Proposed Minimum Flows and Levels for the Upper and Middle Withlacoochee River Appendices

Southwest Florida Water Management District

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Rainfall Appendix

Summary Statistics of Rainfall Data for Sites in the West-Central Florida

A Simple Conceptualized Rainfall/Discharge Relationship

Stream or river flows are, of course, integrally associated with rainfall. In his 1974 book entitled*, Water: A Primer*, Luna B. Leopold notes that *"[s]treamflow is what is left over after precipitation has supplied the demands of vegetation and the process of evaporation. Leftovers or differences tend to vary greatly with time. For example, suppose the rainfall in one year is 40 inches and that evaporation and plant transpiration 20 inches. This leaves 20 inches to be carried off by the streams. Suppose that in the next year rainfall is 30 inches, 25 percent less than the year before. If evaporation and transpiration were the same, which is quite possible, streamflow would be only 10 inches, 50 percent less than in the year before. Thus a 25 percent change in rainfall becomes a 50 percent change in runoff. This means that the flow of streams is highly variable and sensitive to changes in rainfall."*

In the Southwest Florida Water Management District, average annual rainfall at most sites is between approximately 50 to 52 inches per year. Evapotranspiration is generally assumed to be about 38 inches per year; thus using Leopold's simplified equation, one might expect streamflow (in the absence of withdrawals or discharges, no changes in storage, and without significant gains or losses from/to groundwater) to average about 12 inches per year (i.e., 50 – 38 = 12). Interannual variabililty in rainfall may, however, be expected to lead to substantial variation in annual streamflow. For example, suppose the rainfall in one year is 50 inches and that evaporation and plant transpiration 38 inches. This leaves 12 inches to be carried off by the streams. Suppose that in the next year rainfall is 45 inches, 10 percent less than the year before. If evaporation and transpiration were the same, which is quite possible, streamflow would be only 7 inches, 42 percent less than in the year before. Thus a 10 percent change in rainfall becomes a 42 percent change in runoff. This means that the flow of streams is highly variable and sensitive to changes in rainfall, and that relatively small changes in rainfall can lead to relatively large changes in discharge.

To characterize regional rainfall variability for consideration when developing minimum flows, we examined rainfall data for a number of sites in and around the District (Figure 1). For this effort, we restricted analyses to sites with relatively long rainfall records that coincide with warm and cool cycles of the Atlantic Multidecadal Oscillation (AMO; see Enfield et al. 2001). We also chose not to in-fill missing daily rainfall total values, and excluded yearly rainfall totals for sites where the number of missing daily total rainfall values exceeded 30. While in-filling of missing rainfall records may be acceptable for some analyses, we elected to base our evaluation of annual and longer-term rainfall statistics on only reported, measured records. We acknowledge that this may have led to underestimation of some yearly rainfall totals and in some instances, limited identification of some of the wettest or driest 10-year periods, simply because when one year of data was deleted, the determination of a 10-year mean would have to wait until 10 more contiguous years of data were available.

To illustrate our approach, graphical and tabular summary results are presented here for a rainfall data set created from reported daily rainfall at three long term National Weather Service (NWS) sites. The average-site data set is referred to as the BIO_AVG and was based on records collected at the BROOKSVILLE CHINSEGUT HILL NWS, INVERNESS 3 SE NWS, and OCALA NWS sites (see Figure 1). We developed the BIO_AVG data set to represent average rainfall conditions across the Withlacoochee River basin, and because when missing data occurred at any one of the NWS sites, a mean could be calculated using the other two. This approach resulted in a fairly complete rainfall record that contained no missing yearly, seasonal or monthly totals.

