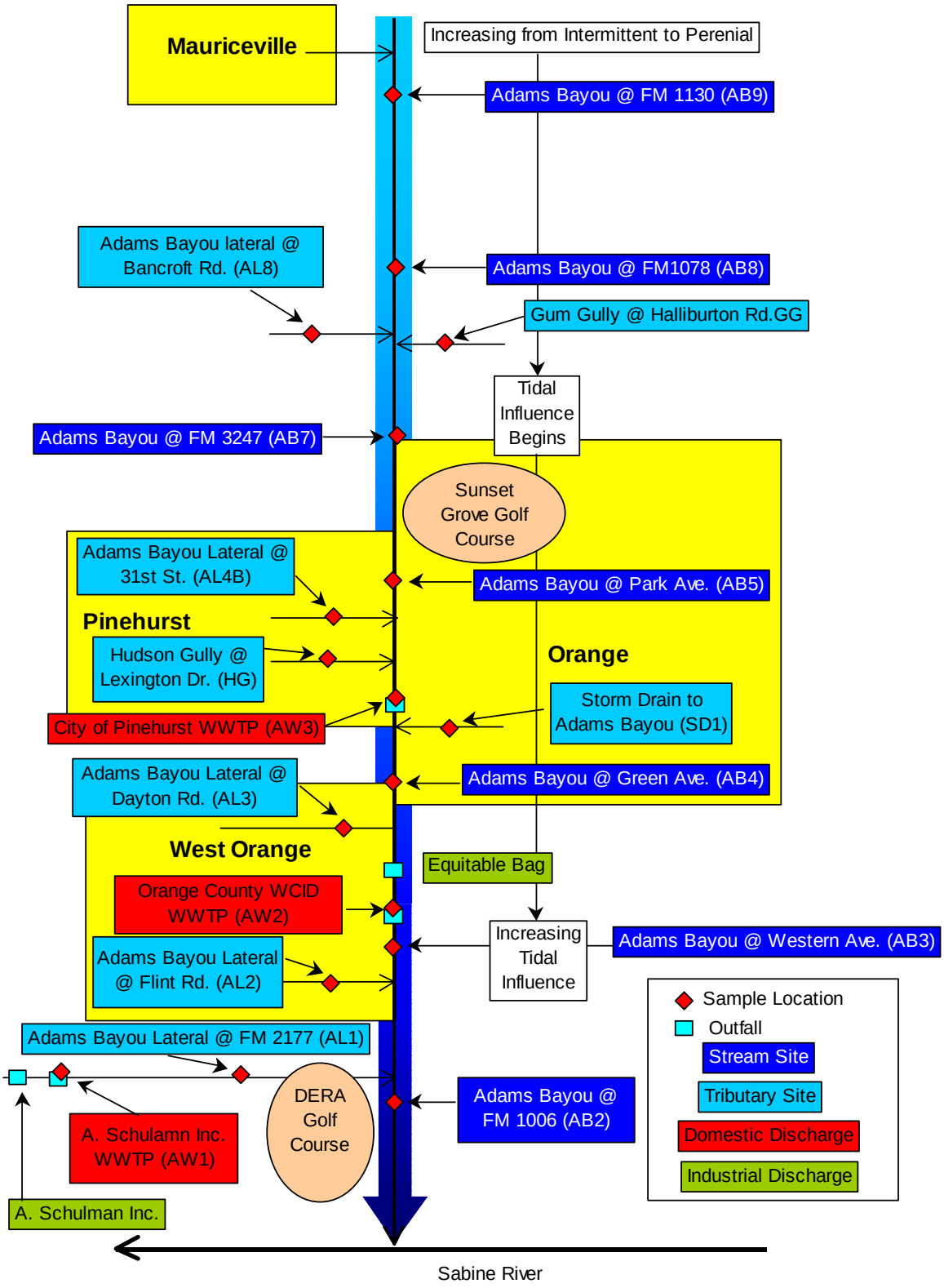
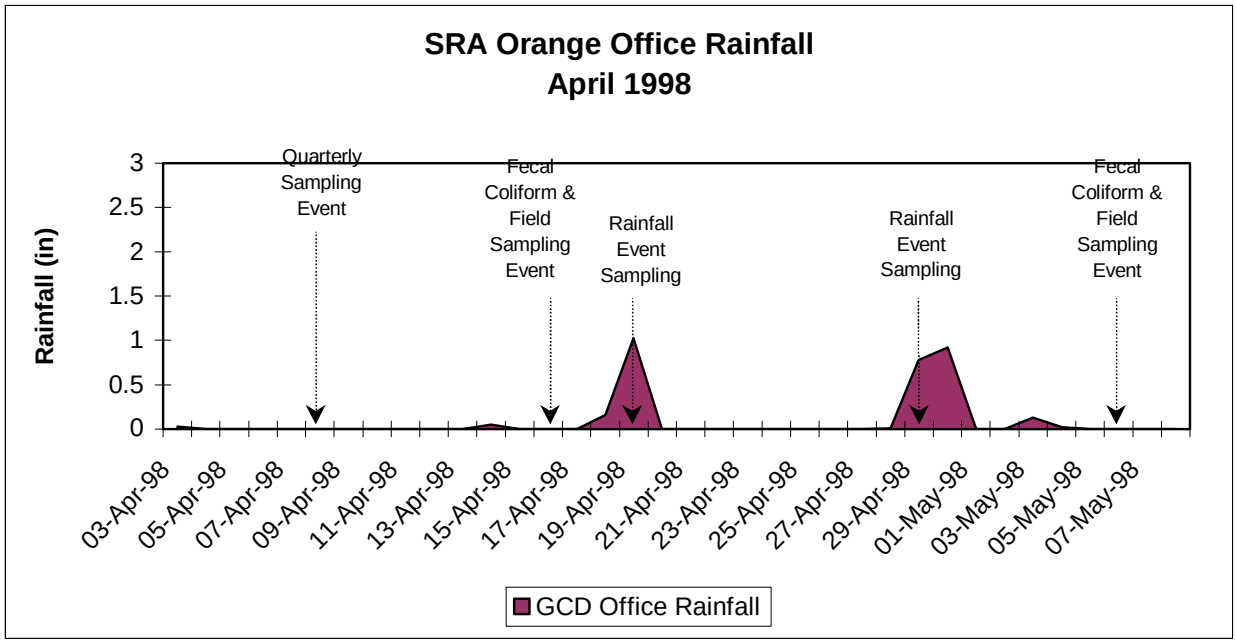


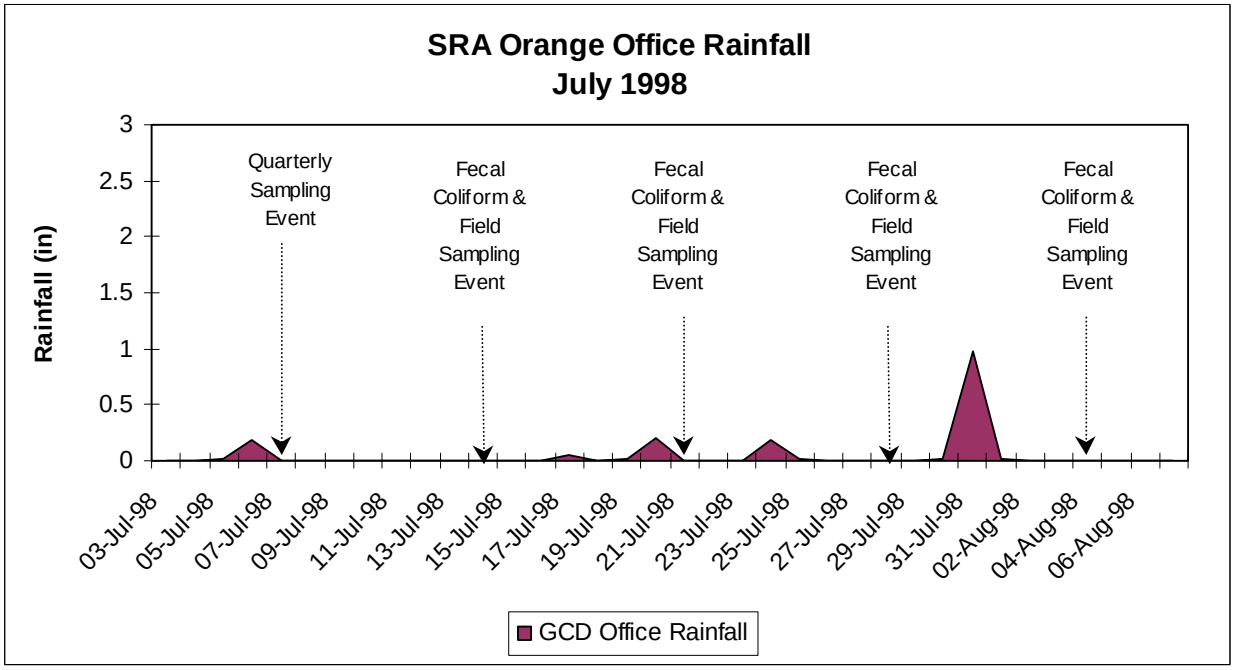
Figure 3. Schematic Diagram of Adams Bayou Subwatershed

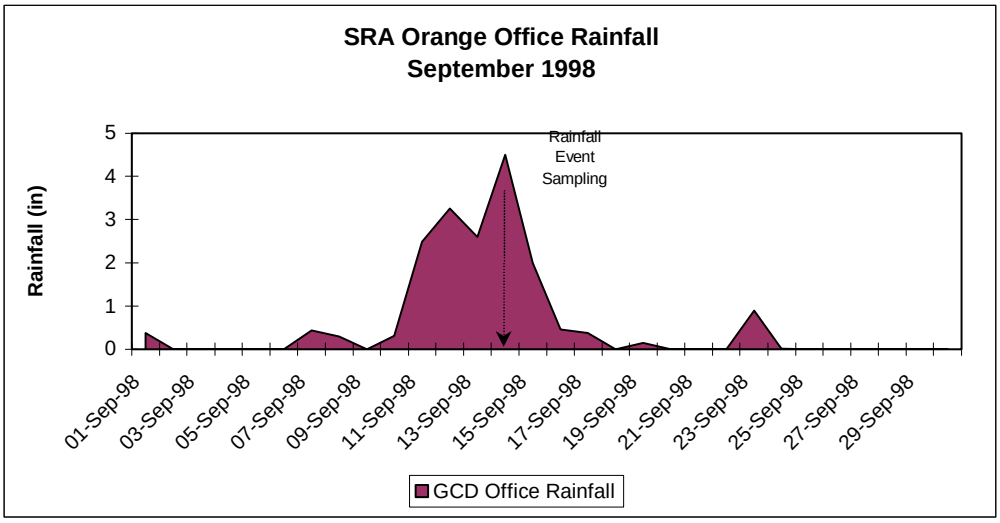


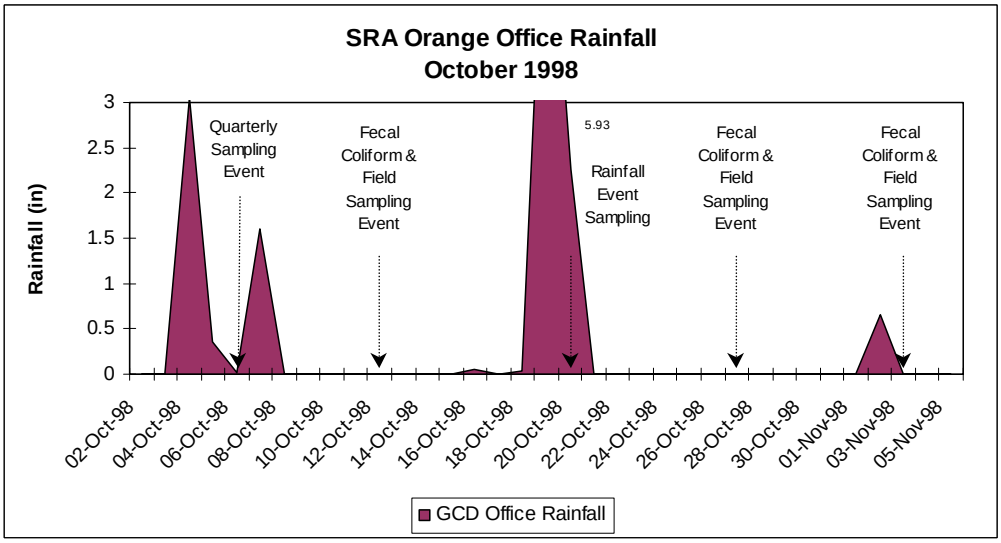
Sampling Periods and Rainfall Events

Rainfall was measure at the SRA Gulf Coast Division Office near Orange, Texas. The rainfall events were not evenly distributed throughout the Subwatershed and because of this, not all sites were sampled during every rainfall event. Rainfall event sampling was performed only when the field biologists determined runoff from rainfall had occurred. The distribution of the rainfall is more readily apparent in the flow measurements.






SRA Orange Office Rainfall
September 1998
Rainfall (in)
Rainfall Event Sampling
01-Sep-98
03-Sep-98
05-Sep-98
07-Sep-98
09-Sep-98
11-Sep-98
13-Sep-98
15-Sep-98
17-Sep-98
19-Sep-98
21-Sep-98
23-Sep-98
25-Sep-98
27-Sep-98
29-Sep-98
GCD Office Rainfall


SRA Orange Office Rainfall
October 1998
Rainfall (in)
Quarterly Sampling Event
Fecal Coliform & Field Sampling Event
5.93
Rainfall Event Sampling
Fecal Coliform & Field Sampling Event
Fecal Coliform & Field Sampling Event
02-Oct-98
04-Oct-98
06-Oct-98
08-Oct-98
10-Oct-98
12-Oct-98
14-Oct-98
16-Oct-98
18-Oct-98
20-Oct-98
22-Oct-98
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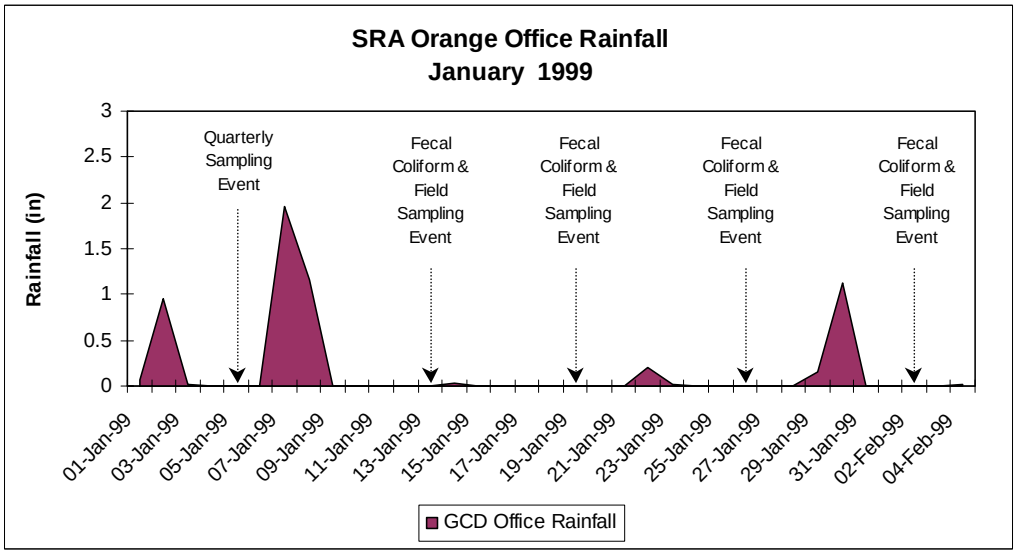
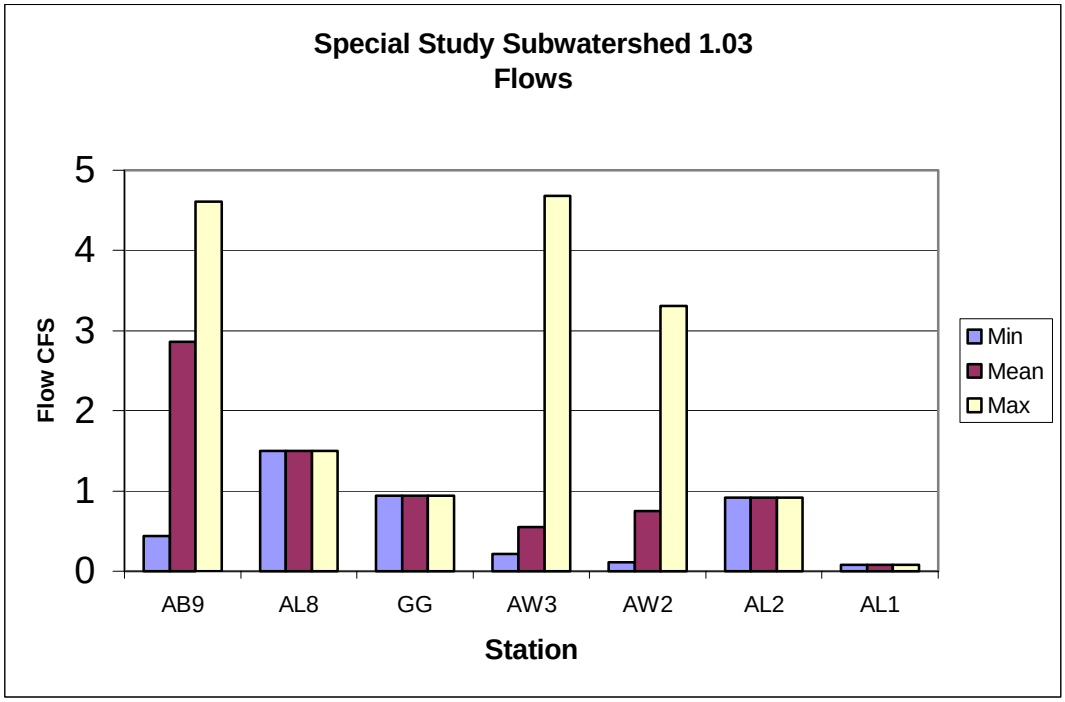
30-Oct-98
01-Nov-98
03-Nov-98
05-Nov-98
GCD Office Rainfall


SRA Orange Office Rainfall
January 1999
Rainfall (in)
Quarterly Sampling Event
Fecal Coliform & Field Sampling Event
Fecal Coliform & Field Sampling Event
Fecal Coliform & Field Sampling Event
Fecal Coliform & Field Sampling Event
01-Jan-99
03-Jan-99
05-Jan-99
07-Jan-99
09-Jan-99
11-Jan-99
13-Jan-99
15-Jan-99
17-Jan-99
19-Jan-99
21-Jan-99
23-Jan-99
25-Jan-99
27-Jan-99
29-Jan-99
31-Jan-99
02-Feb-99
04-Feb-99
GCD Office Rainfall

Flow

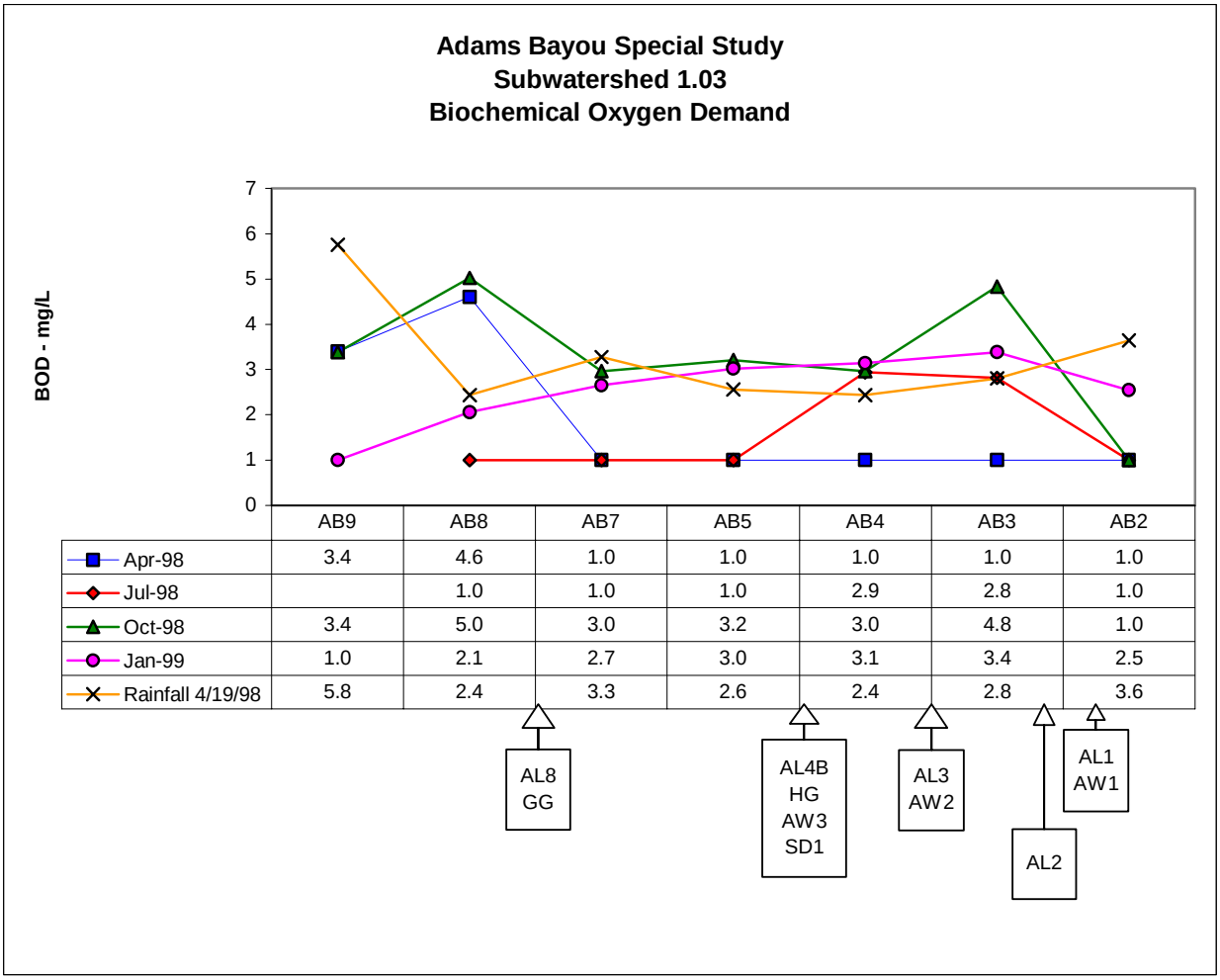
Flow measured at stream sites ranged from 4.6 cubic feet per second (cfs) at AB9 to less than 1 cfs at GG, AL2, and AL1. Flow measurements were not measured in the lower part of the Subwatershed due to the tidal nature of Adams Bayou, which makes flow measurements difficult to obtain and often meaningless. Flows were measured during rainfall events at sites where flow was obvious. The only stream sites with flows greater than 1 cfs were AB9 and AL8. Flows were obtained from permitted discharge sites AW3 and AW2 during each sampling event. A maximum flow of 4.7 cfs was recorded at AW3.