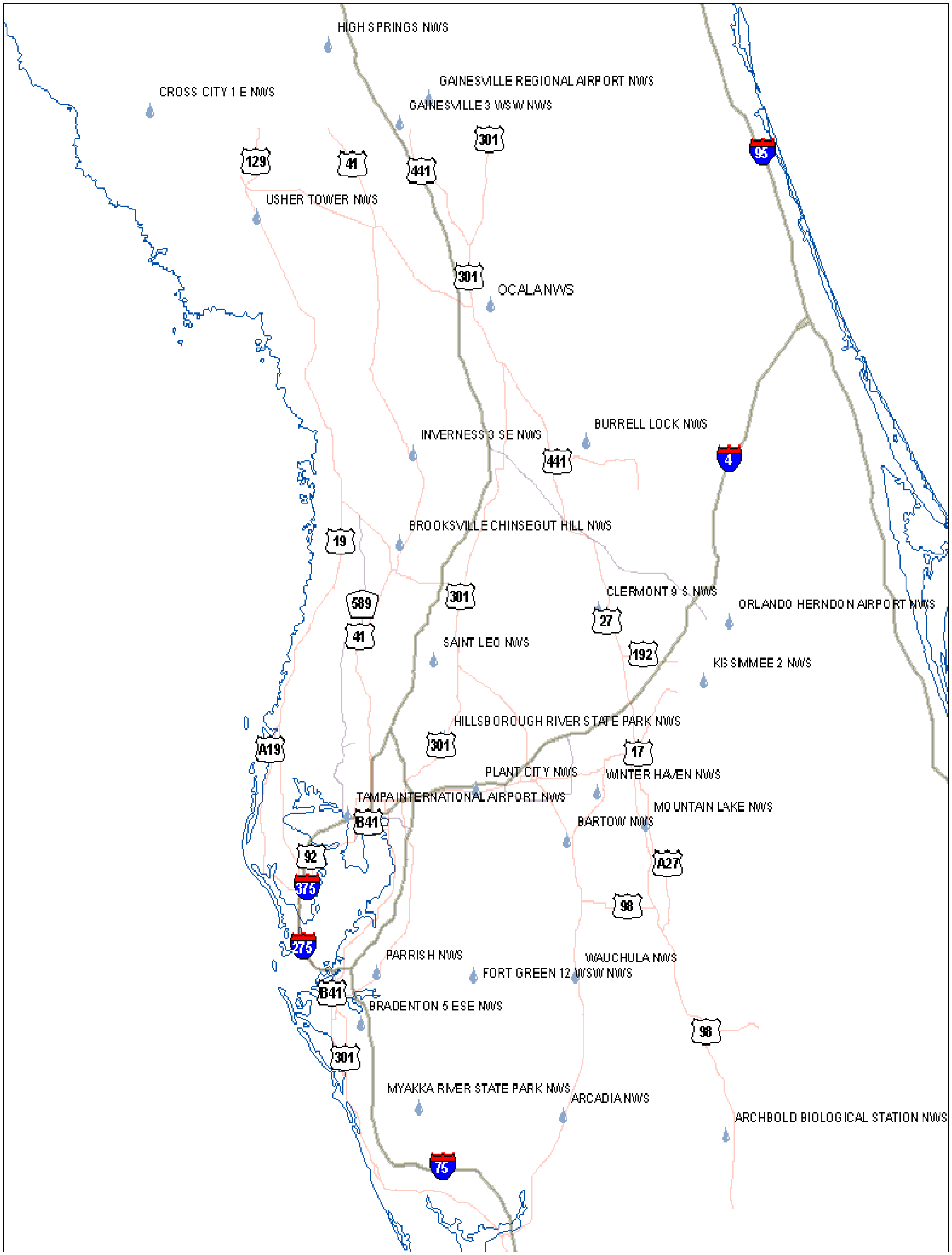
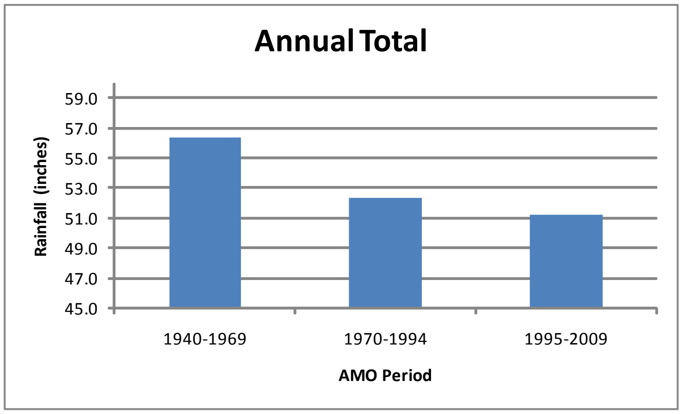


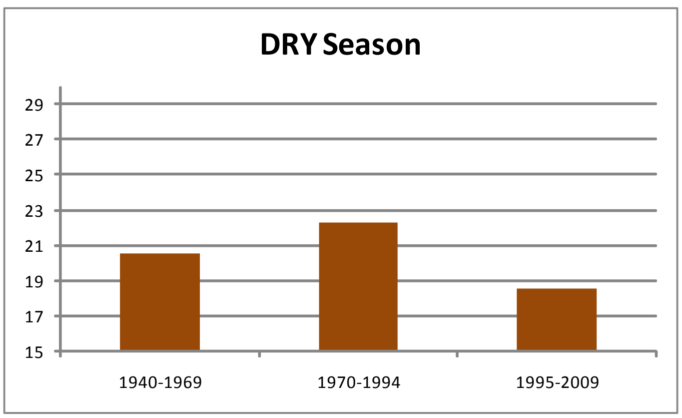
Figure 1. Locations of rainfall gaging stations (including the three sites used to develop the BIO_AVG data set) used for analyses of rainfall variation in west-central Florida.

Mean annual, dry and wet season rainfall totals (in inches) for the three AMO periods associated with the period of record for the BIO_AVG data set are shown in Figure 2. The bar charts in the figure illustrate rainfall totals for two warm AMO periods (1940-1969 and 1970-1994) and a single, cool AMO period (1970 to 1994).