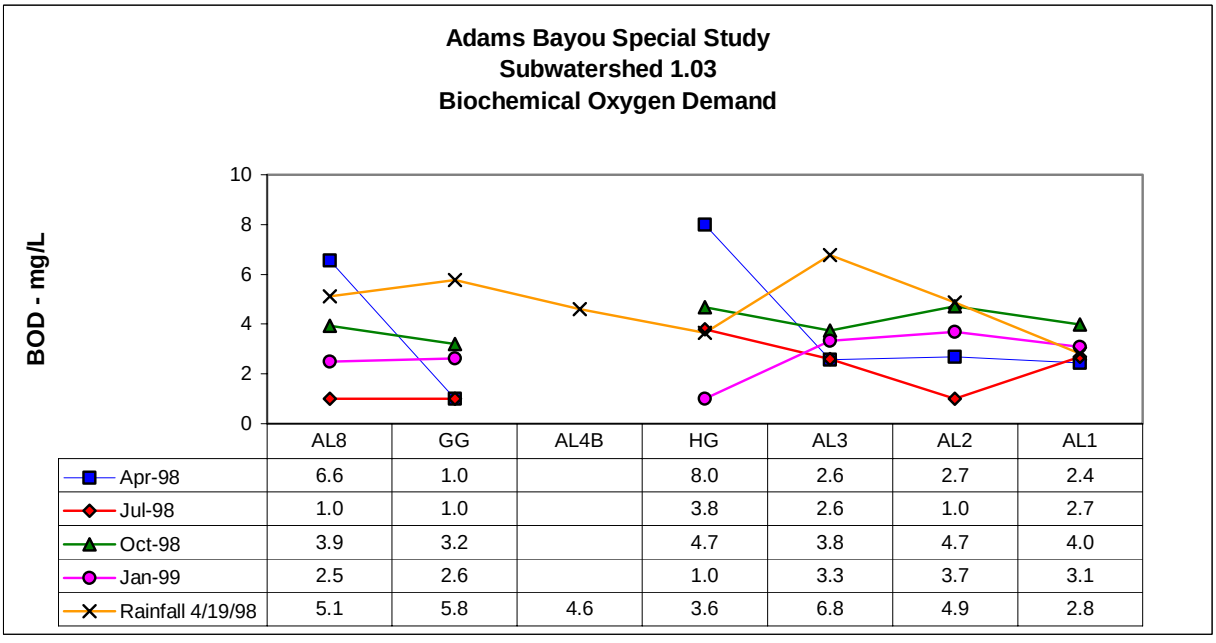
Results

Biochemical Oxygen Demand

The biochemical oxygen demand (BOD) is a measure of the amount of oxygen removed from aquatic environments by aerobic micro-organisms for their metabolic requirements. BOD is used to determine the level of organic pollution of a stream or lake. Stream sites typically have low BOD values, usually less than 5 mg/L. The BOD ranged from 5.8 mg/L at Station AB9 to less than 2 mg/L at several sites. Slightly elevated values of 3 mg/L or higher were observed at all stream sites during at least one of the sampling events. Values were also slightly elevated during the rainfall sampling event. The highest BOD value at the tributary sites was 8.0 mg/L at HG. Levels were generally higher at the tributary sites than at the stream sites, which is normal. Elevated BOD values were recorded at sites AW3 and AW2 during at least one sampling event. Permitted discharges are limited to releasing low levels of oxygen demanding material. Typically, the limits are 10 – 20 mg/L as a daily average and 30 – 40 mg/L as a weekly average. Daily maximums can be as high as 45 mg/L.



	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	3.4	4.6	1.0	1.0	1.0	1.0	1.0
Jul-98		1.0	1.0	1.0	2.9	2.8	1.0
Oct-98	3.4	5.0	3.0	3.2	3.0	4.8	1.0
Jan-99	1.0	2.1	2.7	3.0	3.1	3.4	2.5
Rainfall 4/19/98	5.8	2.4	3.3	2.6	2.4	2.8	3.6



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	6.6	1.0		8.0	2.6	2.7	2.4
Jul-98	1.0	1.0		3.8	2.6	1.0	2.7
Oct-98	3.9	3.2		4.7	3.8	4.7	4.0
Jan-99	2.5	2.6		1.0	3.3	3.7	3.1
Rainfall 4/19/98	5.1	5.8	4.6	3.6	6.8	4.9	2.8

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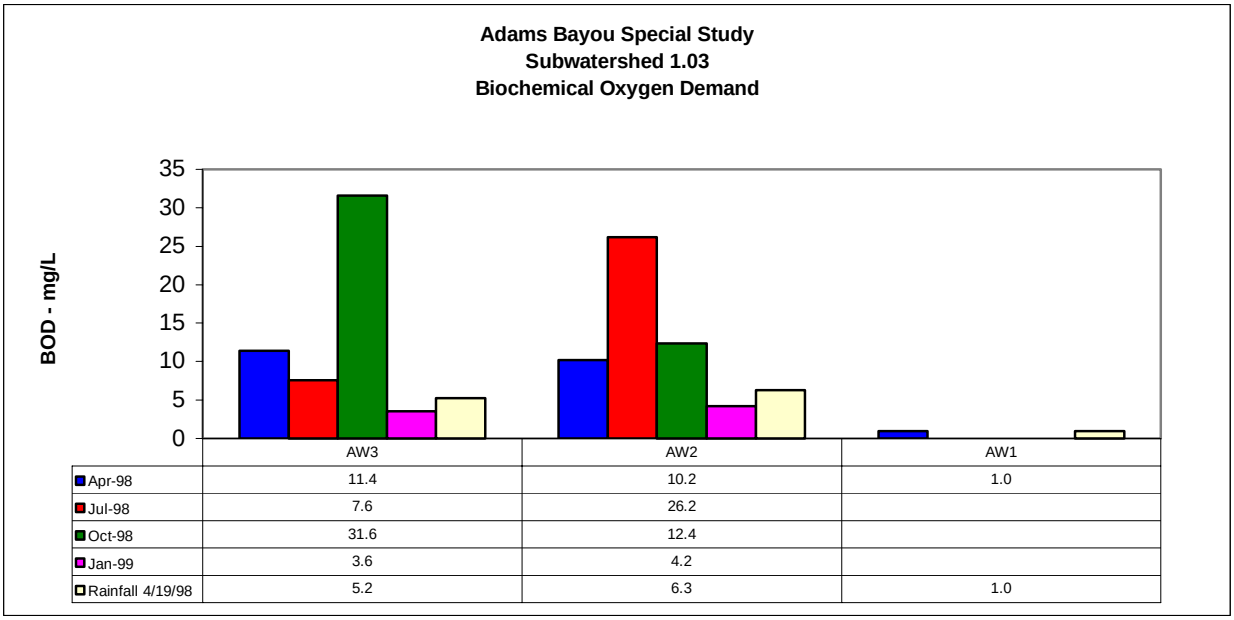
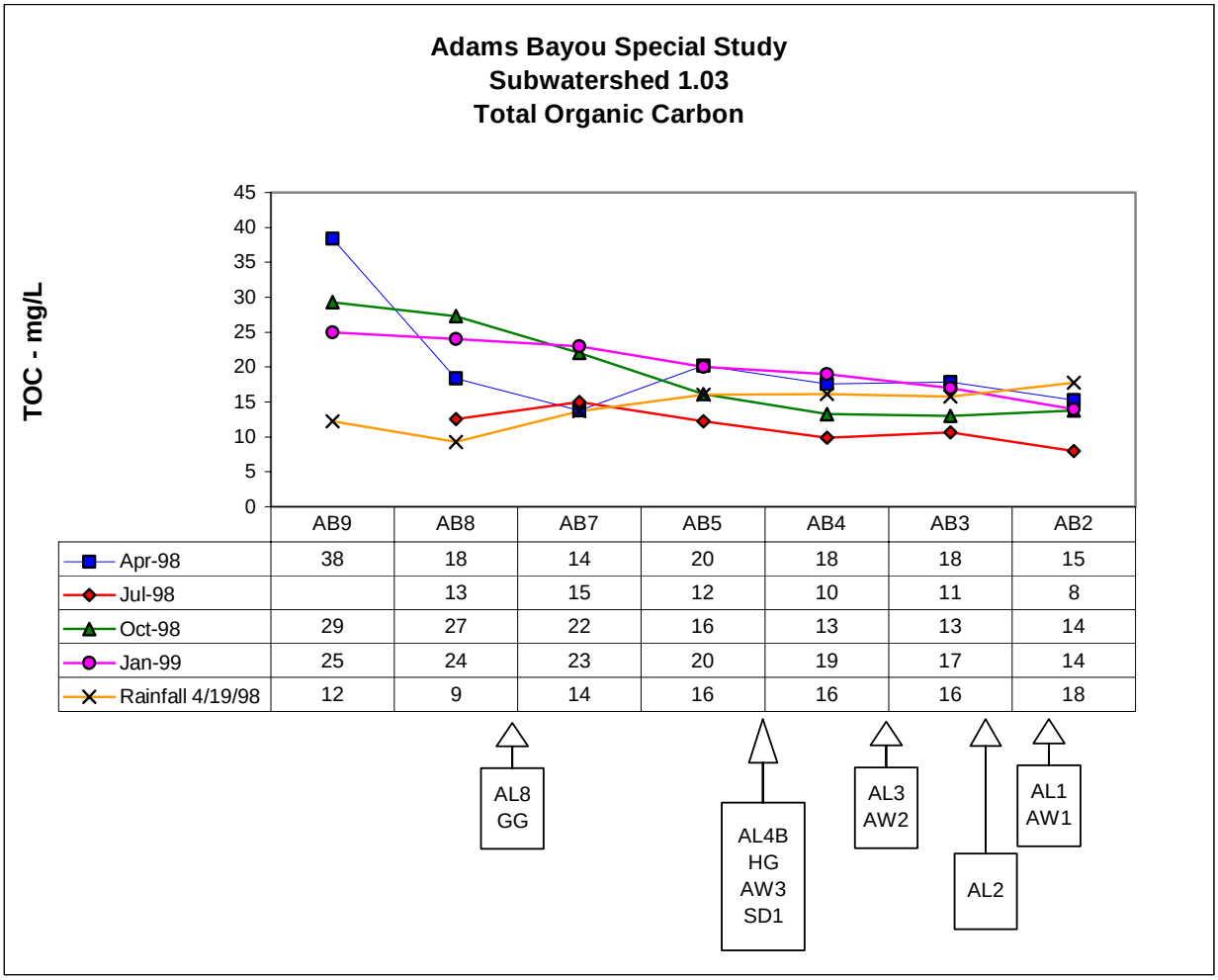


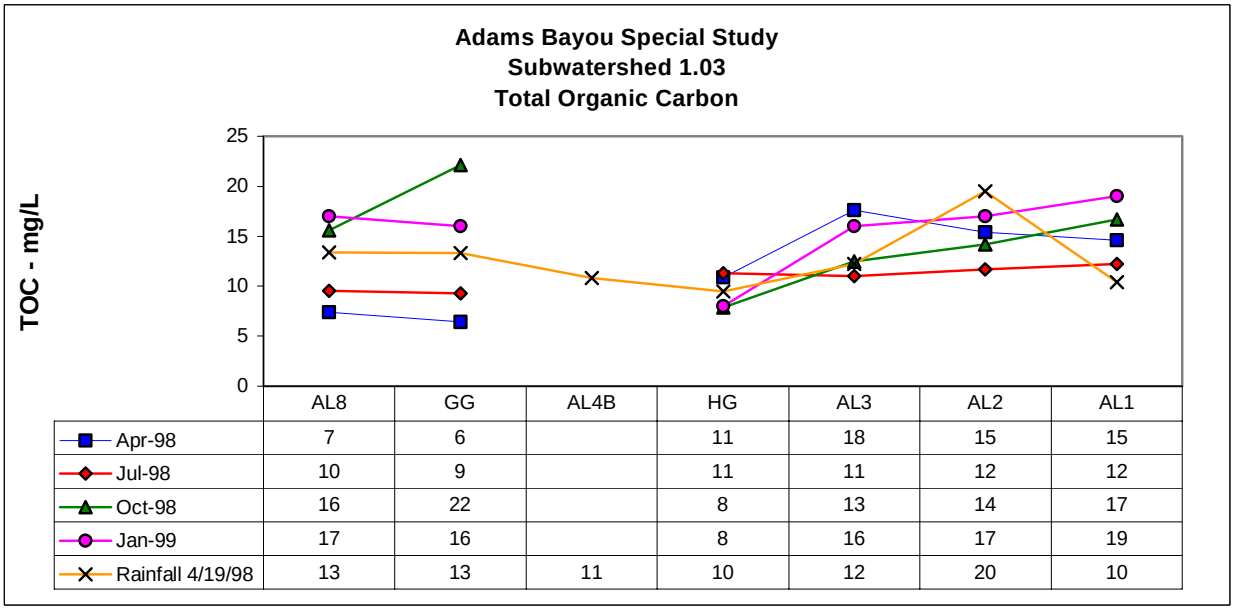
	AW3	AW2	AW1
Apr-98	11.4	10.2	1.0
Jul-98	7.6	26.2	
Oct-98	31.6	12.4	
Jan-99	3.6	4.2	
Rainfall 4/19/98	5.2	6.3	1.0

Total Organic Carbon

Total organic carbon (TOC) is another measure of organic material in water. Stream values are usually less than 10 mg/L. The TOC values at the stream sites ranged from 38 mg/L at AB9 to 8 mg/L at AB2. TOC values were higher at Station AB9 than any other stream site except during the rainfall event sampling. The trend for TOC decreased from upstream sites to downstream sites. During rainfall events, only site AB2 showed an increase in TOC. The impact from the discharges and surrounding land use activities appears to be evenly distributed at most of the stream sites. TOC levels at the tributary sites ranged from 22 mg/L to 8 mg/L. Values for TOC at the discharge sites ranged from 47 mg/L at Station AW2 to 3 mg/L at Station AW3. Treated wastewater usually has a TOC value of less than 10 mg/L.



	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	38	18	14	20	18	18	15
Jul-98		13	15	12	10	11	8
Oct-98	29	27	22	16	13	13	14
Jan-99	25	24	23	20	19	17	14
Rainfall 4/19/98	12	9	14	16	16	16	18



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	7	6		11	18	15	15
Jul-98	10	9		11	11	12	12
Oct-98	16	22		8	13	14	17
Jan-99	17	16		8	16	17	19
Rainfall 4/19/98	13	13	11	10	12	20	10

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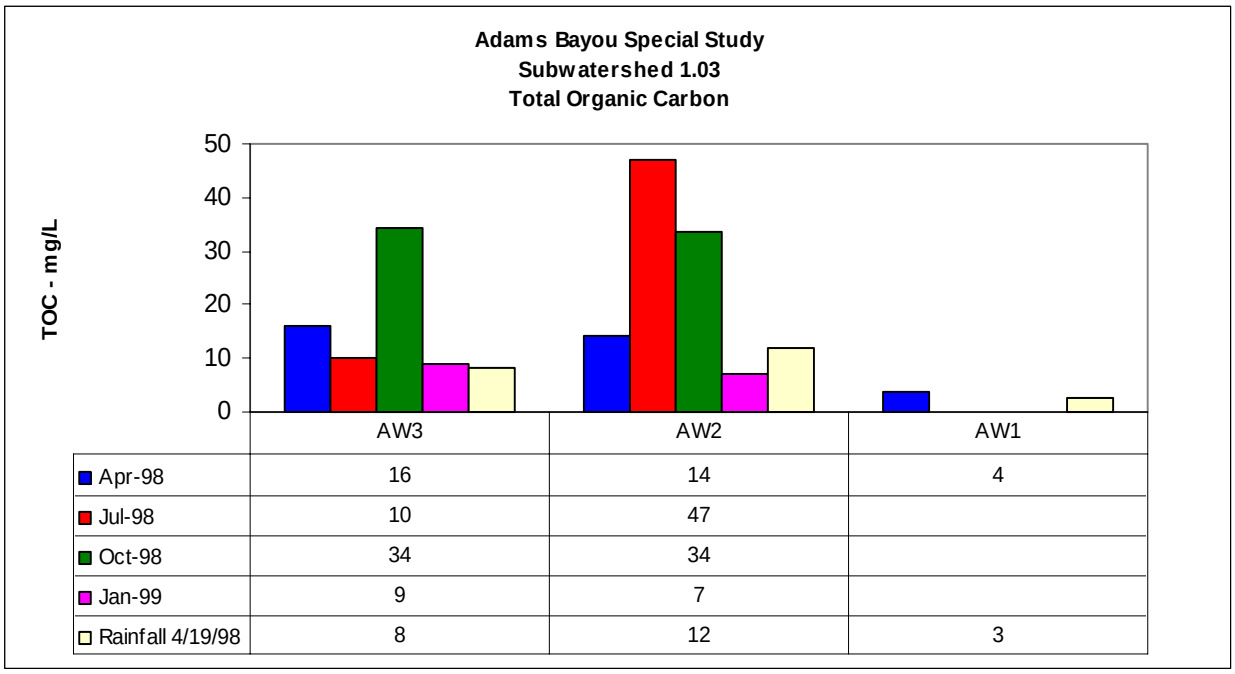
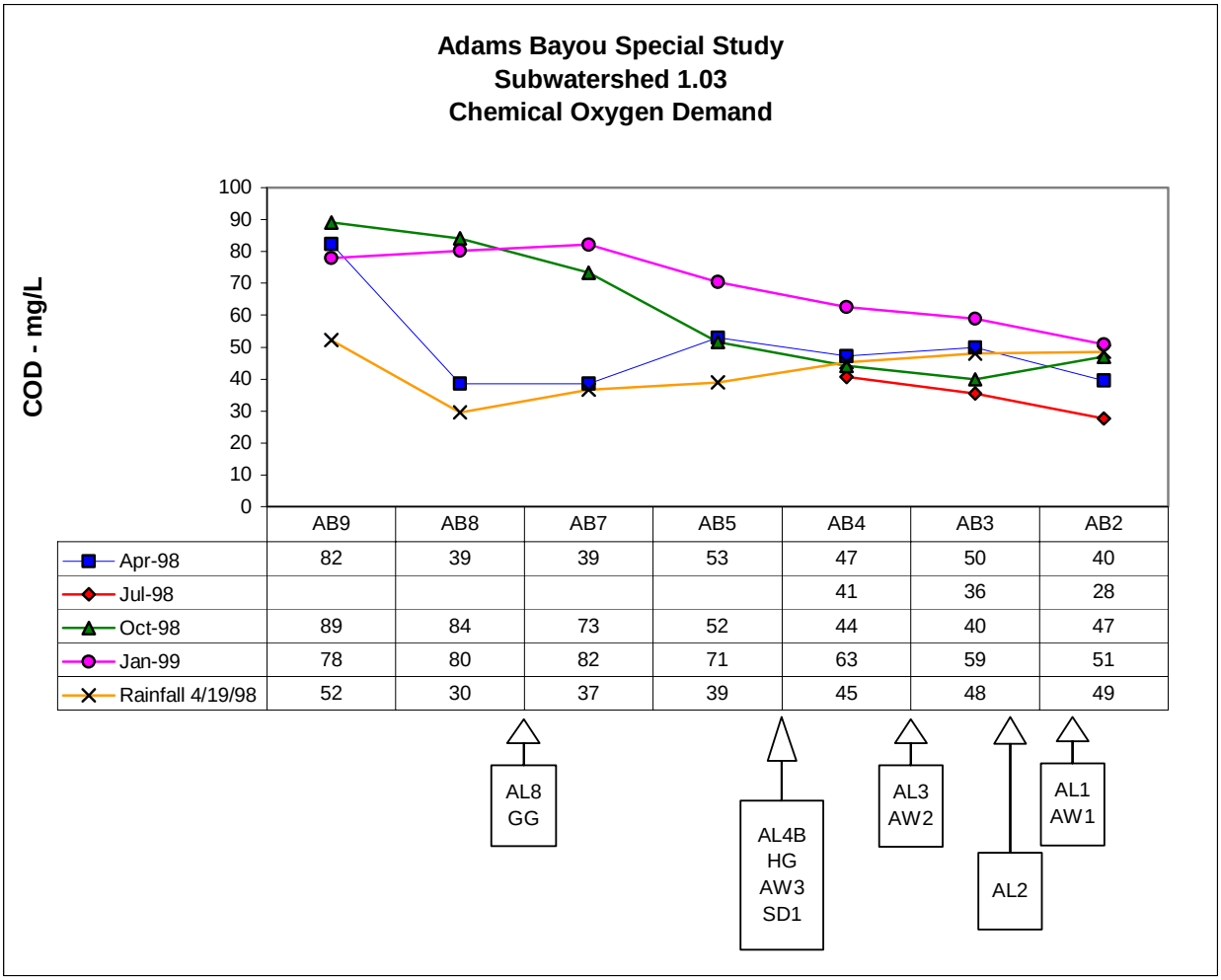


	AW3	AW2	AW1
Apr-98	16	14	4
Jul-98	10	47	
Oct-98	34	34	
Jan-99	9	7	
Rainfall 4/19/98	8	12	3

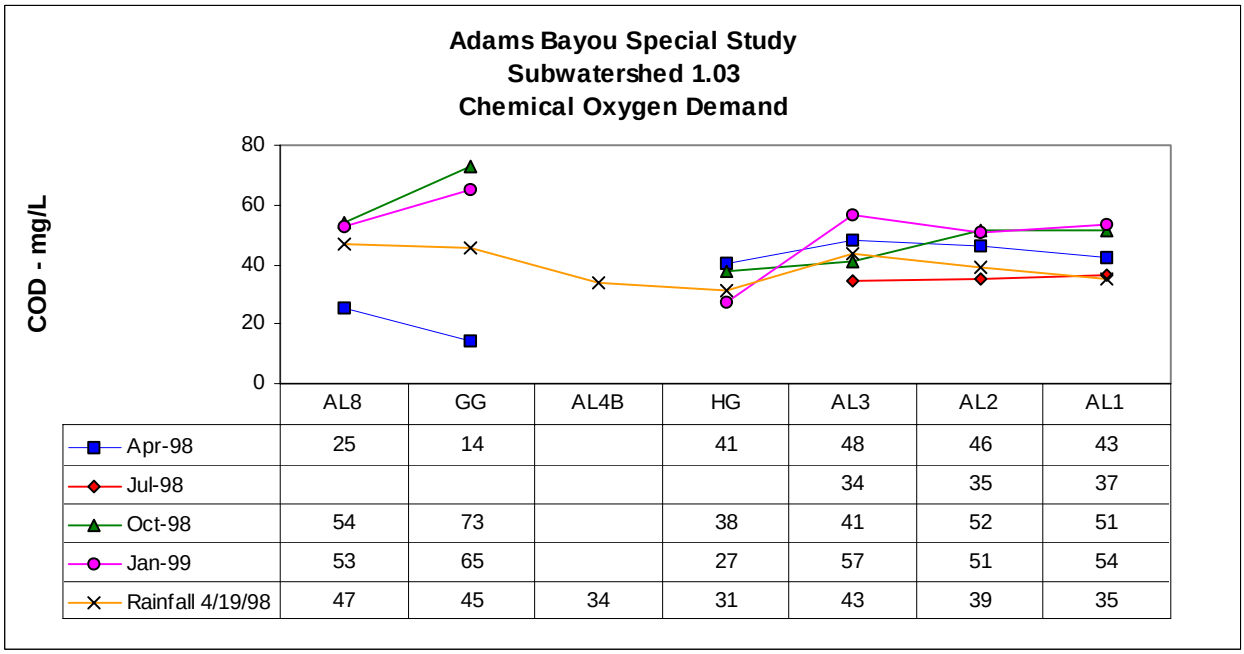
Chemical Oxygen Demand

Chemical Oxygen Demand (COD) is a measure of the amount of organic substances in water or wastewater. COD values are typically higher than BOD values and COD values in streams are normally less than 50 mg/L. The COD values in Adams Bayou ranged from 89 mg/L at AB9 to 28 mg/L at AB2 with a median value of 49 mg/L. Levels at the tributary sites were about the same as the stream sites with a median value of 43 mg/L. The highest value at the discharge sites was 176 mg/L found at AW3. Typical COD values in treated wastewater are about 30 mg/L. Stream sites appear to be impacted mainly from nonpoint sources, although some impact could be attributed to the permitted discharge sites.