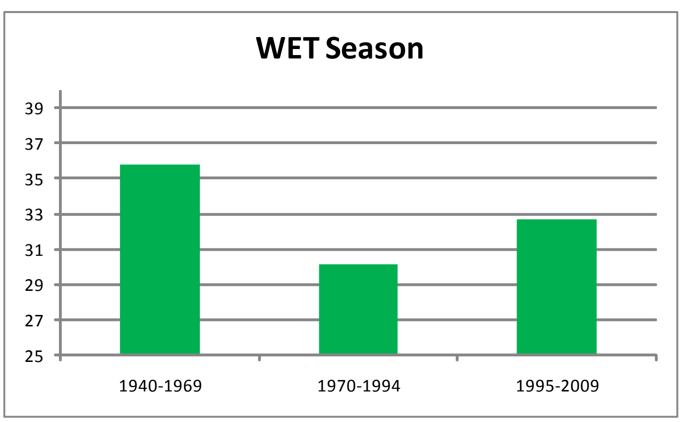
BIO_AVG



	Annual Total (inches)
1940-1969	56.3
1970-1994	52.4
1995-2009	51.3
POR	54.1



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	20.6	36%
1970-1994	22.3	42%
1995-2009	18.6	36%
POR	20.6	38%



	Wet Season Total (inches)	X% of Annual Totals
1940-1969	35.8	64%
1970-1994	30.1	58%
1995-2009	32.7	64%
POR	33.5	62%

Figure 2. Summary information on mean annual, dry season and wet season rainfall for the BIO_AVG data set for three AMO periods.

For southwest Florida (and peninsular Florida in general, as discussed by Kelly 2004), the wet season rainfall occurs during the summer rainy season which is defined as the months of June, July, August and September; remaining months are considered the “dry” months. As explained by Enfield et al. (2001), and the premise of work done by Kelly (2004) and Kelly and Gore (2008), warm North Atlantic Sea Surface Temperatures (SST) have a positive effect on rainfall in peninsular Florida due to the associated increase in tropical storm and hurricane activity attributable to warmer SST. The tropical storm / hurricane season is generally defined as extending from June to November, with the majority of activity occurring in August and September. This activity would, therefore, tend to lead to greater rainfall totals during the normal peninsular Florida rainy season with increased tropical storm activity further contributing to the convective rainfall characteristic of the rainy season. As noted by Enfield (2001), Kelly (2004) and Kelly and Gore (2008), we hypothesize that the greater mean annual rainfall totals for the period 1940 to 1969, and decreased rainfall totals for the period 1970 to 1994 could be explained by the increase or decrease in tropical storm activity, respectively, that characterized the rainy season of these two periods.

If this argument holds, however, it might be expected that mean annual total rainfall should have again increased for the period 1995 to 2009, since we are reportedly in a warmer AMO phase. Mean annual rainfall totals for many sites throughout central Florida have actually remained low during this period and in some cases are lower than the “dry” (cool) AMO period that extended from 1970 through 1994. Inspection of the bar graphs of the wet and dry seasons for the three time periods, at least with respect to BIO_AVG (Figure 2), indicates that as might be expected actual wet season mean annual rainfall was higher in both the 1940-1969 (35.8 inches) and the 1995-2009 (33.5 inches) AMO warm periods than in the cool AMO period (1970-1994; 30.1 inches). However, increased wet season rainfall for the 1995-2009 period was offset by decreased dry season rainfall. Similar results were observed for a number rainfall gaging sites we evaluated (see data figures/tables to follow).

Because the amount of runoff to a river is dependent in most cases on the amount of storage in the watershed that must be filled before runoff occurs, it is helpful to have a sense of multi-year wet and dry periods and the cumulative effects of multi-year rainfall surpluses or deficits. Periods of extended drought may greatly increase the amount of storage in lakes, wetlands, and soils that must be overcome before runoff occurs. In the case of the BIO_AVG data set, the wettest consecutive years occurred during the early to mid-1960’s (Figure 3). This extended period was generally a period of high discharge for many District rivers. Expectations regarding flows similar to those that occurred in the 1960s in the Withlacoochee River, for example, should be tempered by the knowledge that that this time period included the wettest 2 to 10 year rainfall periods based on 100-year rainfall records for the Ocala, Brooksville, and Inverness area. Also of note, the driest 2, 3, 4, 5 and 10 year periods of rainfall for that region occurred during the late 1990's to early 2000's, so it is reasonable to expect that flows in the Withlacoochee River were relatively low during that period. Figure 3 also includes a plot of cumulative deviation from period of record mean annual rainfall for the BIO_AVG data site. This type of plot is useful for identifying periods of above average rainfall (upward sloping line) or below average rainfall (downward sloping line) with the extent or length of the downward or upward sloping segment indicative of the cumulative effect of wet or dry periods. The plot in Figure 3 clearly illustrates that the period of 1920 to approximately 1970 was much wetter than more recent decades.

	Mean	Year Ending
Driest 2 yr mean annual	39.68	2000
Driest 3 yr mean annual	42.36	2000
Driest 4 yr mean annual	44.32	2001
Driest 5 yr mean annual	45.24	2000
Driest 10 year mean annual	48.68	2001
Wetest 2 yr mean annual	75.30	1960
Wetest 3 yr mean annual	70.83	1960
Wetest 4 yr mean annual	67.81	1960
Wetest 5 yr mean annual	63.16	1961
Wetest 10 year mean annual	59.74	1966

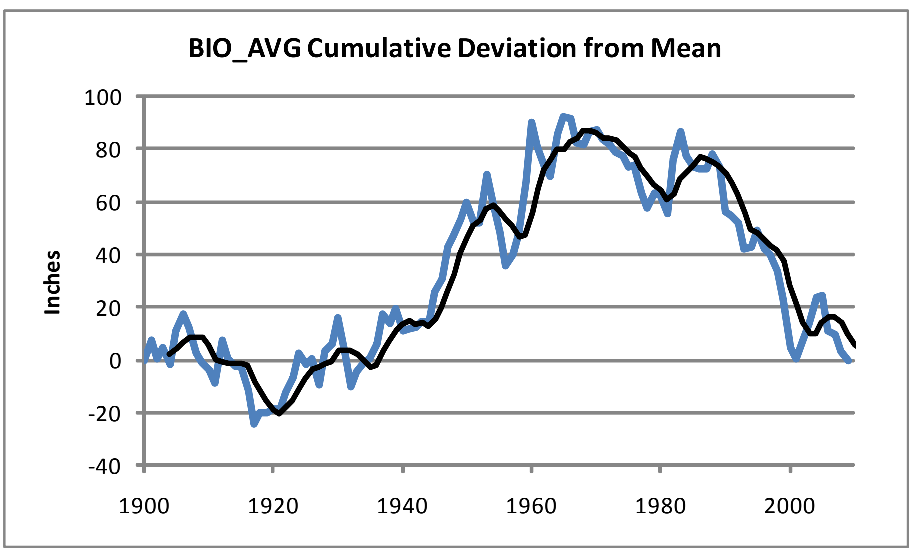
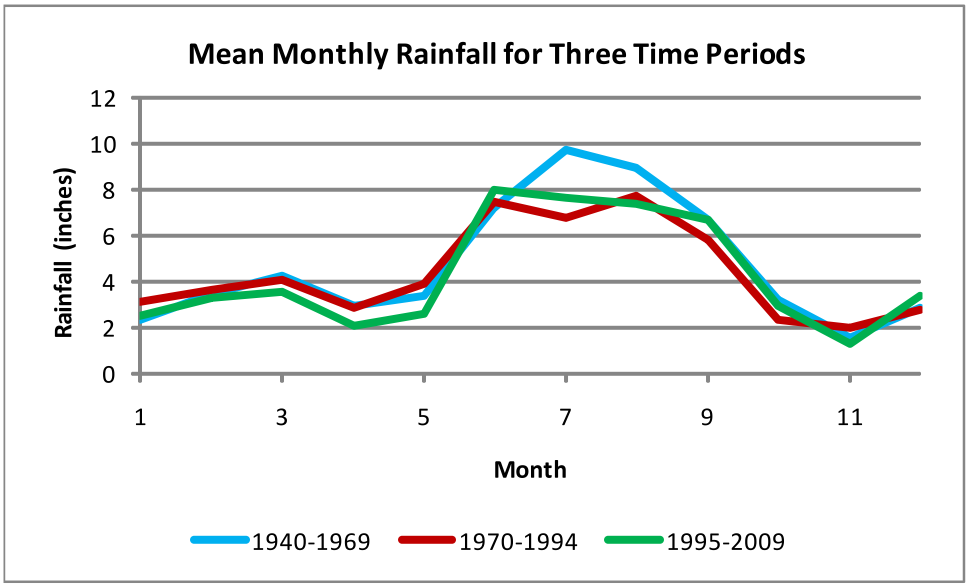


Figure 3. Average multi-year rainfall totals for the driest and wettest periods (table) and cumulative annual deviation from period of record rainfall (blue line) for the BIO_AVG data set. The black line is the 5-year moving average of the cumulative deviations.

Our final figure for each site summarizes variation in rainfall on a monthly basis for the three AMO periods we evaluated. Figure 4 illustrates results for the BIO_AVG site, and includes a plot and summary table of mean monthly rainfall totals. Blue shading in the table indicates the wettest of each monthly total for three AMO periods, and tan shading denotes the driest month among the three periods.

BIO_AVG



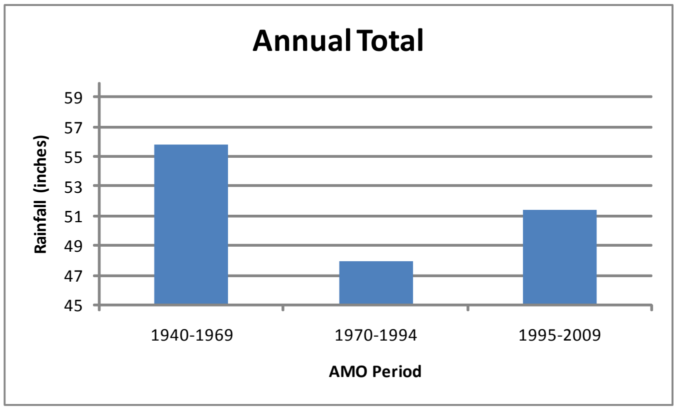
Month	1940-1969	1970-1994	1995-2009
1	2.34	3.09	2.54
2	3.50	3.67	3.27
3	4.22	4.06	3.59
4	2.92	2.84	2.07
5	3.41	3.86	2.56
6	7.19	7.45	8.01
7	9.71	6.79	7.66
8	8.94	7.72	7.34
9	6.72	5.79	6.71
10	3.21	2.36	2.96
11	1.54	2.00	1.27
12	2.81	2.78	3.38
Total	56.51	52.41	51.35

Figure 4. Mean monthly rainfall totals for three AMO periods (line chart and table) for the BIO_AVG data set.