Special Study on Subwatershed 1.03 – Adams Bayou

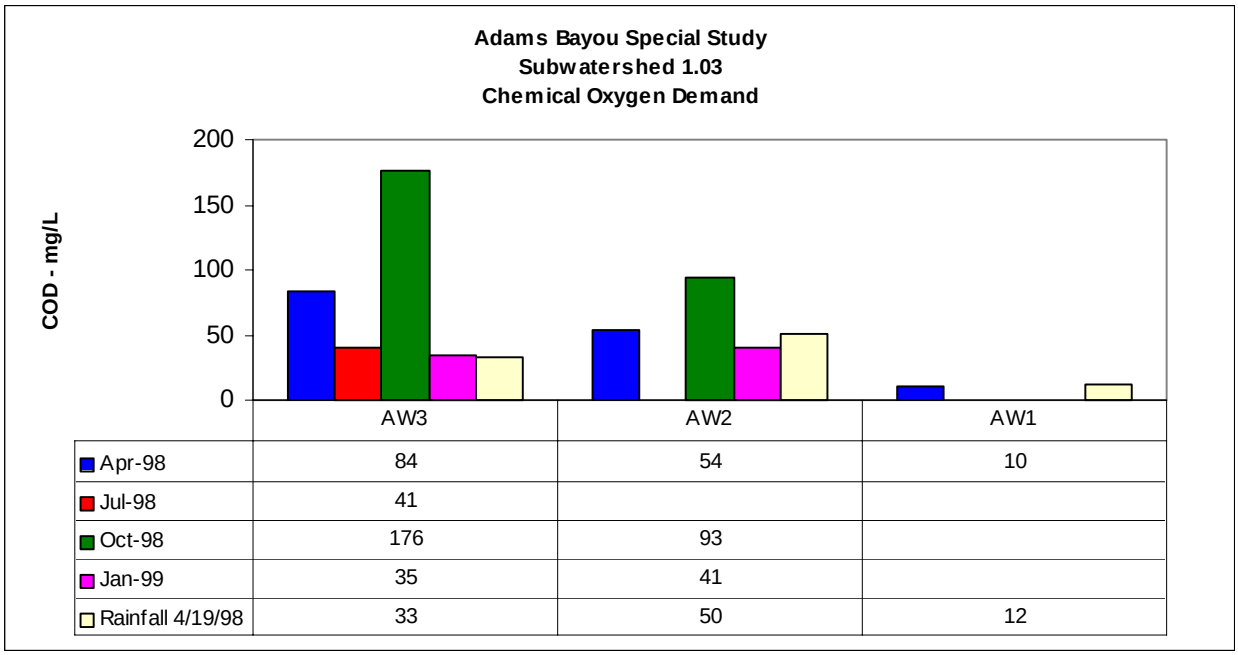


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	82	39	39	53	47	50	40
Jul-98					41	36	28
Oct-98	89	84	73	52	44	40	47
Jan-99	78	80	82	71	63	59	51
Rainfall 4/19/98	52	30	37	39	45	48	49



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	25	14		41	48	46	43
Jul-98					34	35	37
Oct-98	54	73		38	41	52	51
Jan-99	53	65		27	57	51	54
Rainfall 4/19/98	47	45	34	31	43	39	35

Special Study on Subwatershed 1.03 – Adams Bayou



	AW3	AW2	AW1
Apr-98	84	54	10
Jul-98	41		
Oct-98	176	93	
Jan-99	35	41	
Rainfall 4/19/98	33	50	12

Ammonia

Although there are no stream standards for ammonia, it can be toxic to fish in very small amounts. The toxicity is dependent on pH and increases as pH increases. Stream values from natural sources of ammonia are rarely above 1 mg/L. Ammonia levels at the stream sites ranged from 1 mg/L at AB3 to less than measurable amounts at AB2. Although most tributary sites had lower levels than the stream sites, a peak value of 1.37 mg/L was observed at AL8. The highest value for ammonia at the discharge sites was 7.75 mg/L recorded at Station AW2 and elevated values were also observed at AW3. Slight increases were observed at stream sites during rainfall events. The slightly elevated values at Stations AB4 and AB3 were apparently due to nearby permitted discharges. Values for pH in the Adams Bayou Subwatershed are usually neutral to somewhat acidic, but occasionally values above 8.0 have been recorded. The levels of ammonia detected in the Subwatershed would not cause toxicity problems at the normally neutral pH levels, but the aquatic community would be stressed from the ammonia levels at pH values greater than 8.0.

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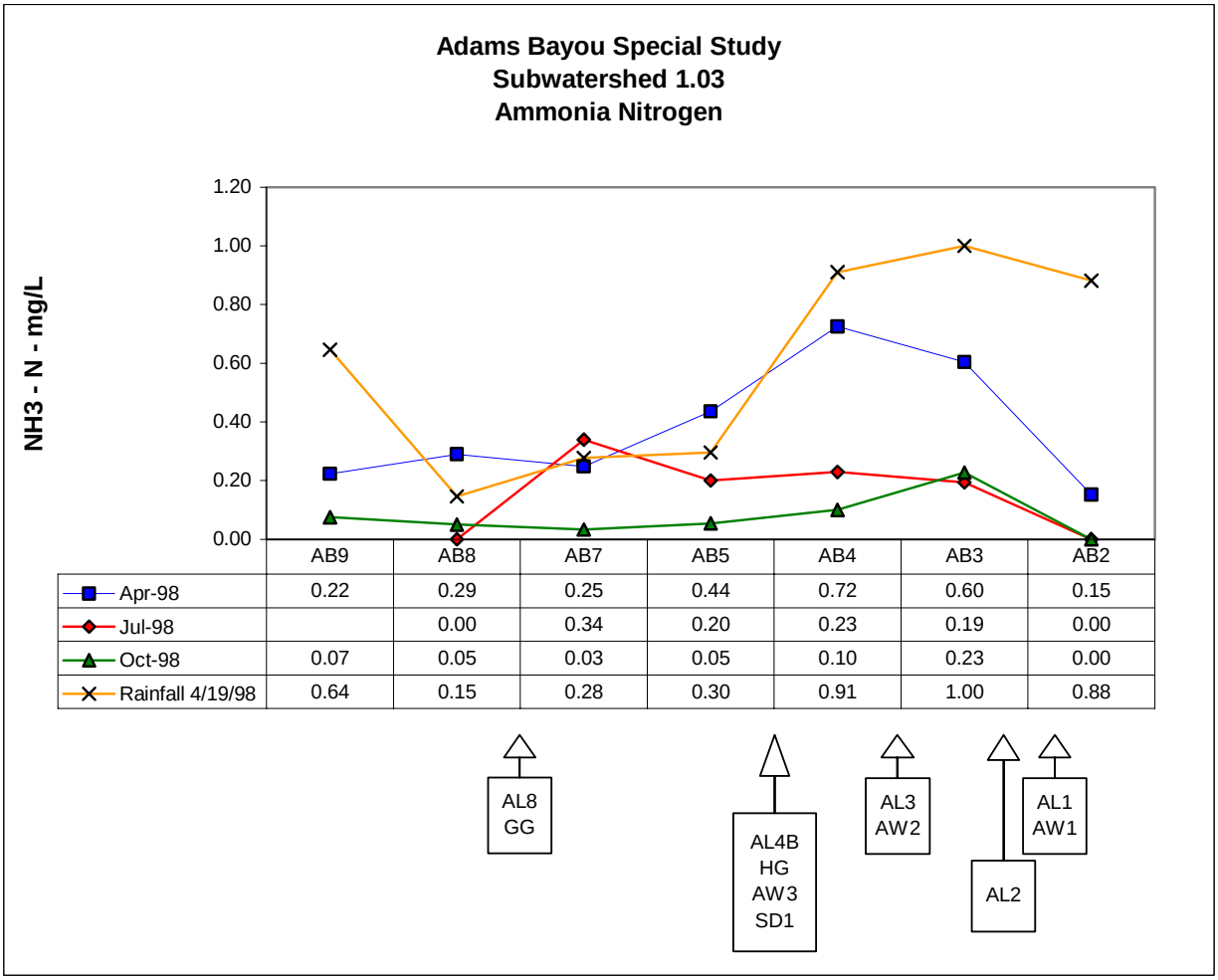
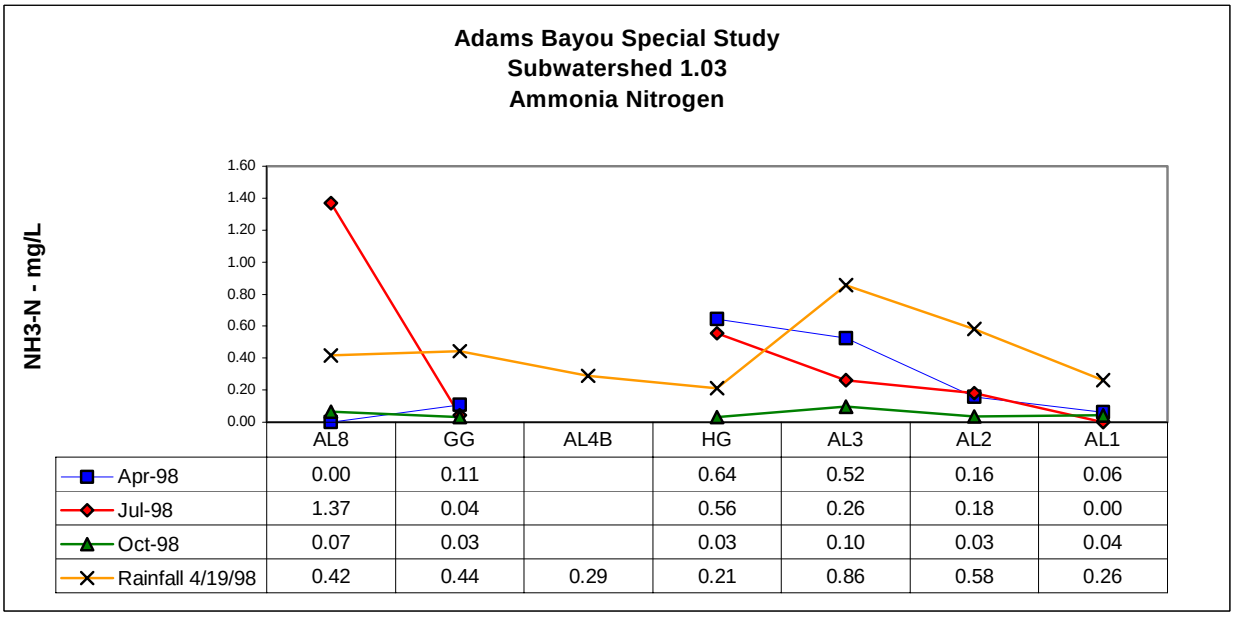


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	0.22	0.29	0.25	0.44	0.72	0.60	0.15
Jul-98		0.00	0.34	0.20	0.23	0.19	0.00
Oct-98	0.07	0.05	0.03	0.05	0.10	0.23	0.00
Rainfall 4/19/98	0.64	0.15	0.28	0.30	0.91	1.00	0.88



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	0.00	0.11		0.64	0.52	0.16	0.06
Jul-98	1.37	0.04		0.56	0.26	0.18	0.00
Oct-98	0.07	0.03		0.03	0.10	0.03	0.04
Rainfall 4/19/98	0.42	0.44	0.29	0.21	0.86	0.58	0.26

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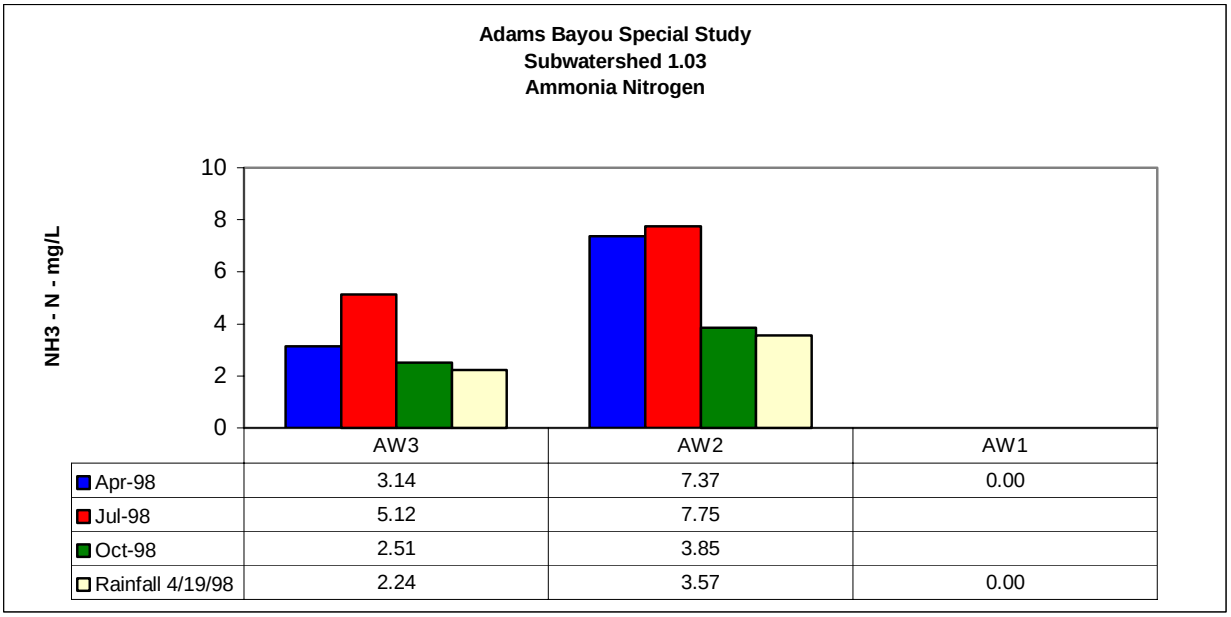

	AW3	AW2	AW1
Apr-98	3.14	7.37	0.00
Jul-98	5.12	7.75	
Oct-98	2.51	3.85	
Rainfall 4/19/98	2.24	3.57	0.00

Nitrate and Nitrite

The primary concern for nitrogen compounds in water is nutrient enrichment that can lead to excessive growth of unwanted plants. High nitrates in drinking water can cause digestive disturbances in people and high nitrites can cause toxicity in fish. Levels of nitrate and nitrite in streams should not exceed 10 mg/L, although no limits are listed in TSWQS. The stream values were generally low with no value exceeding 1.0 mg/L. Nitrate values were elevated at Stations AW2 and AW1. The highest value was 48 mg/L at Station AW1. The low values at the stream sites indicate very little impact from the permitted discharges even during rainfall events.

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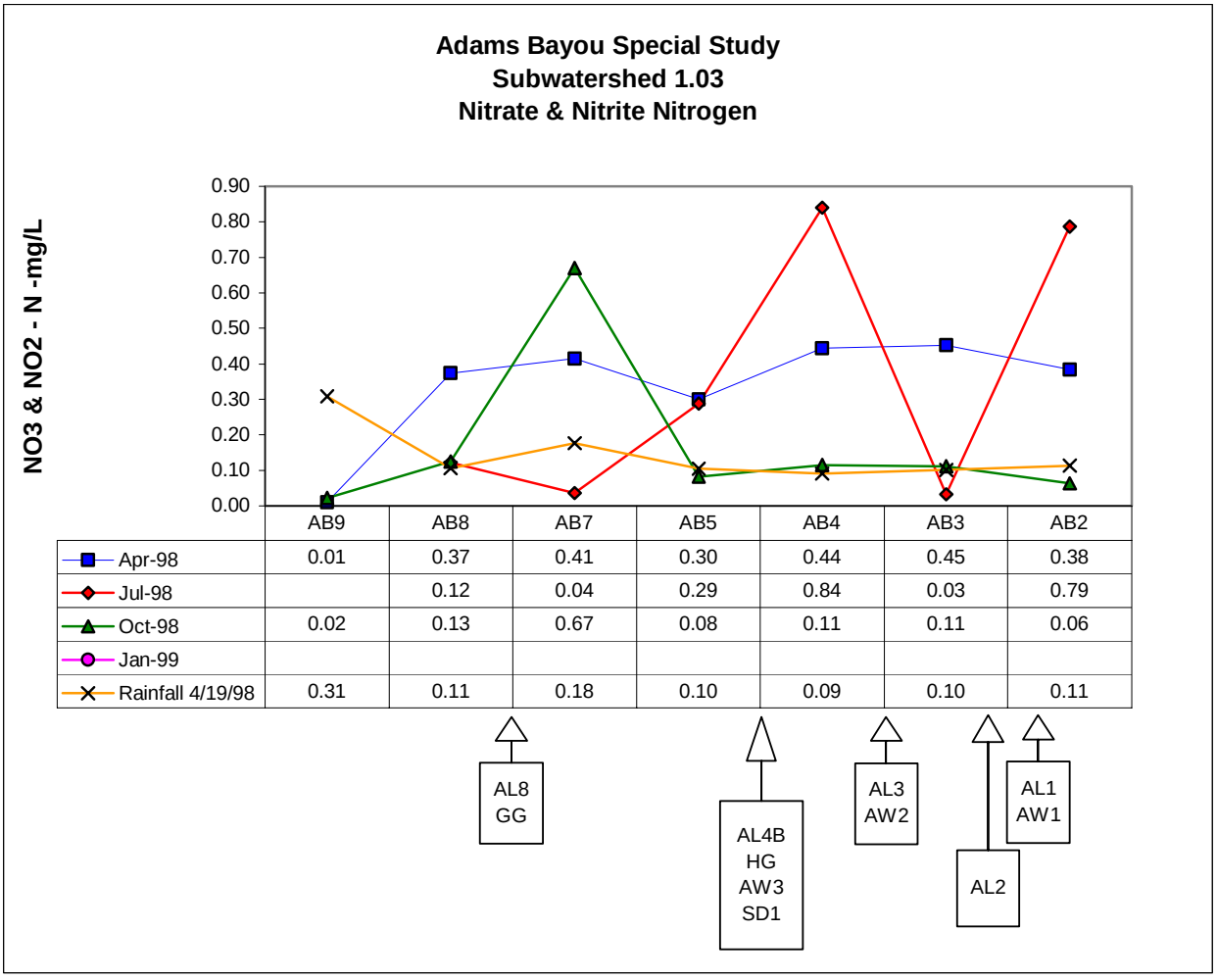
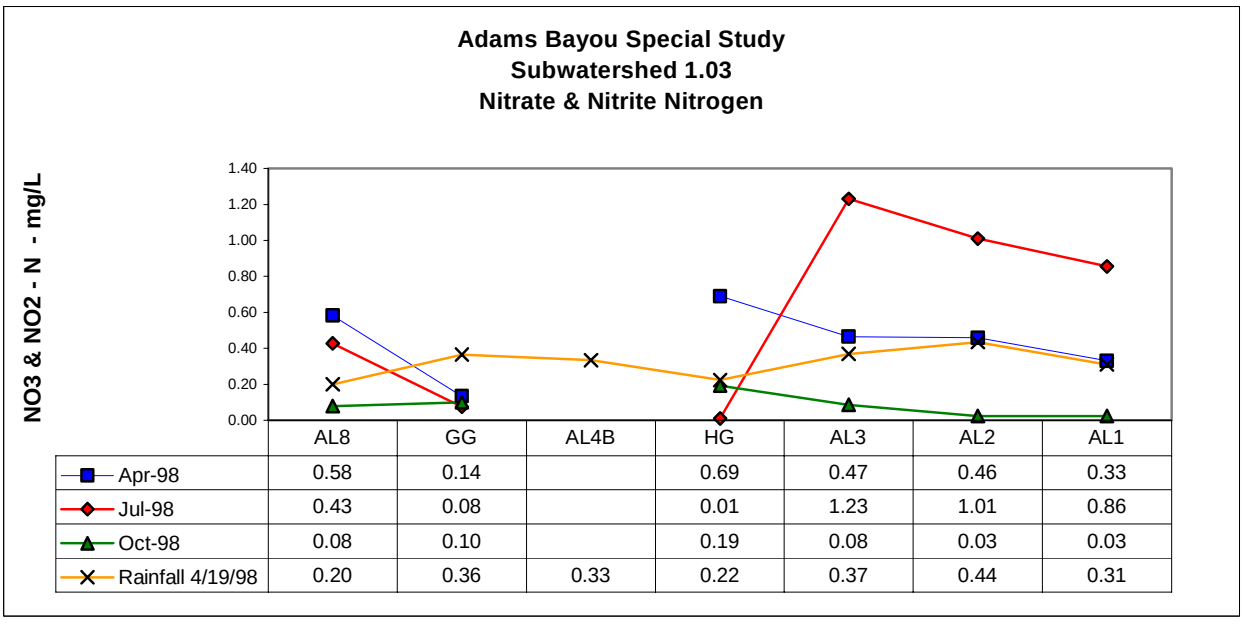
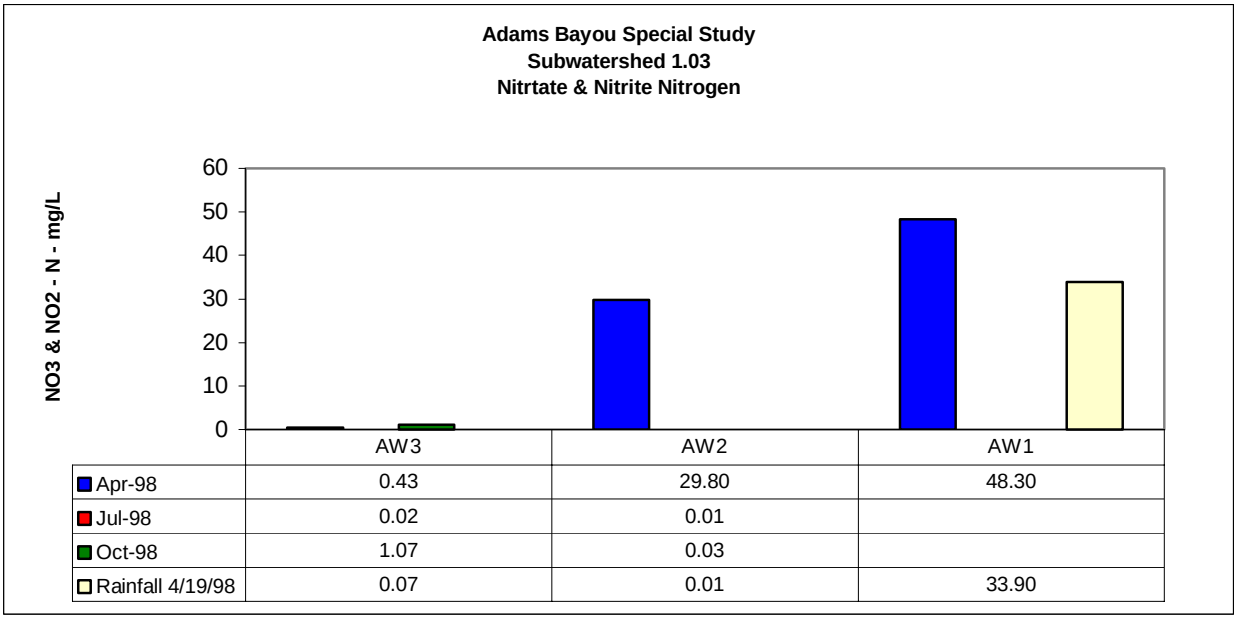


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	0.01	0.37	0.41	0.30	0.44	0.45	0.38
Jul-98		0.12	0.04	0.29	0.84	0.03	0.79
Oct-98	0.02	0.13	0.67	0.08	0.11	0.11	0.06
Jan-99							
Rainfall 4/19/98	0.31	0.11	0.18	0.10	0.09	0.10	0.11



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	0.58	0.14		0.69	0.47	0.46	0.33
Jul-98	0.43	0.08		0.01	1.23	1.01	0.86
Oct-98	0.08	0.10		0.19	0.08	0.03	0.03
Rainfall 4/19/98	0.20	0.36	0.33	0.22	0.37	0.44	0.31

Special Study on Subwatershed 1.03 – Adams Bayou

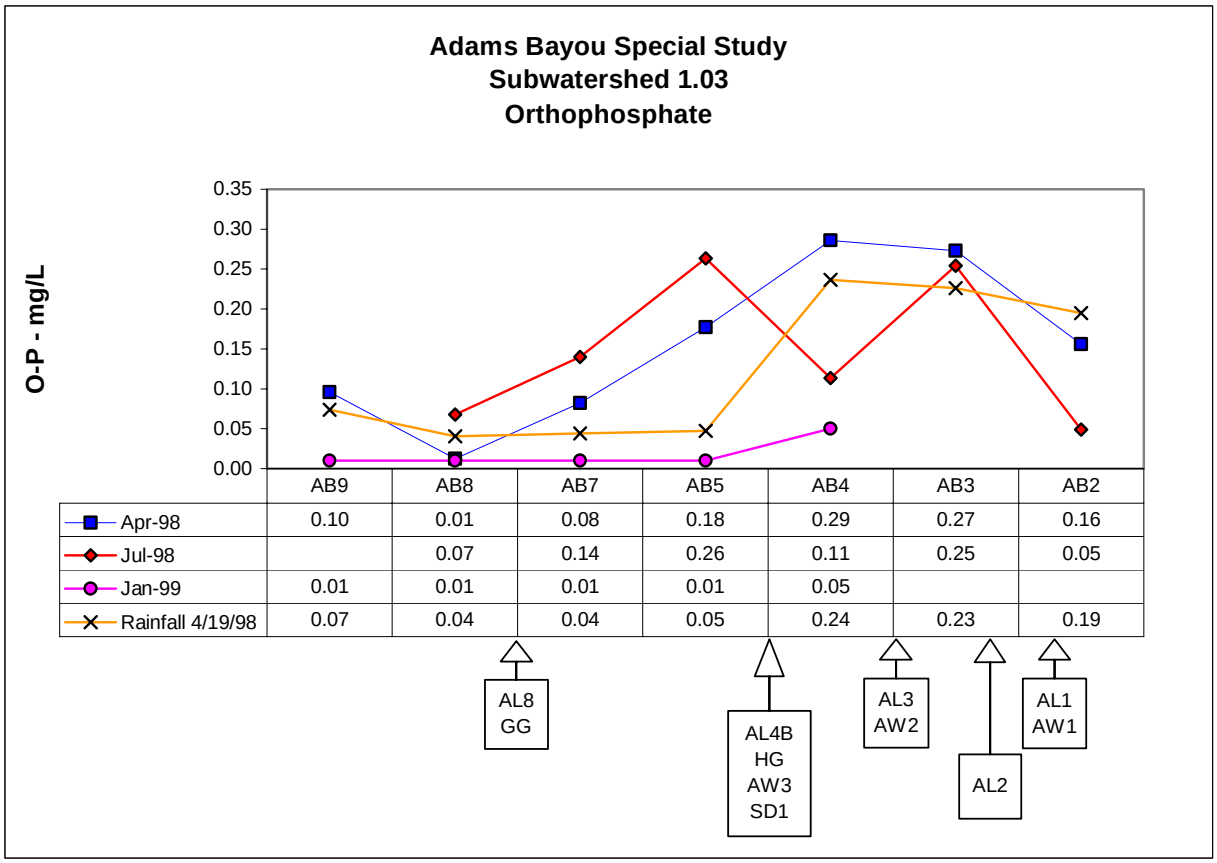


	AW3	AW2	AW1
Apr-98	0.43	29.80	48.30
Jul-98	0.02	0.01	
Oct-98	1.07	0.03	
Rainfall 4/19/98	0.07	0.01	33.90

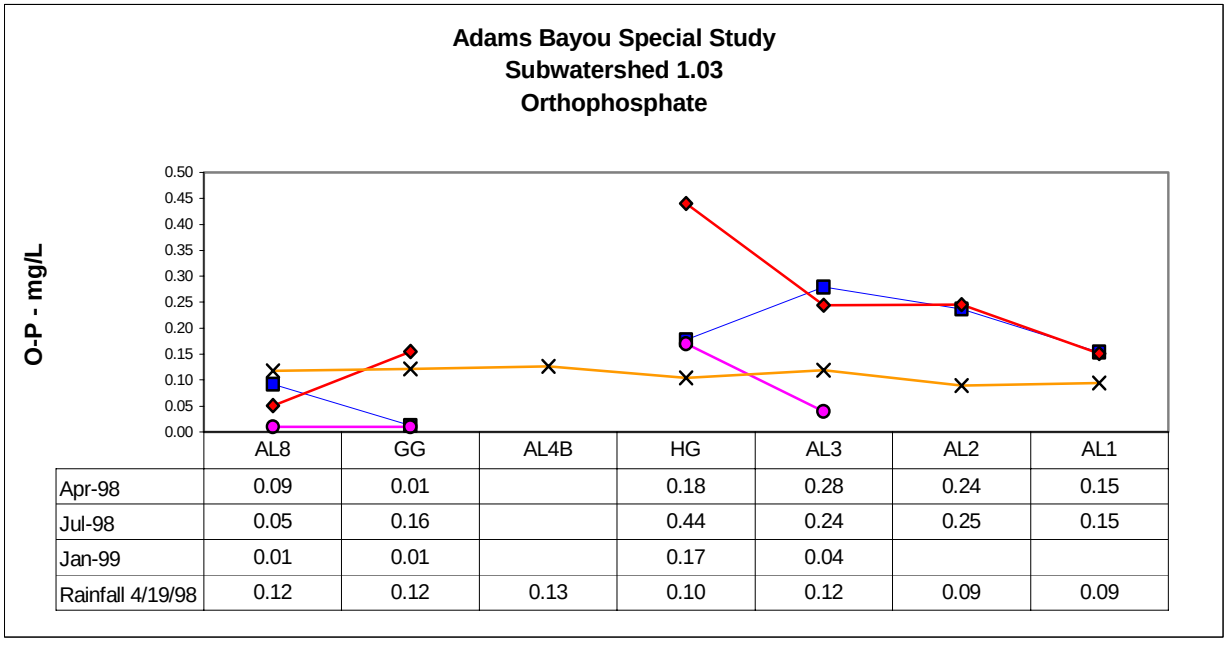
Orthophosphate

There are no stream standards for orthophosphate and the greatest threat it poses for waterbodies is nutrient enrichment. The presence of even small amounts (1 mg/L) in water can lead to excessive growth of aquatic weeds and algae. Levels of orthophosphate were low (<0.3 mg/L) at all stream sites. Values at the tributary sites were also low, but a level of 0.44 mg/L was recorded at HG. Elevated values were observed at the discharge sites and the highest value recorded was 12 mg/L at Station AW2. Treated wastewater often has elevated levels of Orthophosphate. Rainfall events did not appear to impact the orthophosphate values at the stream sites.

Special Study on Subwatershed 1.03 – Adams Bayou

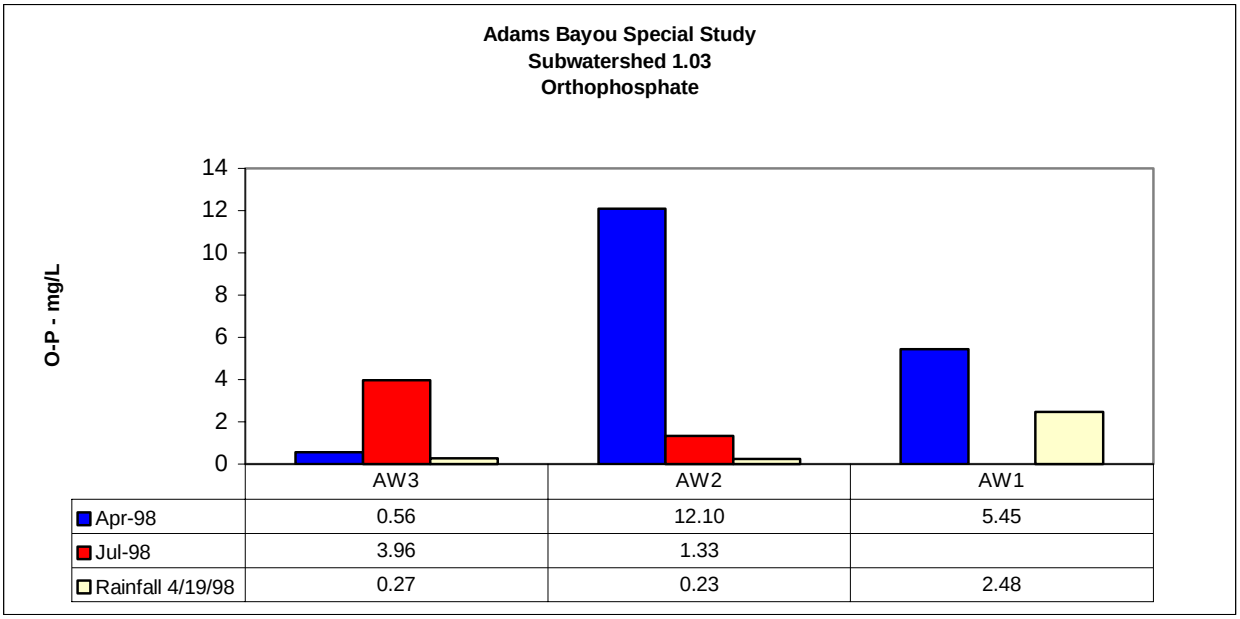


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	0.10	0.01	0.08	0.18	0.29	0.27	0.16
Jul-98		0.07	0.14	0.26	0.11	0.25	0.05
Jan-99	0.01	0.01	0.01	0.01	0.05		
Rainfall 4/19/98	0.07	0.04	0.04	0.05	0.24	0.23	0.19



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	0.09	0.01		0.18	0.28	0.24	0.15
Jul-98	0.05	0.16		0.44	0.24	0.25	0.15
Jan-99	0.01	0.01		0.17	0.04		
Rainfall 4/19/98	0.12	0.12	0.13	0.10	0.12	0.09	0.09

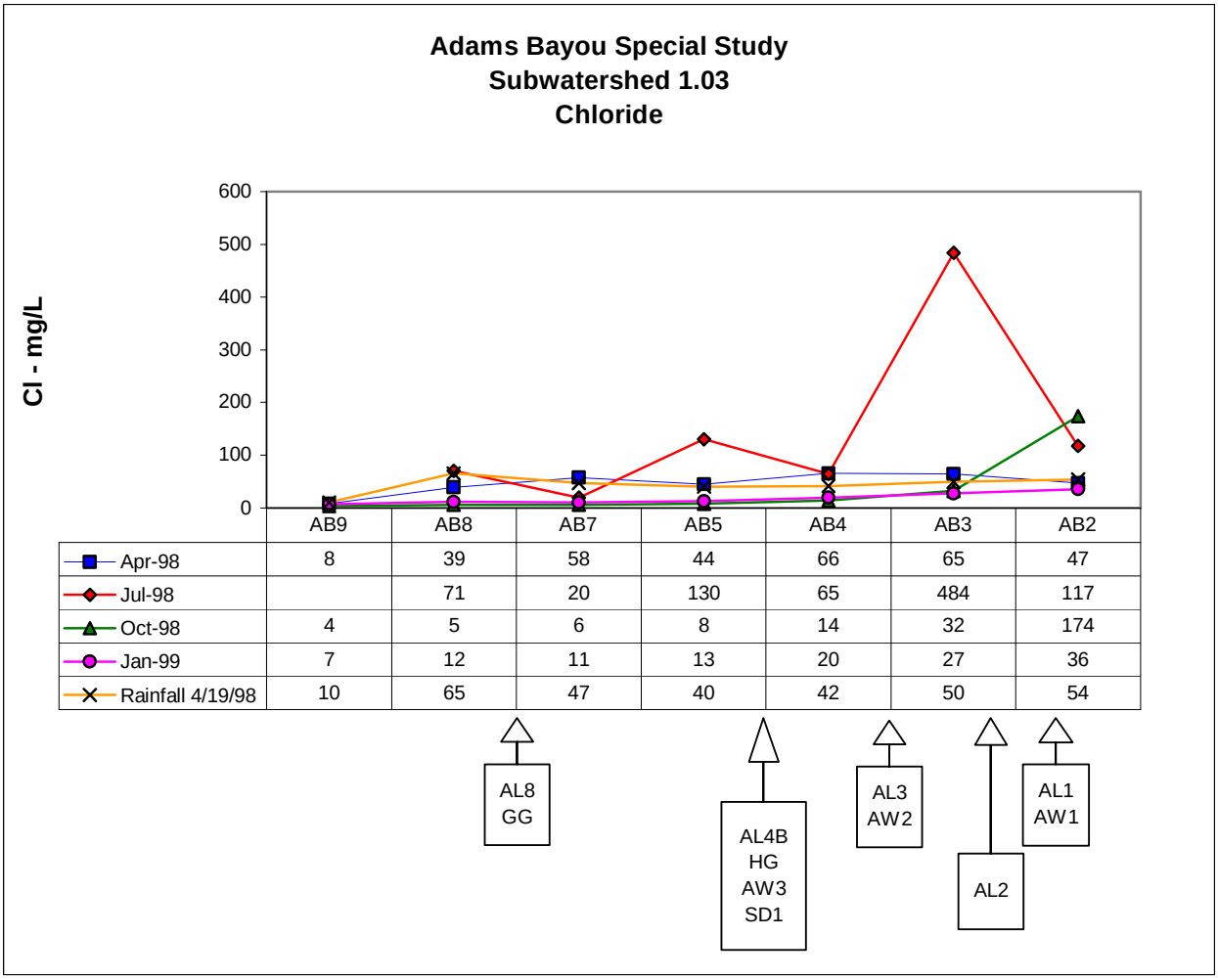
Special Study on Subwatershed 1.03 – Adams Bayou



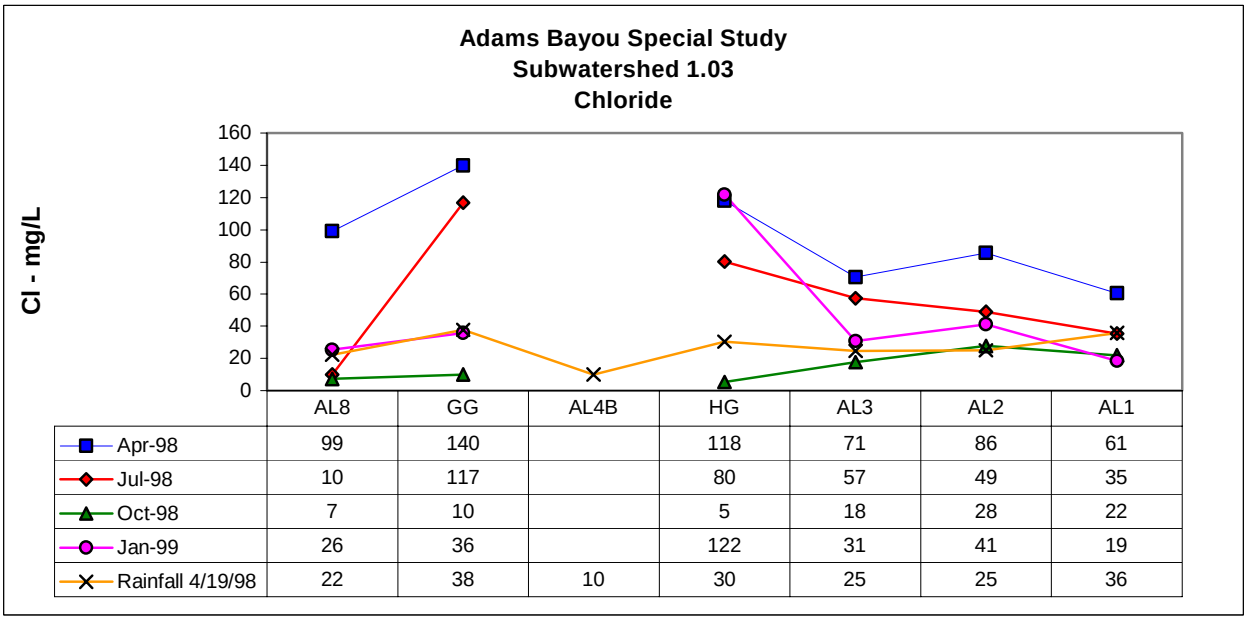
	AW3	AW2	AW1
Apr-98	0.56	12.10	5.45
Jul-98	3.96	1.33	
Rainfall 4/19/98	0.27	0.23	2.48

Chloride

No limits for chloride levels are set in TSWQS for tidally influenced segments. High levels of chlorides (600 mg/L) can negatively impact freshwater streams and higher levels (1200 mg/L) can be toxic to fish. Fluctuating levels of chlorides are normal in estuarine systems and the aquatic community is adapted for these conditions. The high chloride values in the stream sites appear to be due to natural conditions. The highest values were found at the most tidally influenced sites. Chloride levels were relatively high at the discharge sites, but well below 600 mg/L. The stream sites do not appear to be negatively impacted by the discharge sites.