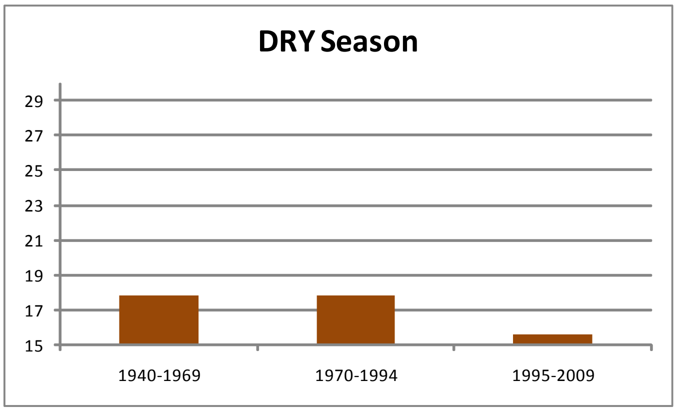
Data

What follows is a series of figures (and tables) for rainfall sites shown in Figure 1. Information for each site is formatted as described above. Microsoft Excel spreadsheets used to generate the figures/tables for each site are available on request.

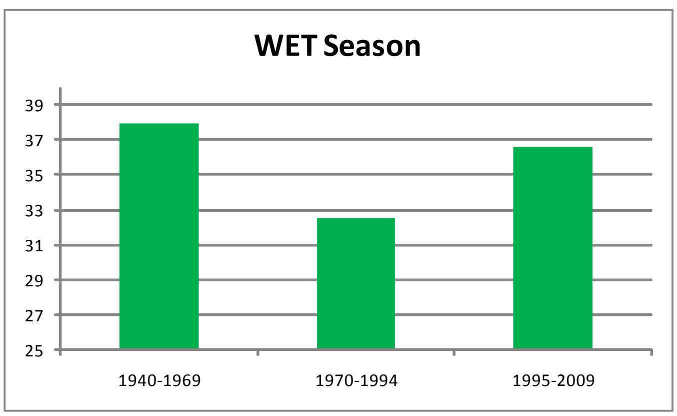
ARCADIA NWS RAINFALL



	Annual Total (inches)
1940-1969	55.8
1970-1994	47.9
1995-2009	51.4
POR	50.8



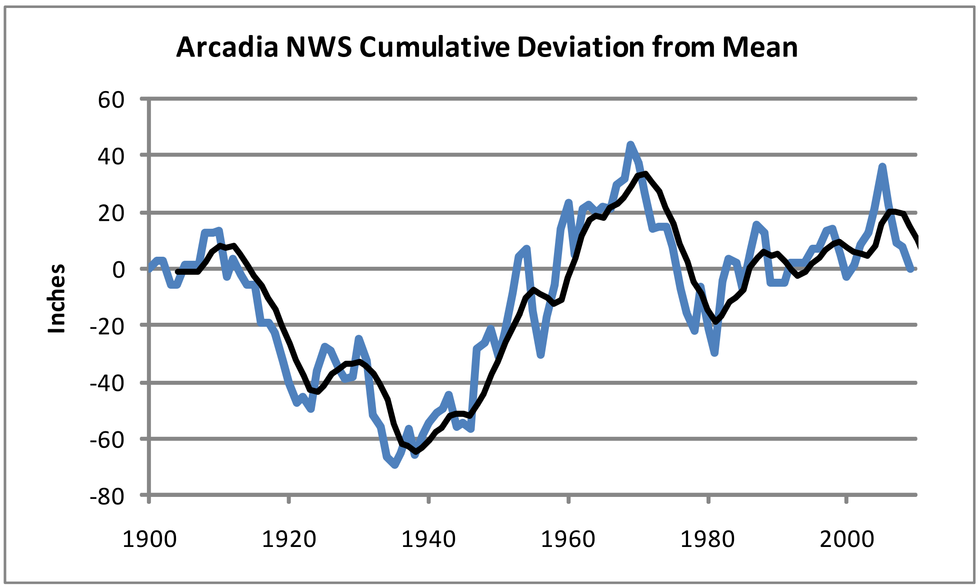
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	17.9	32%
1970-1994	17.8	35%
1995-2009	15.6	30%
POR	16.0	33%