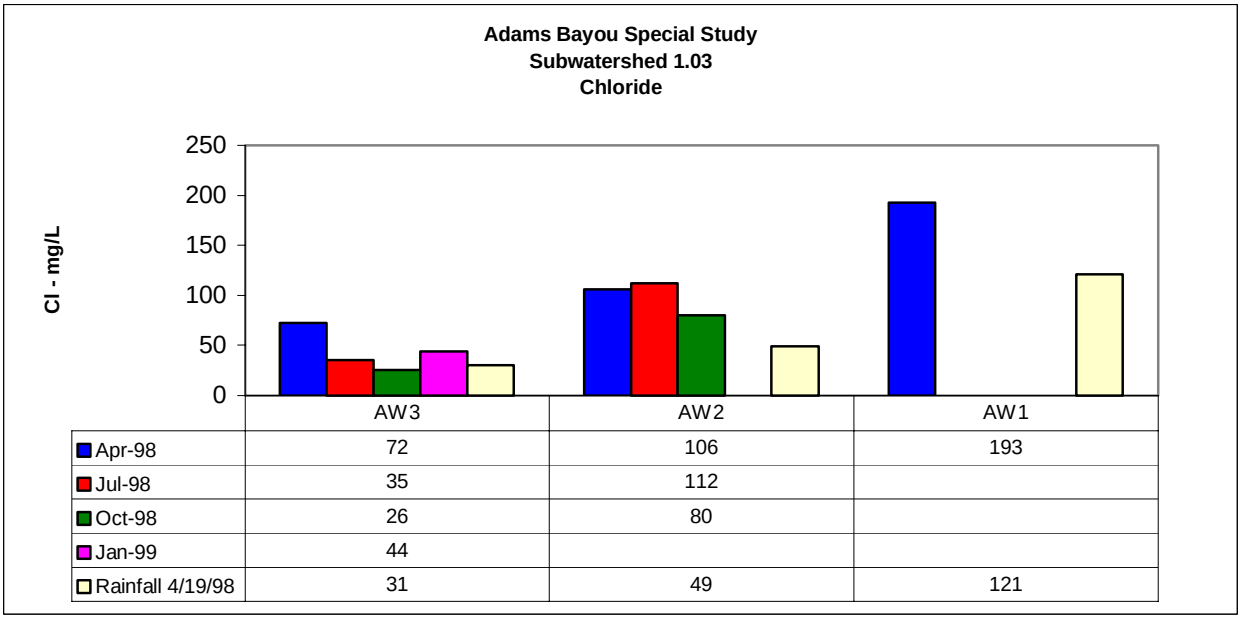


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	8	39	58	44	66	65	47
Jul-98		71	20	130	65	484	117
Oct-98	4	5	6	8	14	32	174
Jan-99	7	12	11	13	20	27	36
Rainfall 4/19/98	10	65	47	40	42	50	54



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	99	140		118	71	86	61
Jul-98	10	117		80	57	49	35
Oct-98	7	10		5	18	28	22
Jan-99	26	36		122	31	41	19
Rainfall 4/19/98	22	38	10	30	25	25	36

Special Study on Subwatershed 1.03 – Adams Bayou

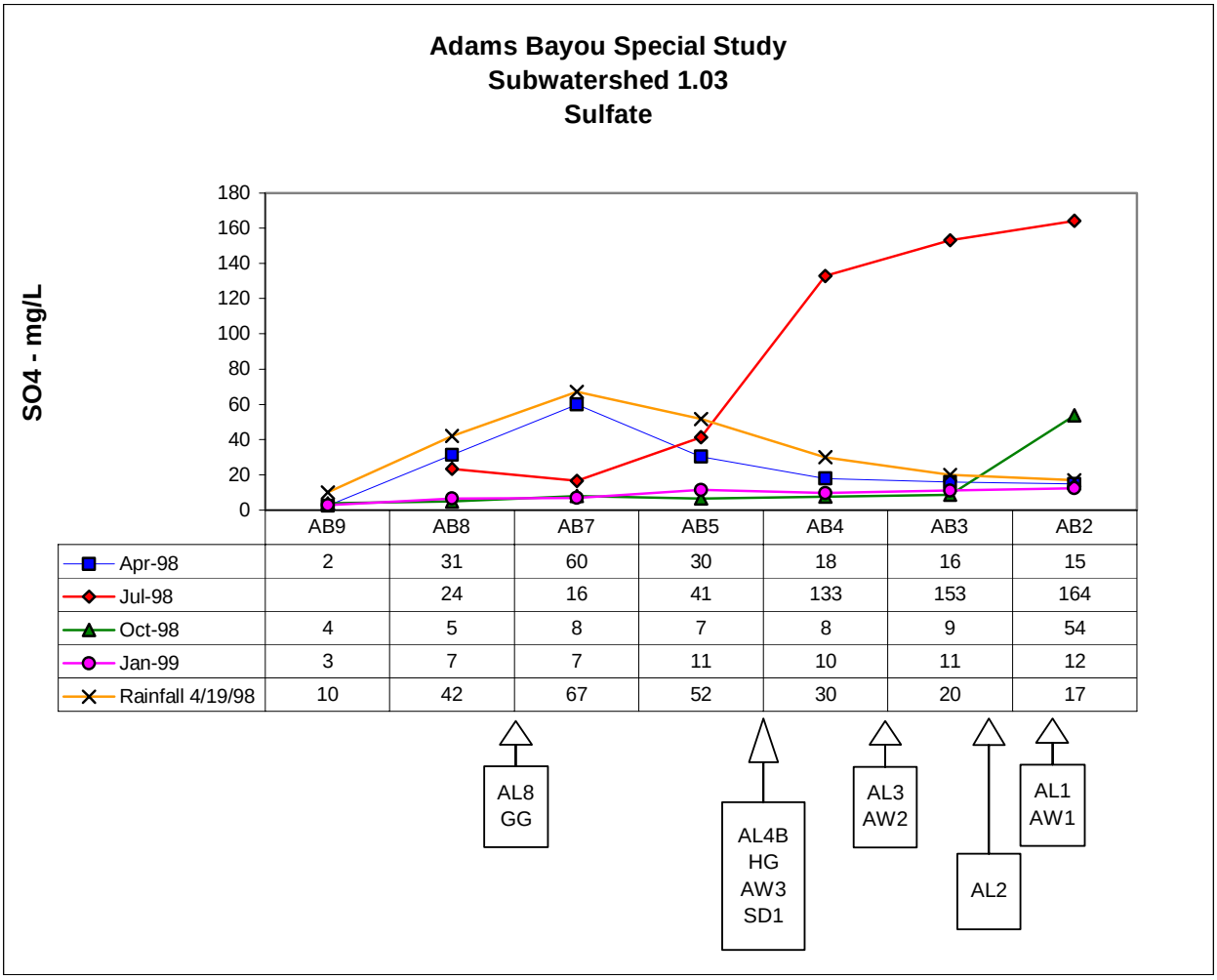


	AW3	AW2	AW1
Apr-98	72	106	193
Jul-98	35	112	
Oct-98	26	80	
Jan-99	44		
Rainfall 4/19/98	31	49	121

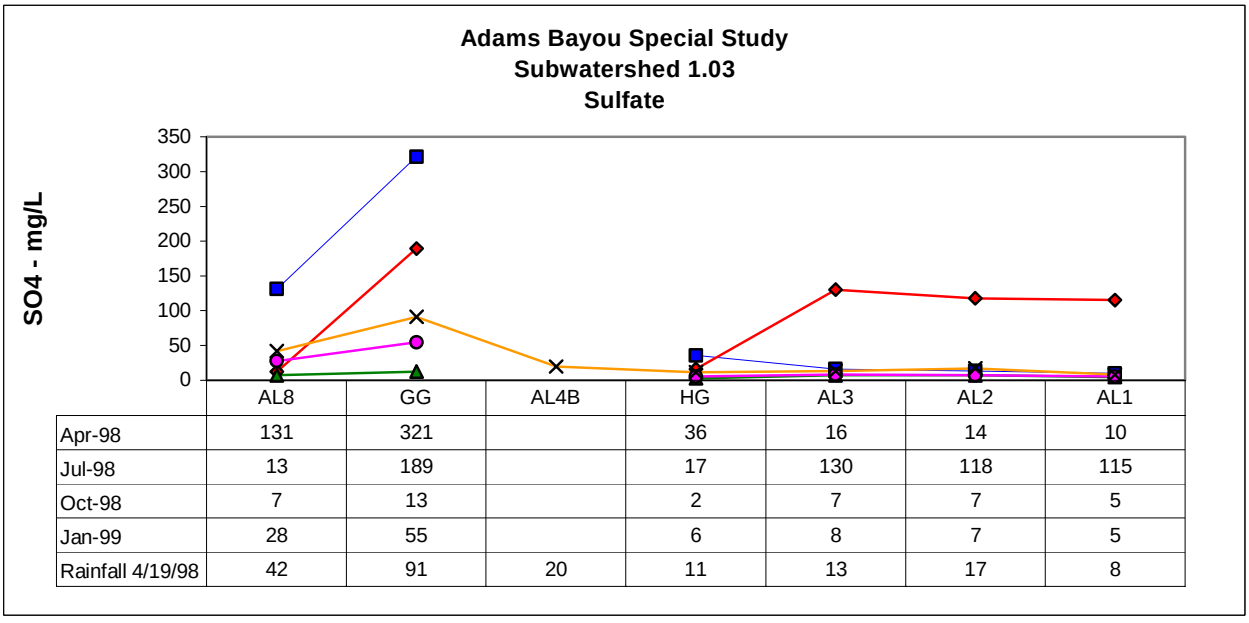
Sulfate

Sulfate limits are not set in TSWQS for tidally influenced segments. Sulfates are not considered toxic to plants or animals at normal concentrations. Taste and odor problems would become apparent long before the levels would be considered hazardous. Levels of sulfate in Sabine Basin streams are generally well below 100 mg/L. Higher levels in streams can result from the breakdown of detritus washed into the stream. Values for sulfate in the stream sites were generally well below 100 mg/L, but levels above that were detected during one sampling event at the most tidally influenced sites. Levels at the tributary sites were similar to those found at the stream sites. Unusually high values were observed at Station GG and were presumably due to nonpoint sources. Levels at the discharge sites were not unusually high and did not appear to negatively impact the stream sites.

Special Study on Subwatershed 1.03 – Adams Bayou

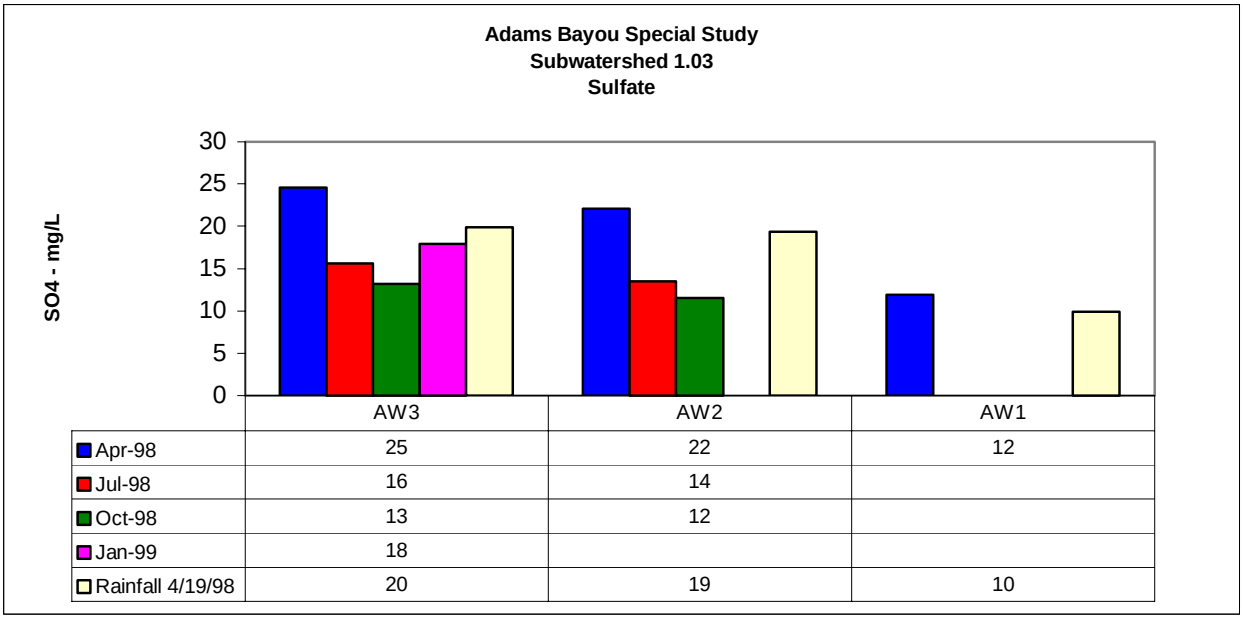


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	2	31	60	30	18	16	15
Jul-98		24	16	41	133	153	164
Oct-98	4	5	8	7	8	9	54
Jan-99	3	7	7	11	10	11	12
Rainfall 4/19/98	10	42	67	52	30	20	17



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	131	321		36	16	14	10
Jul-98	13	189		17	130	118	115
Oct-98	7	13		2	7	7	5
Jan-99	28	55		6	8	7	5
Rainfall 4/19/98	42	91	20	11	13	17	8

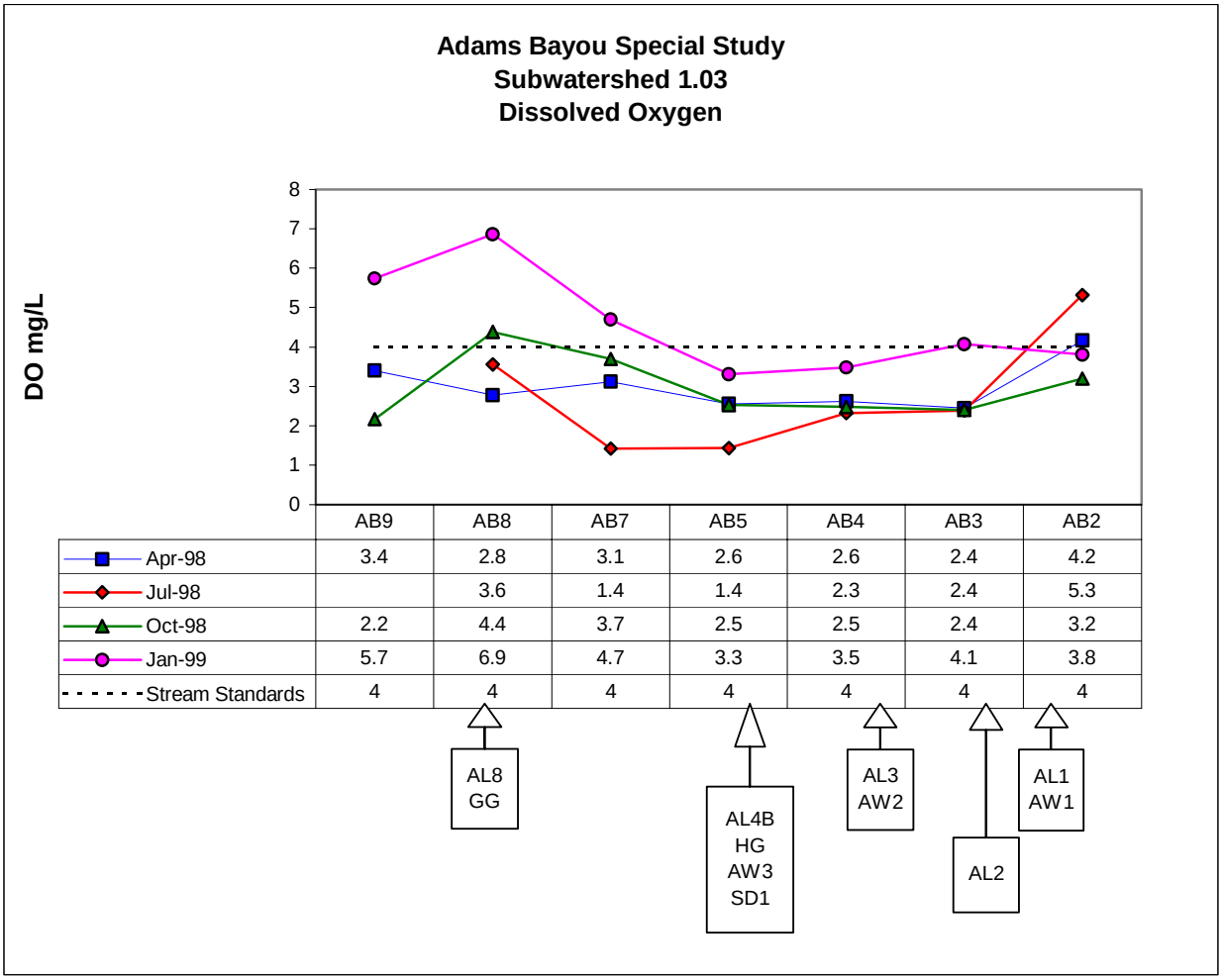
Special Study on Subwatershed 1.03 – Adams Bayou



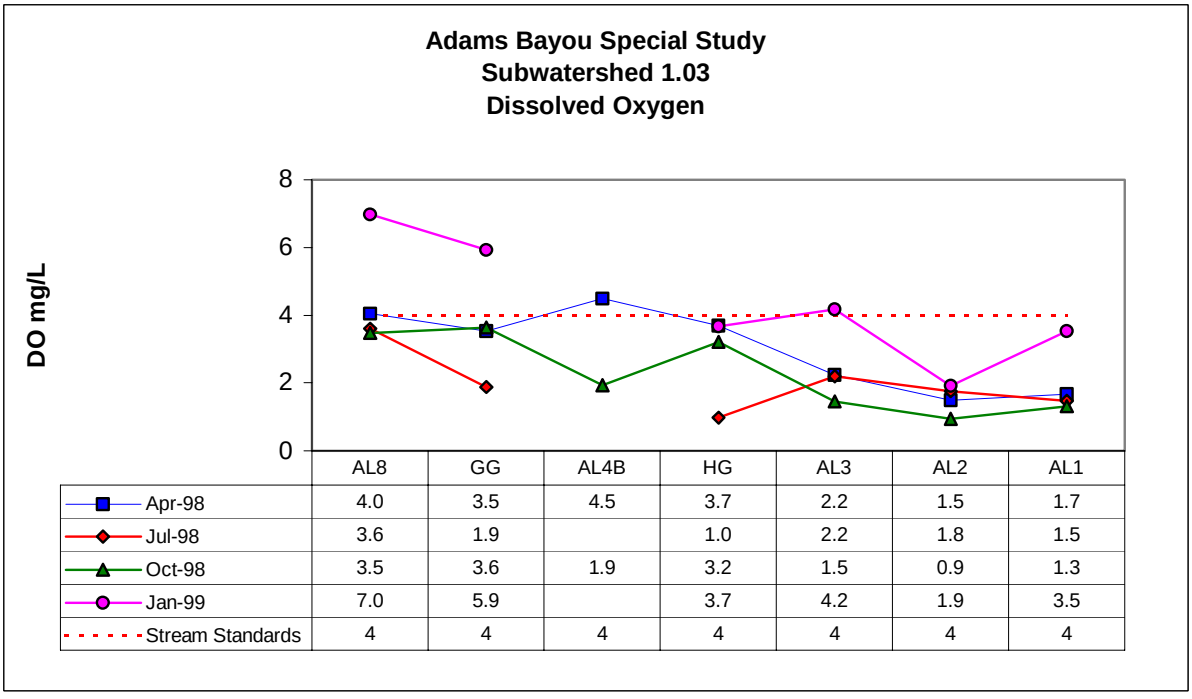
	AW3	AW2	AW1
Apr-98	25	22	12
Jul-98	16	14	
Oct-98	13	12	
Jan-99	18		
Rainfall 4/19/98	20	19	10

Dissolved Oxygen

Adequate dissolved oxygen is necessary for a healthy aquatic community and to provide for aerobic life forms that carry on natural stream purification processes. As dissolved oxygen levels in water drop below 5.0 mg/L, aquatic life is put under stress. The lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills. Stream standards for dissolved oxygen are set as the minimum average value for a 24-hour period. The daily average set in TSWQS is 4.0 mg/L with a minimum instantaneous value of 3.0 mg/L. The dissolved oxygen values were generally low at stream sites and ranged from 6.9 mg/L at AB8 to 1.4 mg/L at sites AB7 and AB5. Oxygen levels were also low at the tributary sites. The highest value was 7.0 mg/L at AL8 and the mean value was 2.9 mg/L. At Stations AB5, HG, AB4, AL2, and AL1 the dissolved oxygen values were never above the 4 mg/L standard during routine quarterly monitoring. Dissolved oxygen readings observed during rainfall events closely followed the values observed during the quarterly monitoring with some improvements seen at Station HG. Values at the permitted discharge sites were consistently above the TSWQS standards of 4 mg/L. The low oxygen levels in Adams Bayou are apparently due to excessive demands from the decomposition of organic material from both point and nonpoint sources.

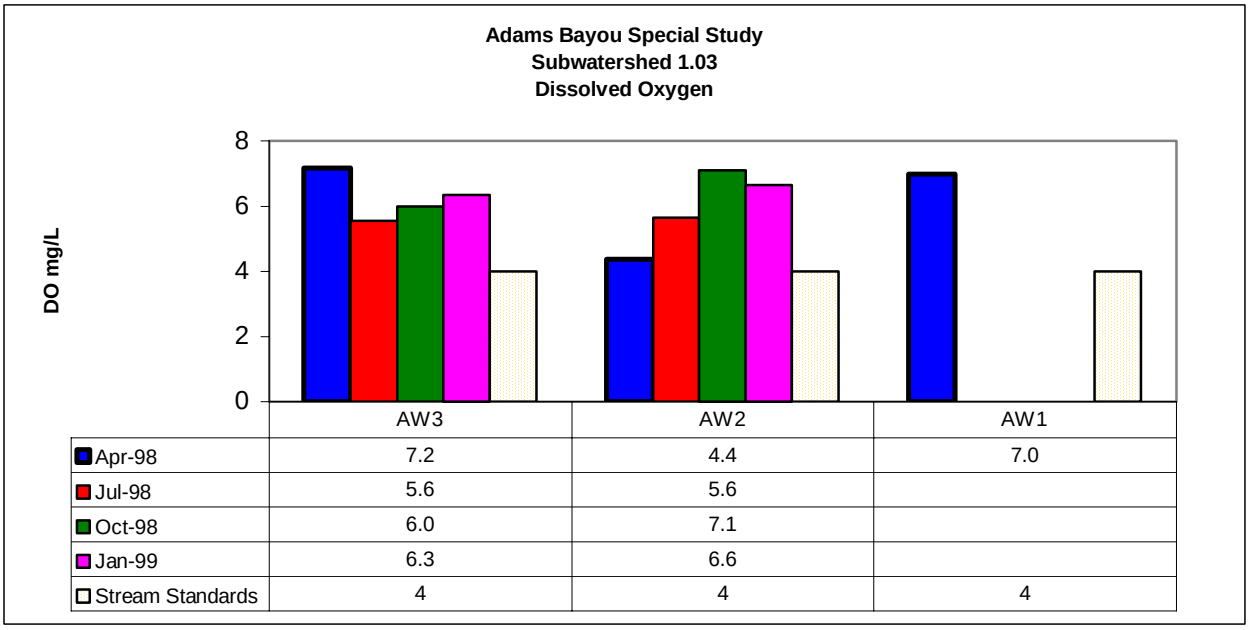


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	3.4	2.8	3.1	2.6	2.6	2.4	4.2
Jul-98		3.6	1.4	1.4	2.3	2.4	5.3
Oct-98	2.2	4.4	3.7	2.5	2.5	2.4	3.2
Jan-99	5.7	6.9	4.7	3.3	3.5	4.1	3.8
Stream Standards	4	4	4	4	4	4	4

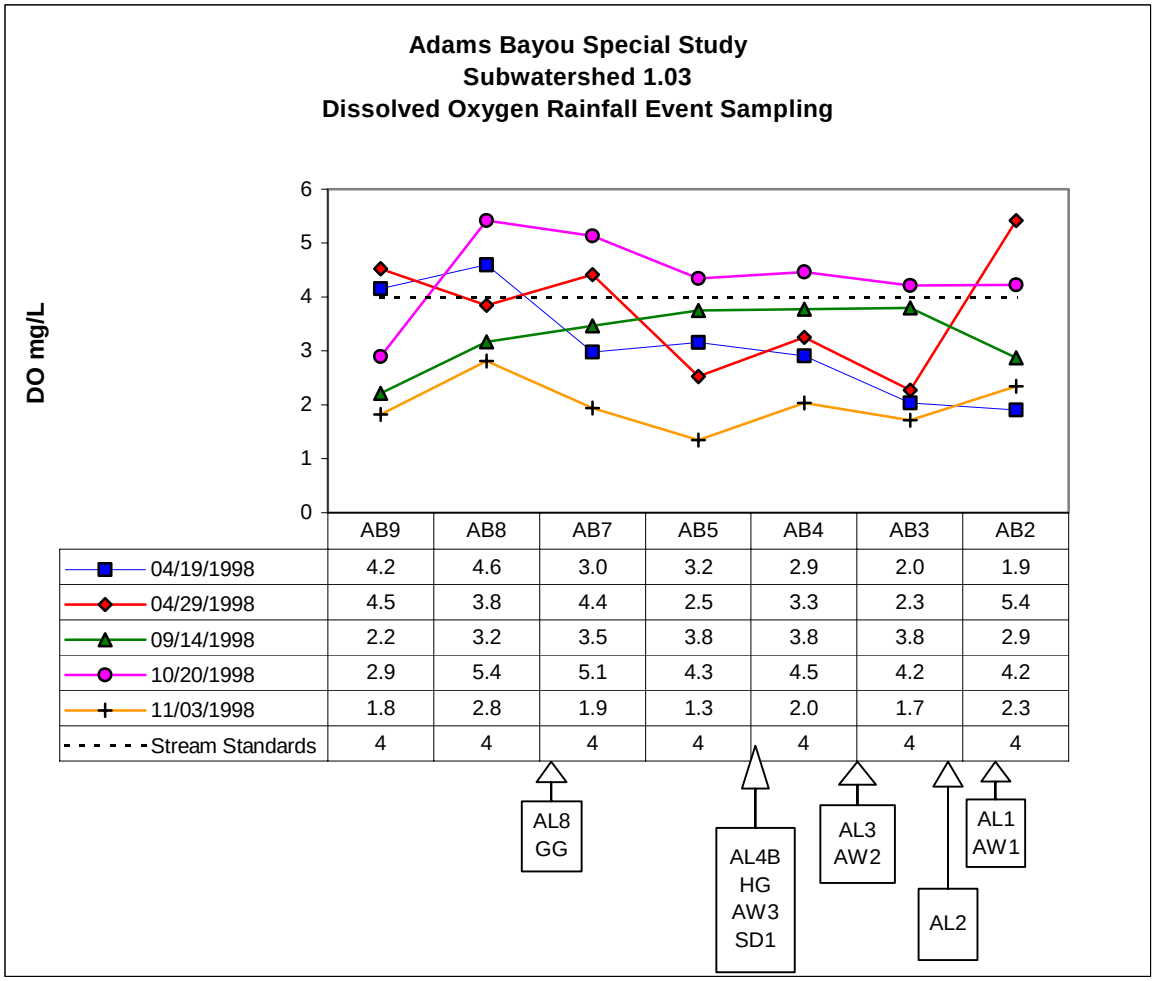


	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	4.0	3.5	4.5	3.7	2.2	1.5	1.7
Jul-98	3.6	1.9		1.0	2.2	1.8	1.5
Oct-98	3.5	3.6	1.9	3.2	1.5	0.9	1.3
Jan-99	7.0	5.9		3.7	4.2	1.9	3.5
Stream Standards	4	4	4	4	4	4	4

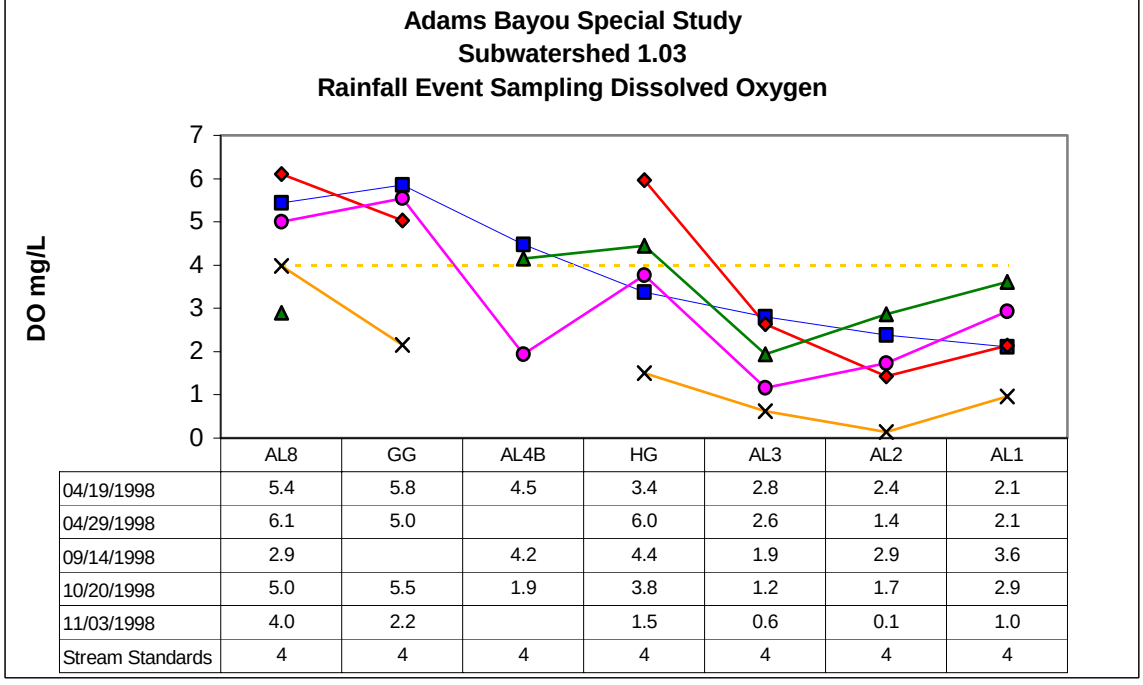
Special Study on Subwatershed 1.03 – Adams Bayou



	AW3	AW2	AW1
Apr-98	7.2	4.4	7.0
Jul-98	5.6	5.6	
Oct-98	6.0	7.1	
Jan-99	6.3	6.6	
Stream Standards	4	4	4

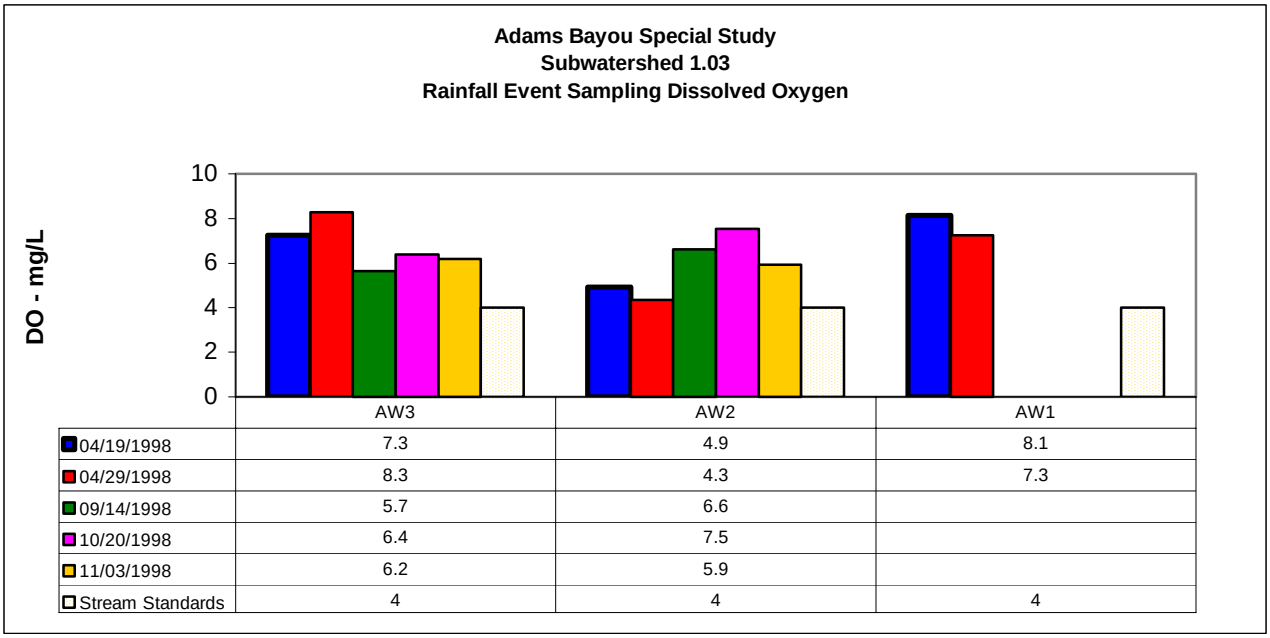


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
04/19/1998	4.2	4.6	3.0	3.2	2.9	2.0	1.9
04/29/1998	4.5	3.8	4.4	2.5	3.3	2.3	5.4
09/14/1998	2.2	3.2	3.5	3.8	3.8	3.8	2.9
10/20/1998	2.9	5.4	5.1	4.3	4.5	4.2	4.2
11/03/1998	1.8	2.8	1.9	1.3	2.0	1.7	2.3
Stream Standards	4	4	4	4	4	4	4



	AL8	GG	AL4B	HG	AL3	AL2	AL1
04/19/1998	5.4	5.8	4.5	3.4	2.8	2.4	2.1
04/29/1998	6.1	5.0		6.0	2.6	1.4	2.1
09/14/1998	2.9		4.2	4.4	1.9	2.9	3.6
10/20/1998	5.0	5.5	1.9	3.8	1.2	1.7	2.9
11/03/1998	4.0	2.2		1.5	0.6	0.1	1.0
Stream Standards	4	4	4	4	4	4	4

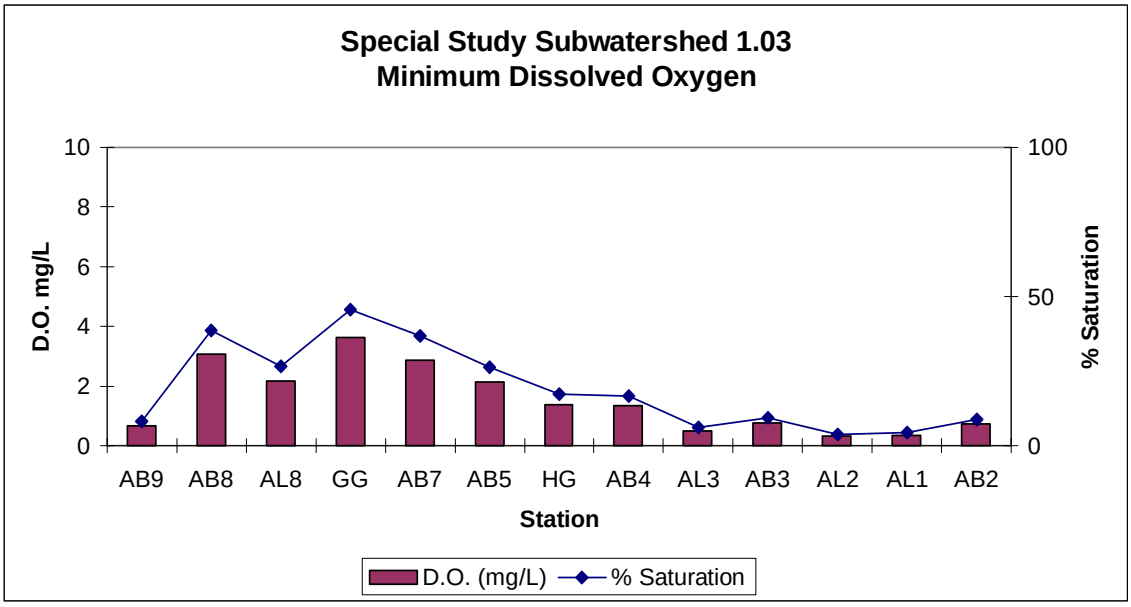
Special Study on Subwatershed 1.03 – Adams Bayou



	AW3	AW2	AW1
04/19/1998	7.3	4.9	8.1
04/29/1998	8.3	4.3	7.3
09/14/1998	5.7	6.6	
10/20/1998	6.4	7.5	
11/03/1998	6.2	5.9	
Stream Standards	4	4	4

Minimum Dissolved Oxygen

Dissolved oxygen concentrations cycle from highs to lows with the cycle of daylight and darkness. In turbid waters such as Adams Bayou, diffusion of atmospheric oxygen can be the major source of oxygen for the stream. Aquatic plants also produce oxygen for the stream in the presence of sufficient light and the oxygen is diffused into the water body. During the periods of darkness, the plants and animals in the aquatic community can consume more oxygen than the stream can supply. Dissolved oxygen is usually at its lowest level just prior to daylight. Dissolved oxygen measurements were taken within two hours of sunrise at selected stream sites to determine minimum values. While sites AB8 and GG had levels above 3.0 mg/L, the values were less than 3 mg/L at the majority of the stations. The lowest values (<1.0 mg/L) were observed at AB9, AL3, AB3, AL2, AL1, and AB2. This indicates an extremely stressed environment for the aquatic community.



Fecal Coliform

Coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals. Their normal function is to aid in the digestion of food. Fecal coliform bacteria are a specific subgroup of this collection and the most common member is *Escherichia coli*. These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals.

The presence of fecal coliform bacteria in aquatic environments indicates contamination with the fecal material of man or other animals. The water may also be contaminated by pathogens or disease producing bacteria or viruses, which can exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water due to the overflow of domestic sewage or nonpoint sources of human and animal waste.

The TSWQS fecal coliform limit in water used for contact recreation is 200 colonies per 100 mL of water. This limit is a geometric mean, which is based on a minimum of five samples collected in a 30-day period. The highest geometric mean for fecal coliform at the stream sites was 3,731 colonies/100 mL at AB9. With the exception of AB2, violations of the stream standards occurred at all of the stream sites during almost every sampling event. Levels of fecal coliform were also in violation of stream standards at all of the tributary sites. Permitted discharge sites were generally lower than the stream sites, but no site was consistently below the acceptable limit. The results from the differentiation tests indicated that all of the bacteria present from the fecal coliform group were *Escherichia coli*. These results indicate sewage contamination is present throughout the Adams Bayou Subwatershed.

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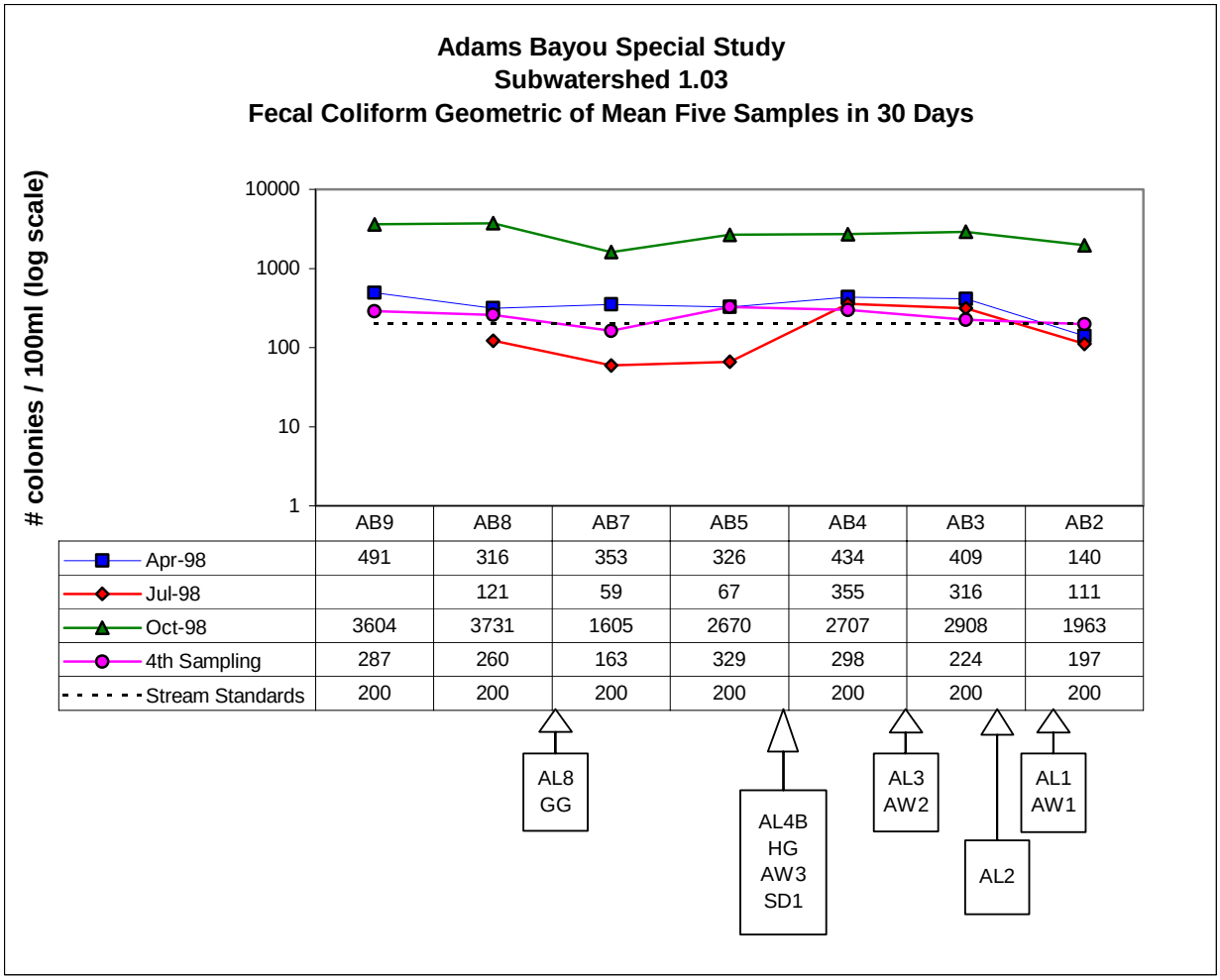
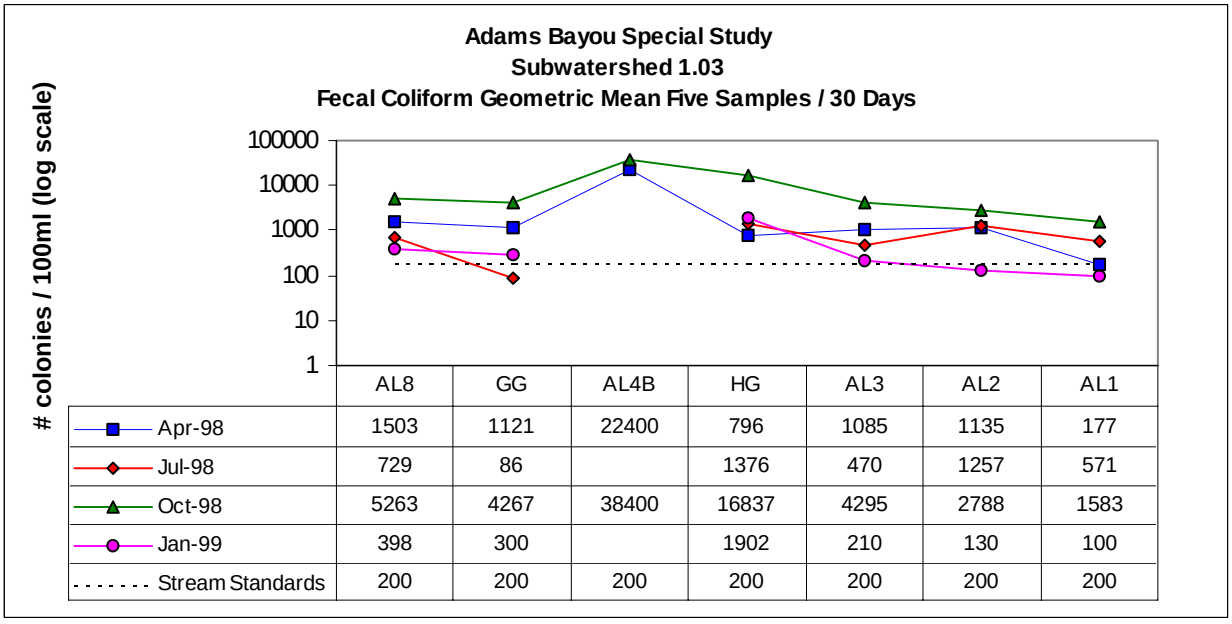