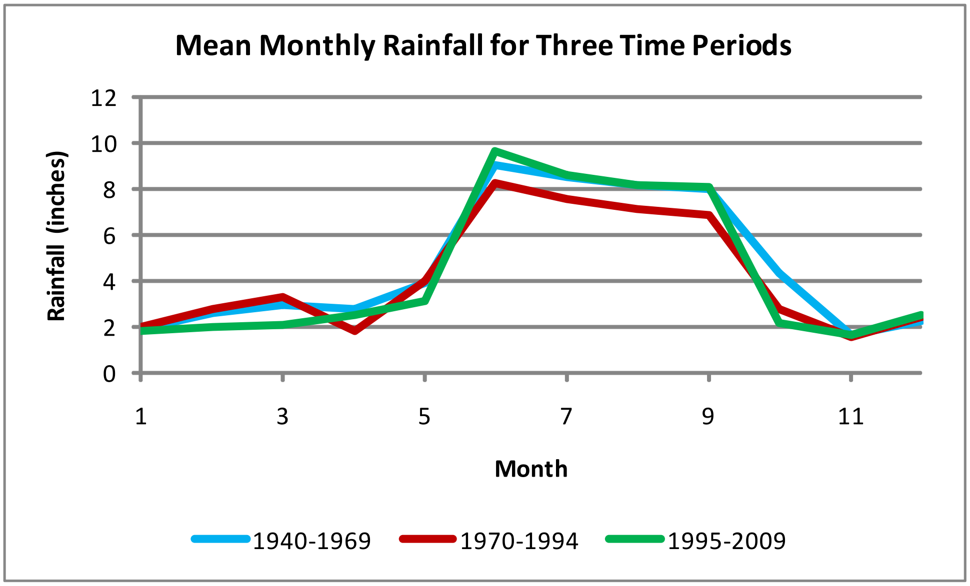
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	38.0	68%
1970-1994	32.6	65%
1995-2009	36.6	70%
POR	35.2	67%

	Mean	Year Ending
Driest 2 yr mean annual	33.77	1956
Driest 3 yr mean annual	40.90	1956
Driest 4 yr mean annual	42.01	1934
Driest 5 yr mean annual	43.54	1935
Driest 10 year mean annual	46.52	1980
Wetest 2 yr mean annual	69.01	1982
Wetest 3 yr mean annual	67.32	1959
Wetest 4 yr mean annual	65.81	1960
Wetest 5 yr mean annual	60.16	2005
Wetest 10 year mean annual	58.61	1954

Period of Record is from 1901 to 2009

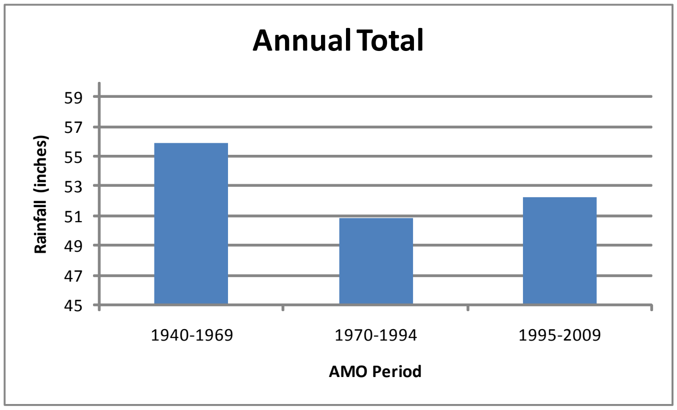


Arcadia NWS Rainfall

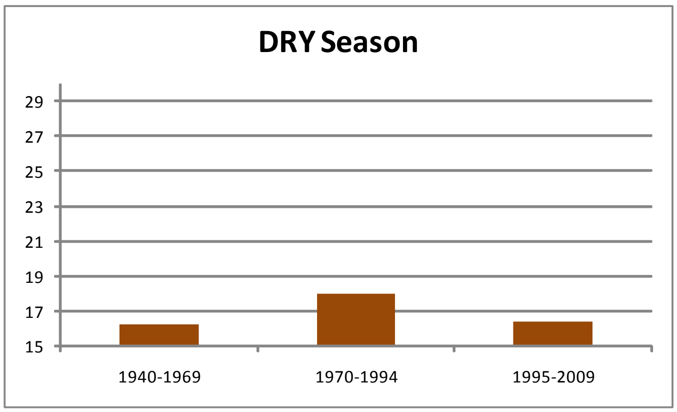


Month	1940-1969	1970-1994	1995-2009
1	1.89	2.01	1.84
2	2.56	2.76	2.00
3	2.95	3.28	2.07
4	2.80	1.83	2.52
5	3.87	4.01	3.10
6	9.05	8.24	9.60
7	8.46	7.54	8.63
8	8.12	7.11	8.17
9	7.97	6.89	8.04
10	4.35	2.78	2.19
11	1.62	1.58	1.64
12	2.28	2.44	2.47
Total	55.92	50.49	52.26