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
Apr-98	491	316	353	326	434	409	140
Jul-98		121	59	67	355	316	111
Oct-98	3604	3731	1605	2670	2707	2908	1963
4th Sampling	287	260	163	329	298	224	197
Stream Standards	200	200	200	200	200	200	200



	AL8	GG	AL4B	HG	AL3	AL2	AL1
Apr-98	1503	1121	22400	796	1085	1135	177
Jul-98	729	86		1376	470	1257	571
Oct-98	5263	4267	38400	16837	4295	2788	1583
Jan-99	398	300		1902	210	130	100
Stream Standards	200	200	200	200	200	200	200

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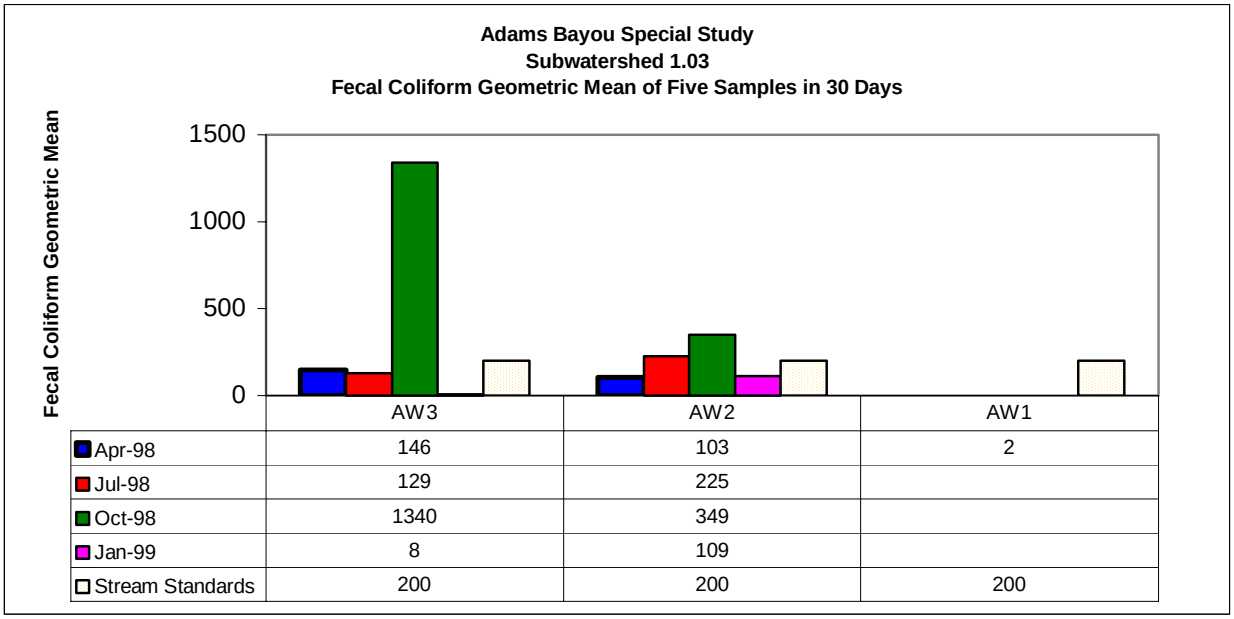

	AW3	AW2	AW1
Apr-98	146	103	2
Jul-98	129	225	
Oct-98	1340	349	
Jan-99	8	109	
Stream Standards	200	200	200

Fecal Coliform - Rainfall Events

Rainfall events typically cause an elevation of fecal coliform levels in streams due to contaminated runoff. Values during rainfall events closely matched results from routine sampling. Fecal coliform levels at AB2 exceeded 200 colonies per 100 mL in four out of the five rainfall sampling events. All of the other stream sites were always above the stream standards during every sampling event. Similar results were observed at the tributary sites with only sites AL2 and AL1 below the 200-colony limit in only one of the five sampling events. The results at the discharge sites were generally higher during the rainfall sampling events than during the routine sampling.

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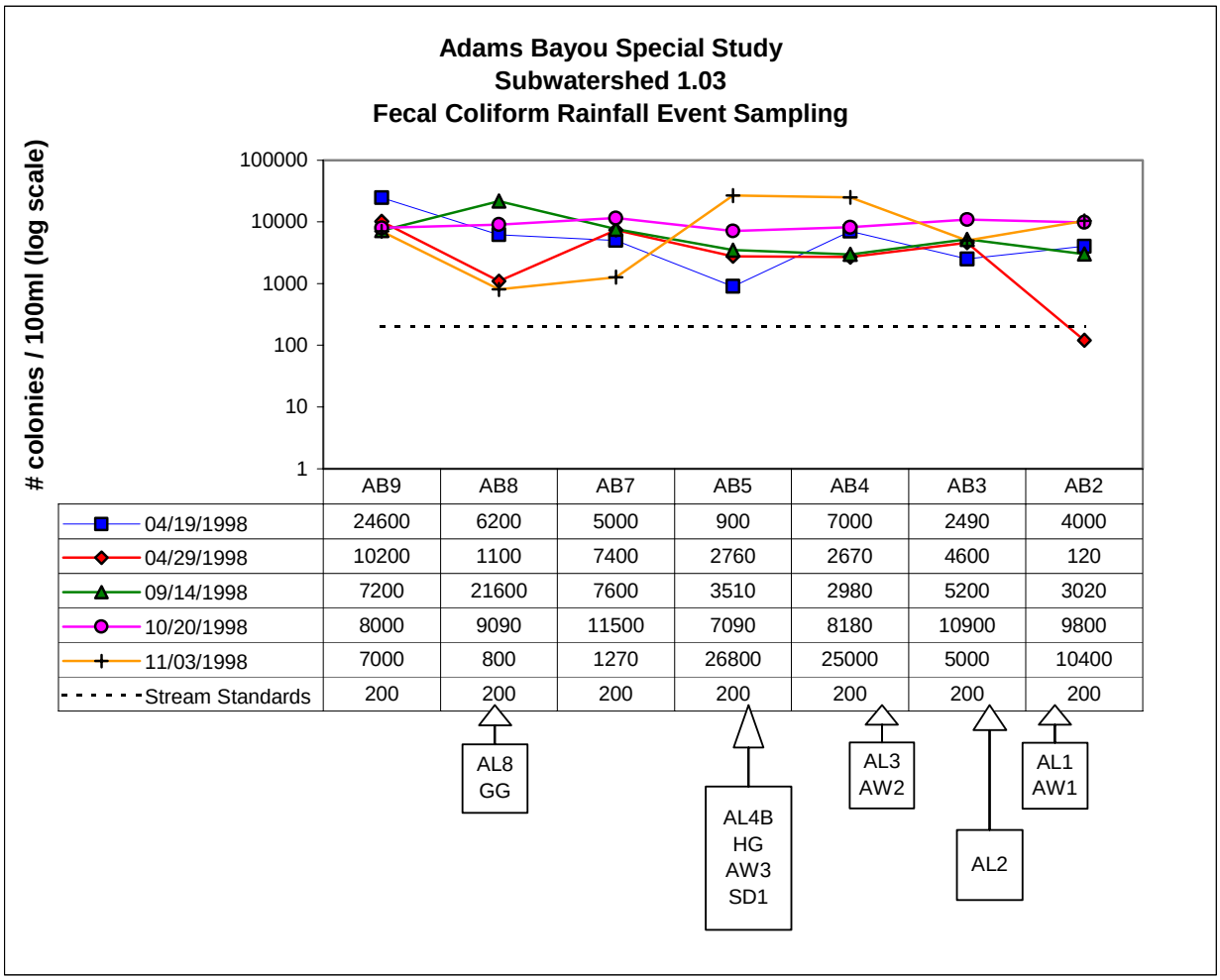
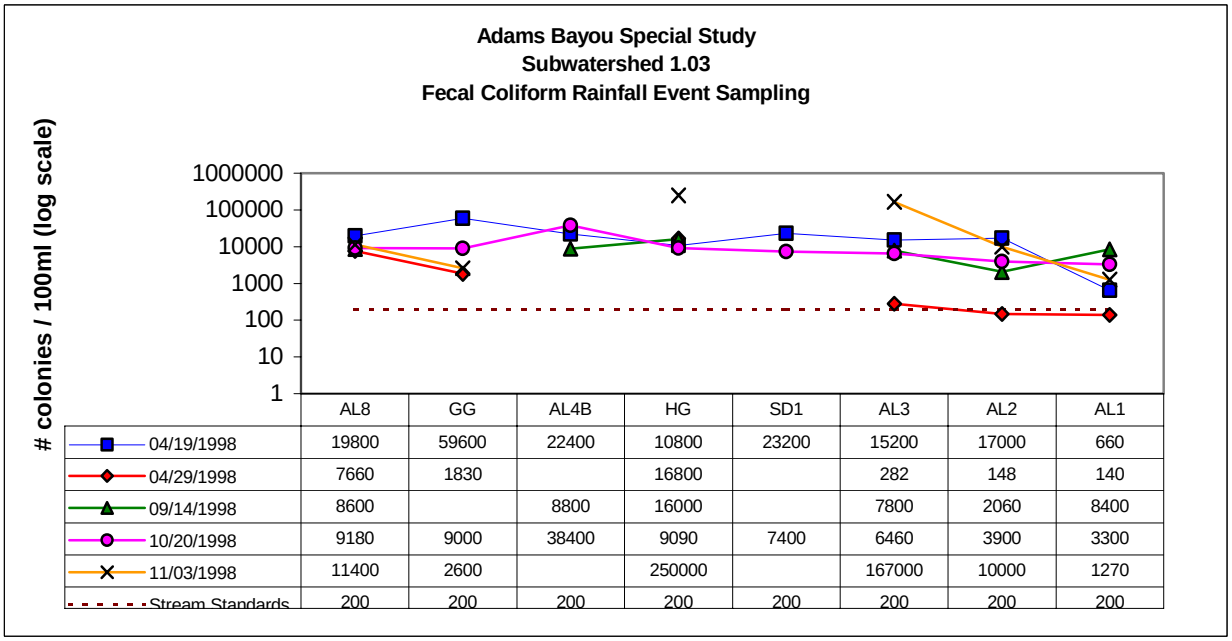
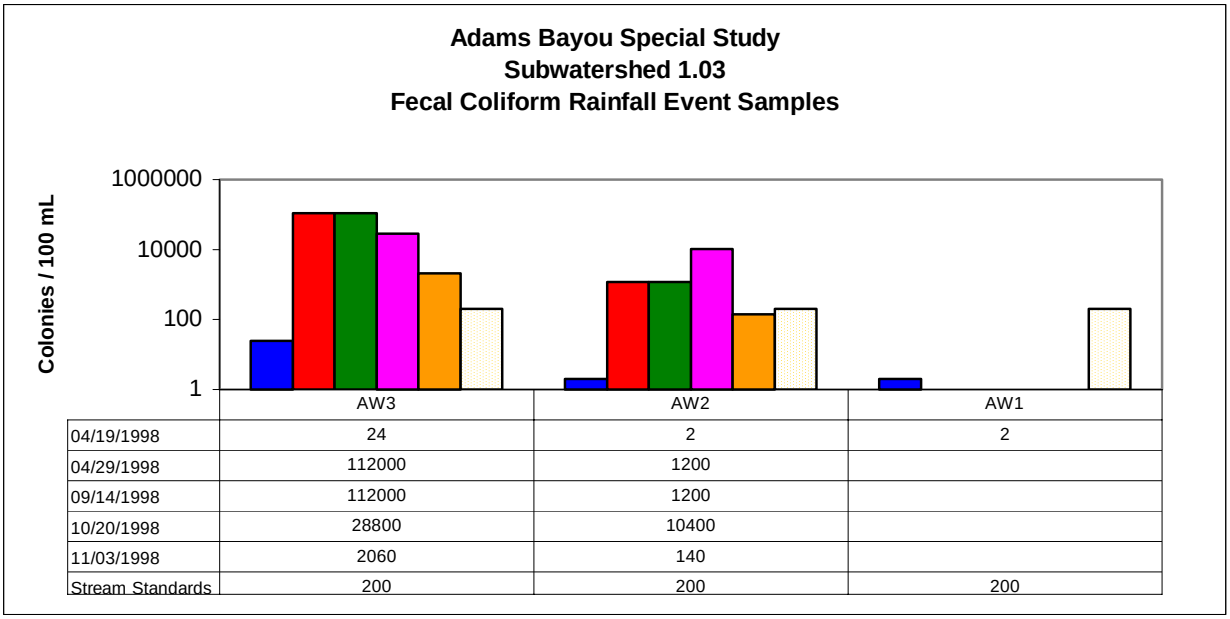


	AB9	AB8	AB7	AB5	AB4	AB3	AB2
04/19/1998	24600	6200	5000	900	7000	2490	4000
04/29/1998	10200	1100	7400	2760	2670	4600	120
09/14/1998	7200	21600	7600	3510	2980	5200	3020
10/20/1998	8000	9090	11500	7090	8180	10900	9800
11/03/1998	7000	800	1270	26800	25000	5000	10400
Stream Standards	200	200	200	200	200	200	200



	AL8	GG	AL4B	HG	SD1	AL3	AL2	AL1
04/19/1998	19800	59600	22400	10800	23200	15200	17000	660
04/29/1998	7660	1830		16800		282	148	140
09/14/1998	8600		8800	16000		7800	2060	8400
10/20/1998	9180	9000	38400	9090	7400	6460	3900	3300
11/03/1998	11400	2600		250000		167000	10000	1270
Stream Standards	200	200	200	200	200	200	200	200

Special Study on Subwatershed 1.03 – Adams Bayou

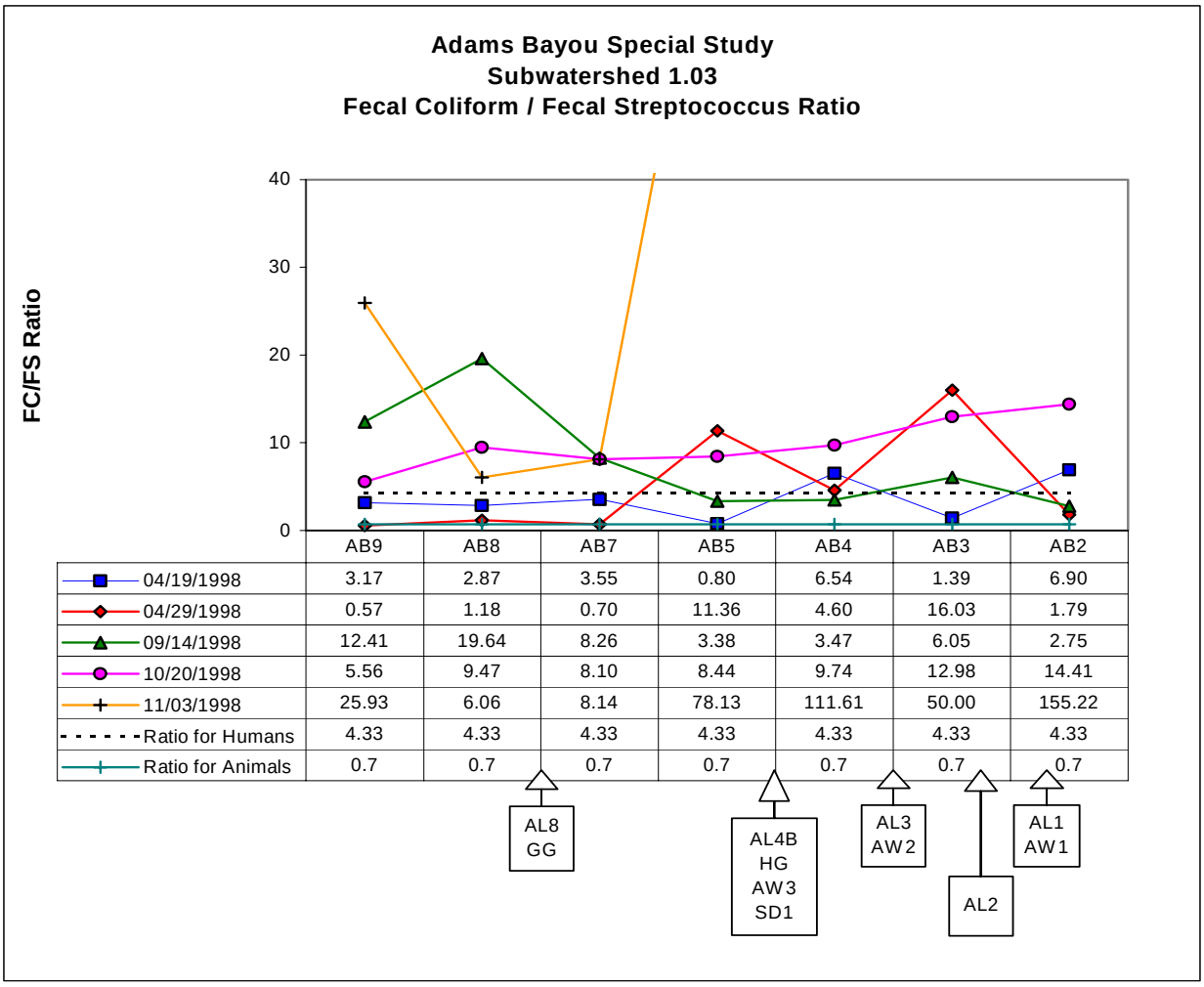


	AW3	AW2	AW1
04/19/1998	24	2	2
04/29/1998	112000	1200	
09/14/1998	112000	1200	
10/20/1998	28800	10400	
11/03/1998	2060	140	
Stream Standards	200	200	200

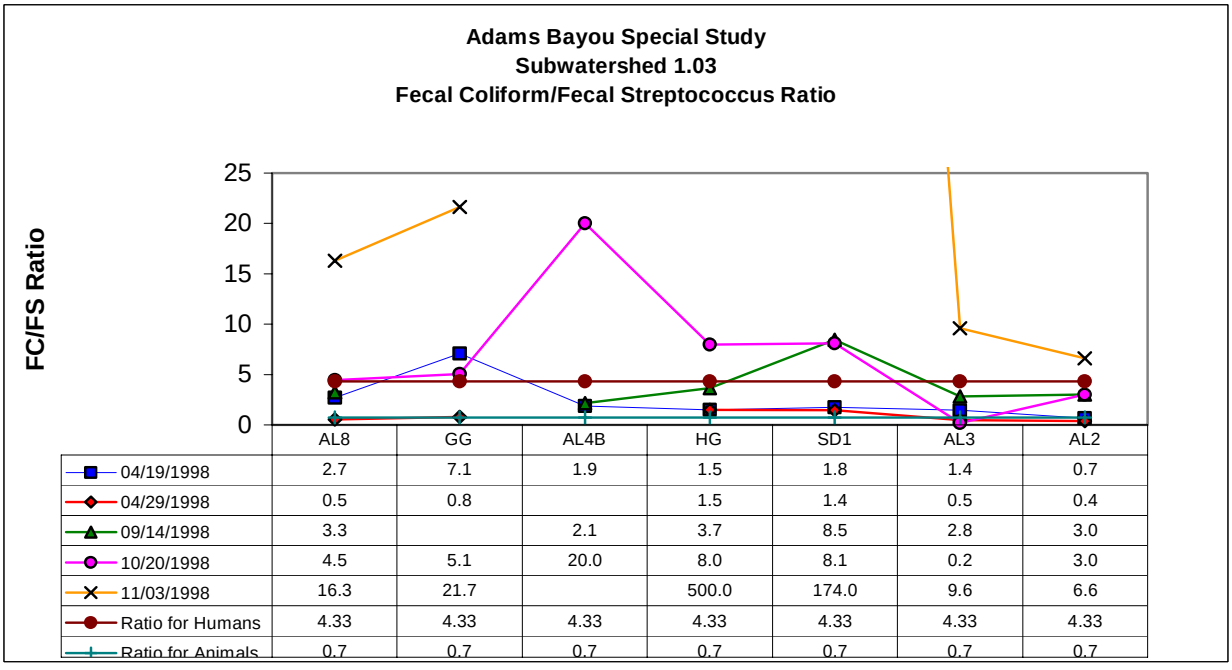
Fecal Coliform/Fecal Streptococcus Ratio

Fecal coliform to fecal streptococcus ratios were measured during rainfall events to help determine the source of fecal contamination. Contamination due to human sources should show ratios at 4.3 or higher and animal sources would have a ratio of 0.7 or less. Ratios of fecal coliform to fecal streptococcus during rainfall events ranged from above 4.3 (ratio for humans) to less than 0.7 (ratio for animals). No site was consistently above 4.3 or below 0.7. These results, while inconclusive, indicate that some of the contamination could be from non-point sources.