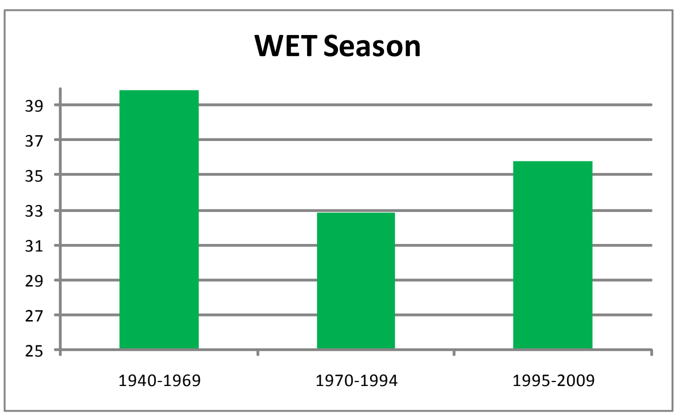
ARCHBOLD BIOLOGICAL STATION NWS



	Annual Total (inches)
1940-1969	55.9
1970-1994	50.9
1995-2009	52.2
POR	53.3

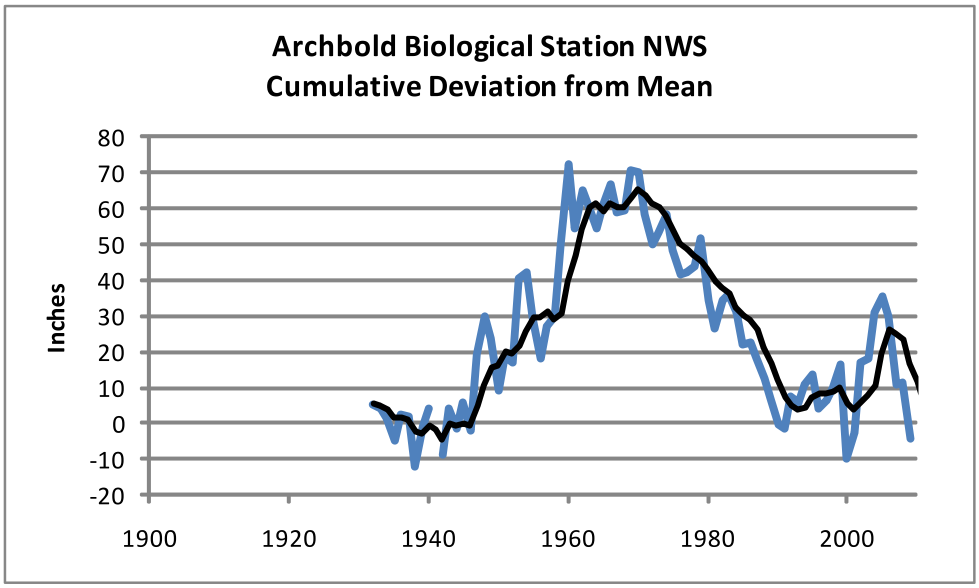


	Dry Season Total (inches)	X% of Annual Totals
1940-1969	16.3	29%
1970-1994	18.0	35%
1995-2009	16.4	31%
POR	17.0	32%

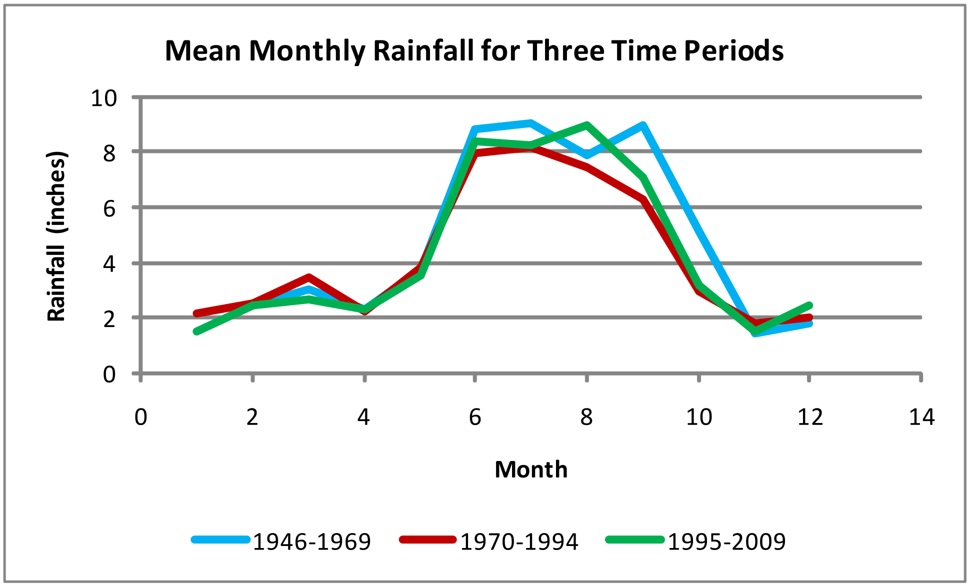


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	39.9	71%
1970-1994	32.9	65%
1995-2009	35.8	69%
POR	36.3	68%

	Mean	Year Ending
Driest 2 yr mean annual	40.65	1981
Driest 3 yr mean annual	41.92	2009
Driest 4 yr mean annual	43.34	2009
Driest 5 yr mean annual	46.19	2009
Driest 10 year mean annual	48.82	1989
Wetest 2 yr mean annual	74.38	1960
Wetest 3 yr mean annual	68.31	1960
Wetest 4 yr mean annual	66.82	1960
Wetest 5 yr mean annual	62.26	2005
Wetest 10 year mean annual	59.55	1960