Special Study on Subwatershed 1.03 – Adams Bayou



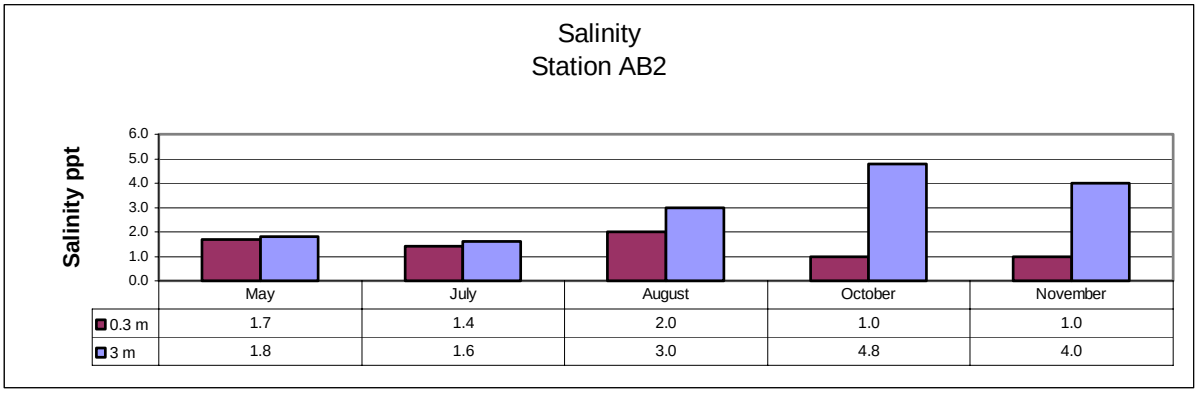
	AB9	AB8	AB7	AB5	AB4	AB3	AB2
04/19/1998	3.17	2.87	3.55	0.80	6.54	1.39	6.90
04/29/1998	0.57	1.18	0.70	11.36	4.60	16.03	1.79
09/14/1998	12.41	19.64	8.26	3.38	3.47	6.05	2.75
10/20/1998	5.56	9.47	8.10	8.44	9.74	12.98	14.41
11/03/1998	25.93	6.06	8.14	78.13	111.61	50.00	155.22
Ratio for Humans	4.33	4.33	4.33	4.33	4.33	4.33	4.33
Ratio for Animals	0.7	0.7	0.7	0.7	0.7	0.7	0.7



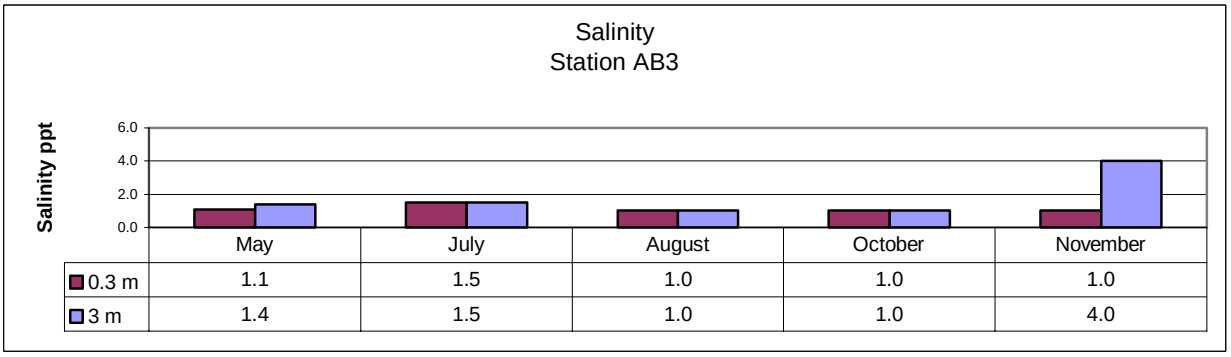
	AL8	GG	AL4B	HG	SD1	AL3	AL2
04/19/1998	2.7	7.1	1.9	1.5	1.8	1.4	0.7
04/29/1998	0.5	0.8		1.5	1.4	0.5	0.4
09/14/1998	3.3		2.1	3.7	8.5	2.8	3.0
10/20/1998	4.5	5.1	20.0	8.0	8.1	0.2	3.0
11/03/1998	16.3	21.7		500.0	174.0	9.6	6.6
Ratio for Humans	4.33	4.33	4.33	4.33	4.33	4.33	4.33
Ratio for Animals	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Salinity

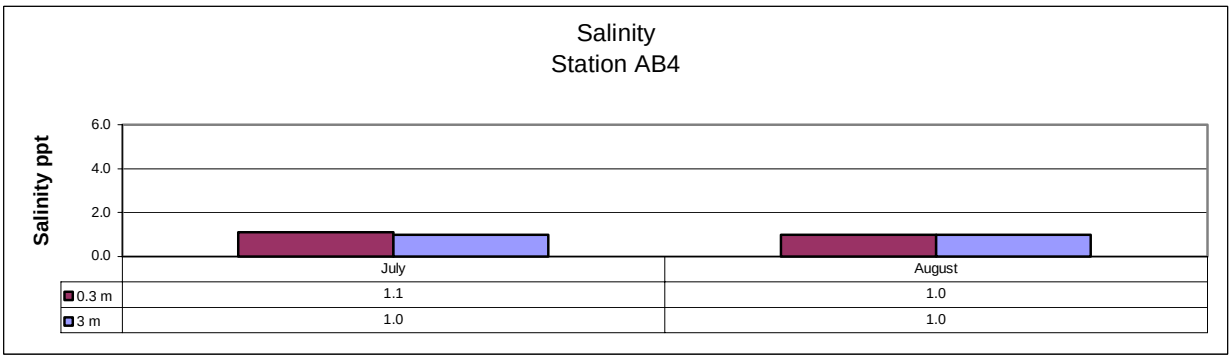
The salinity ranged from 4.8 parts per thousand (ppt) at Station AB2 to 1 ppt at Stations AB3 and AB4. The salinity measurements at Station AB2 showed higher readings at a depth of three meters. This indicates strong tidal influence at this site. Salinity was not observed at the other stream sites.



	May	July	August	October	November
0.3 m	1.7	1.4	2.0	1.0	1.0
3 m	1.8	1.6	3.0	4.8	4.0



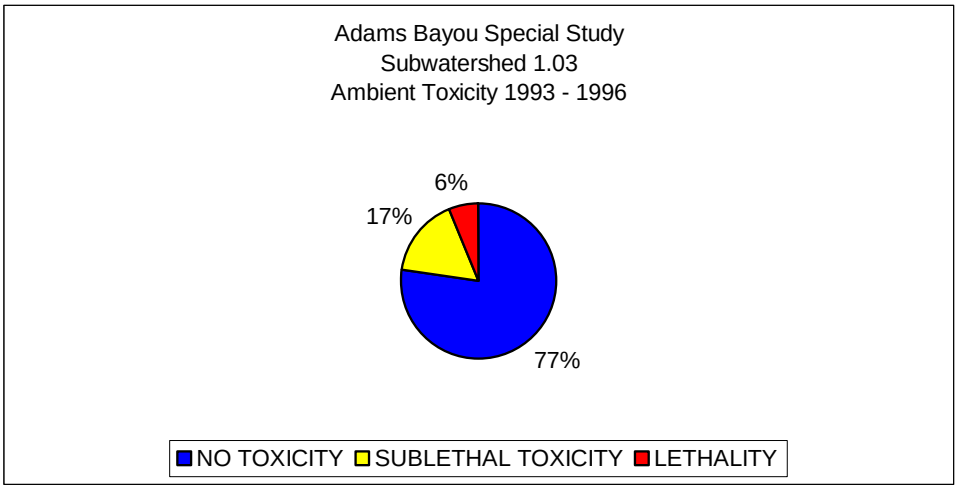
	May	July	August	October	November
0.3 m	1.1	1.5	1.0	1.0	1.0
3 m	1.4	1.5	1.0	1.0	4.0

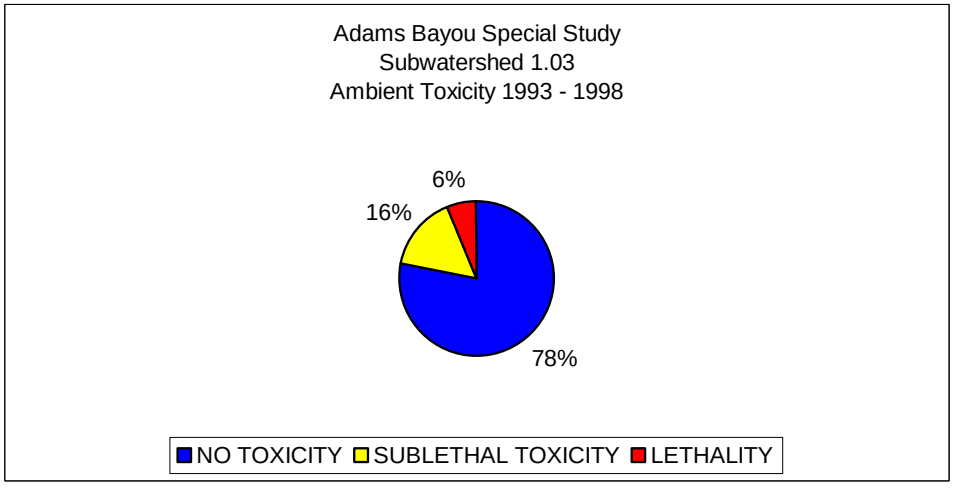


	July	August
0.3 m	1.1	1.0
3 m	1.0	1.0

Ambient Toxicity

Ambient toxicity tests began in the Adams Bayou Subwatershed in 1992 and indicated some problems with toxicity. By 1996, 48 toxicity tests were conducted on Adams Bayou from and the overall results indicate no toxicity in 77% of the tests. Only 6% of the tests showed lethal toxicity to the test organisms. The TNRCC guidelines for screening and assessing water quality data consider waterbodies with toxicity in less than 10% of the samples tested as fully supporting aquatic life. These results show toxicity is not a problem in the Adams Bayou Subwatershed. Ambient toxicity tests were performed on samples from discharge sites where no toxicity data was available from previous tests required by TNRCC or EPA. Ambient toxicity tests were conducted on sites AI1 and AI2. While the results showed some impact on survival in 100% effluent, no impact to the stream was indicated. An additional test was performed on samples from AB2 and no toxicity problems were observed.





Conclusions and Recommendations

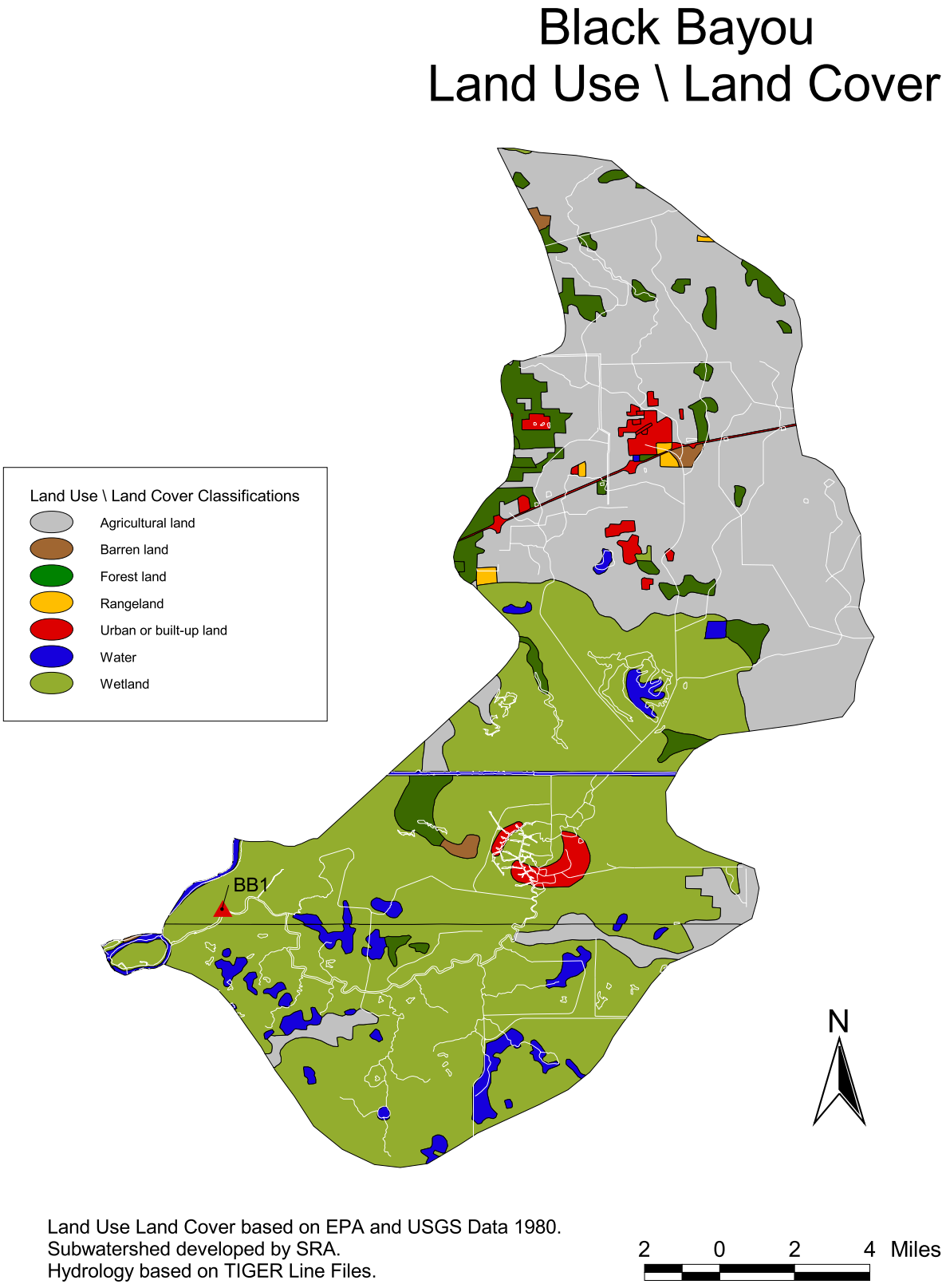
Water quality conditions in the Adams Bayou watershed are limited by the tidal nature of the system, the turbidity due to natural conditions, and the impact from human activities. The dissolved oxygen available for aquatic wildlife is being impacted negatively by point and nonpoint sources. Although the impact from point sources in this study appears to be minimal, the cumulative effect when combined with nonpoint source runoff is a higher oxygen demand than the waterbody can assimilate. The effect of human activities, including point and nonpoint sources, is difficult to measure in tidally influenced streams since there is not always a clear upstream or downstream site to gauge the impact. A comparison can be made to Black Bayou, which is located southeast of Adams Bayou in a sparsely populated area in southwest Louisiana. Monitoring data was collected from a site (BB1) near the mouth of Black Bayou, upstream of the Sabine Lake confluence. The location of this site is similar to the location of AB2 in Adams Bayou with the primary difference being the lack of impact from human activities. The comparison is most applicable to the lower end of both Subwatersheds.

The dissolved oxygen at BB1 was less than 4mg/L only once out of 31 sampling events. The average value for D.O. at this site was 6.3 mg/L. This compares with the average value of 3.6 mg/L at AB2 and the average was 2.6 mg/L at Station AB3 and 2.9 mg/L at AB4.

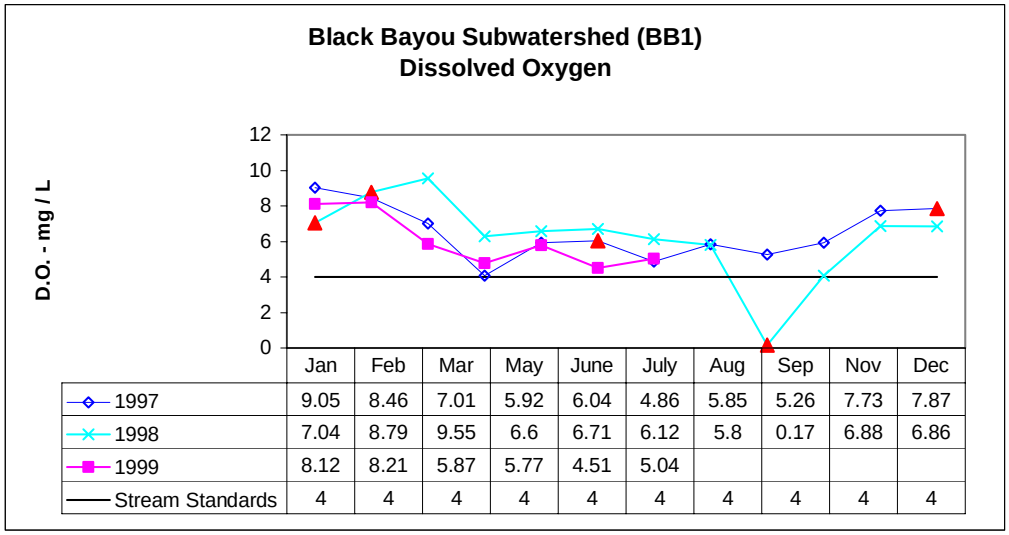
Sewage contamination is evident in Adams Bayou from the elevated fecal coliform values and appears to be from both point and nonpoint sources. Geometric means were above the TSWQS limit of 200 colonies at every stream site for almost every routine sampling event. Elevated values were detected at the stream sites during every rainfall event and were greater than 200 during every rainfall event except at Stations AL3, AL1, and AB2. Fecal coliform values in Black Bayou exceeded the 200 colony limit only once out of 31 sampling events and never during a rainfall event. The geometric mean for fecal coliform at BB1 was 19.

Although most nutrients were not significantly higher at the stream sites in Adams Bayou, elevated ammonia values were observed at HG, AB4, AB3, AL2, AL1, and AB2. Elevated ammonia levels were also observed at the permitted discharge sites AW3 and AW2. Ammonia levels in Black Bayou were consistently less than 0.2 mg/L. The impact on Adams Bayou from the discharge sites is mitigated somewhat due to the low flows of the discharges combined with some assimilation of the nutrients into the stream.

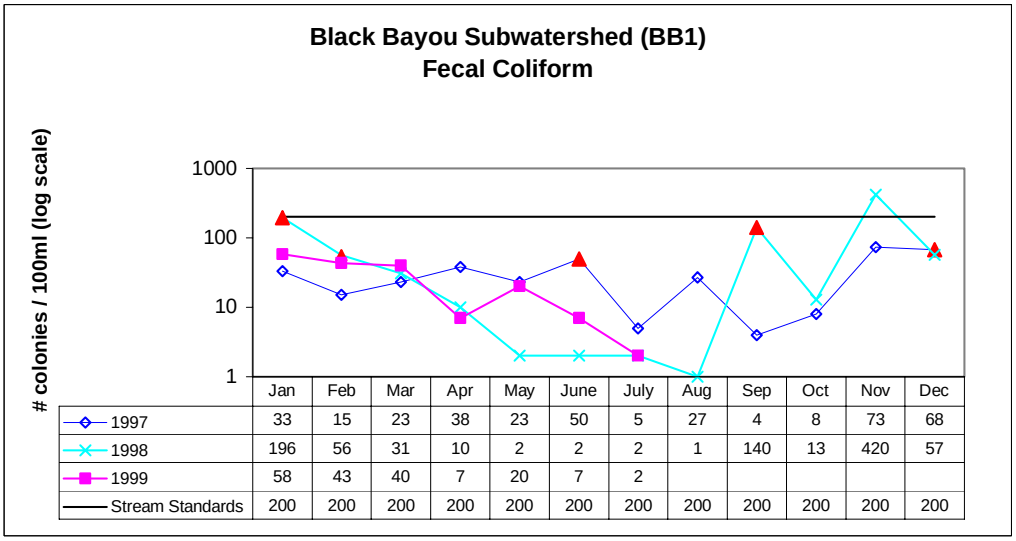
Figure 4. Land Use in the Black Bayou Watershed



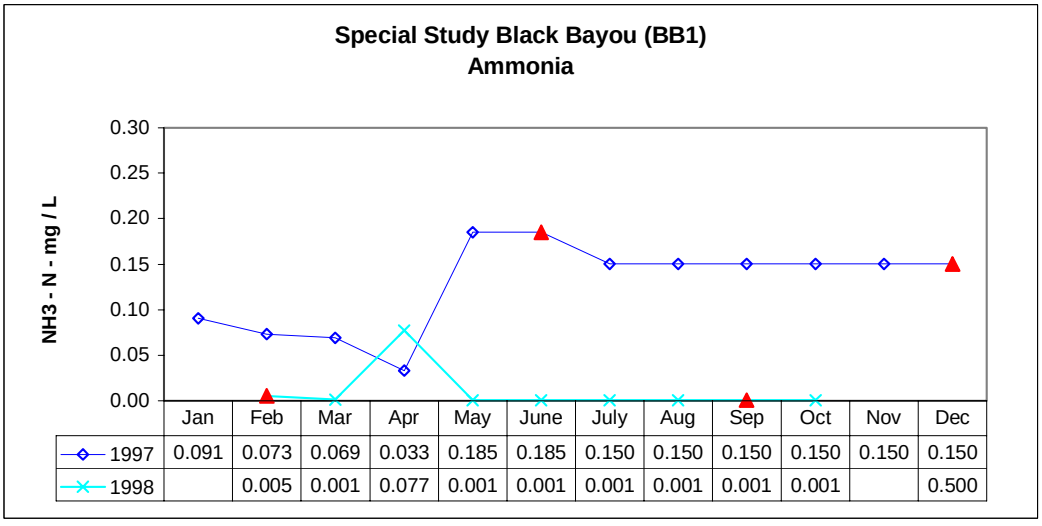
Special Study on Subwatershed 1.03 – Adams Bayou



	Jan	Feb	Mar	May	June	July	Aug	Sep	Nov	Dec
1997	9.05	8.46	7.01	5.92	6.04	4.86	5.85	5.26	7.73	7.87
1998	7.04	8.79	9.55	6.6	6.71	6.12	5.8	0.17	6.88	6.86
1999	8.12	8.21	5.87	5.77	4.51	5.04				
Stream Standards	4	4	4	4	4	4	4	4	4	4



	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1997	33	15	23	38	23	50	5	27	4	8	73	68
1998	196	56	31	10	2	2	2	1	140	13	420	57
1999	58	43	40	7	20	7	2					
Stream Standards	200	200	200	200	200	200	200	200	200	200	200	200



	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1997	0.091	0.073	0.069	0.033	0.185	0.185	0.150	0.150	0.150	0.150	0.150	0.150
1998		0.005	0.001	0.077	0.001	0.001	0.001	0.001	0.001	0.001		0.500

Rainfall events are represented by the red triangles (▲).

Special Study on Subwatershed 1.03 – Adams Bayou

It appears the present wastewater systems in the Adams Bayou watershed are not adequately preventing water quality degradation in the stream. Although most of the populated area in the watershed is being served by treatment plants, the stream is being impacted by both point and nonpoint source pollution. Infiltration from leaking collection system pipes in the sewer system is a likely source of the sewage contamination.

Improvements to the current treatment systems would be beneficial, but to sufficiently reduce the impact on Adams Bayou the entire Subwatershed should be served by a system large enough to eliminate the stress on the natural system. All of the cities and other government entities in the area need to collectively work together and make an application to the Texas Water Development Board to study the feasibility of a regional treatment plant. This alternative would significantly reduce the anthropogenic pollutant loads. The system must address infiltration and wet-weather problems that exacerbate non-point impacts during rainfall events.

A regional wastewater system should also address discharge of treated wastewater into a constructed wetland to further reduce any impact to the receiving stream. Artificial wetlands have been shown to function well in southeast Texas. Constructed wetlands such as the city of Beaumont's not only improve water quality in the stream, but also offer an eco-tourism bonus to the area.