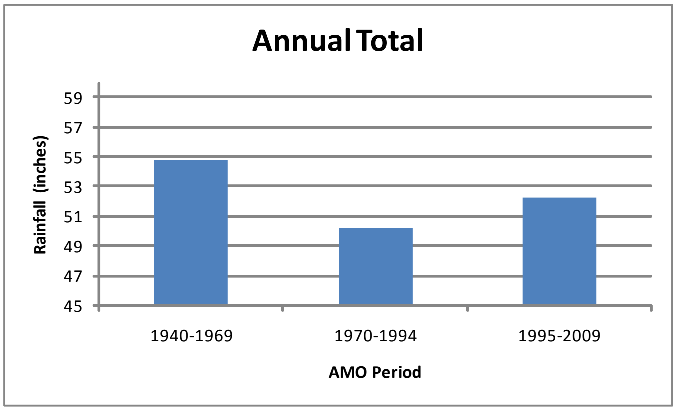


ARCHBOLD BIOLOGICAL STATION NWS

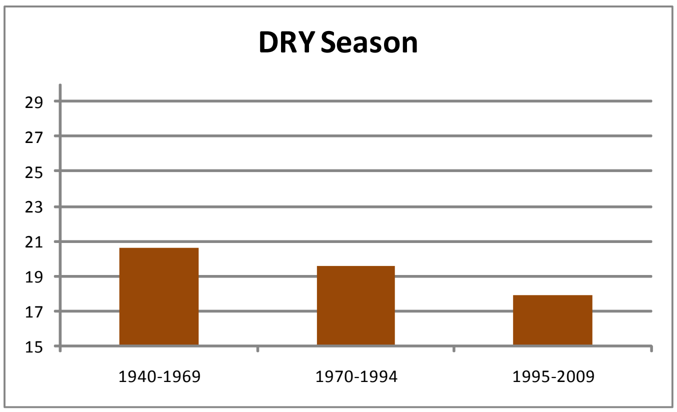


Month	1946-1969	1970-1994	1995-2009
1	1.52	2.14	1.48
2	2.44	2.55	2.46
3	3.03	3.45	2.69
4	2.28	2.21	2.31
5	3.78	3.85	3.55
6	8.80	7.96	8.39
7	9.06	8.20	8.25
8	7.91	7.47	8.94
9	9.00	6.32	7.07
10	5.11	2.95	3.17
11	1.45	1.77	1.52
12	1.79	2.04	2.43
Total	56.16	50.90	52.26

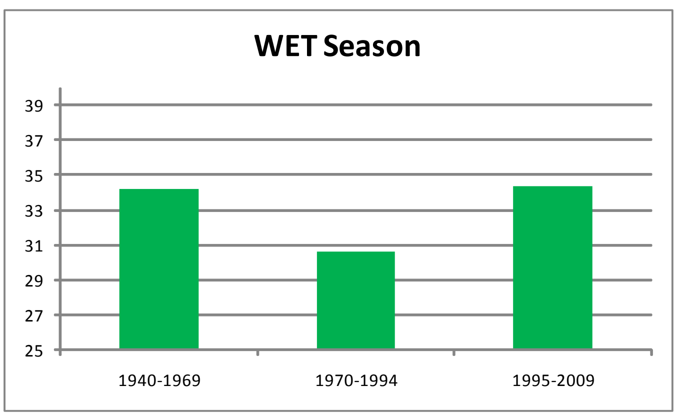
BARTOW NWS



	Annual Total (inches)
1940-1969	54.8
1970-1994	50.2
1995-2009	52.3
POR	53.7



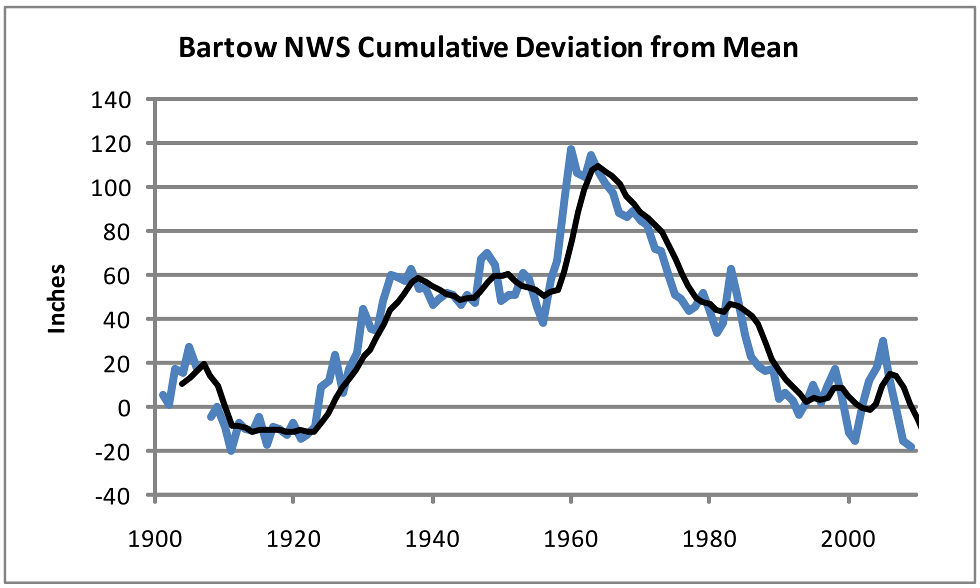
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	20.6	37%
1970-1994	19.6	39%
1995-2009	17.9	34%
POR	19.6	36%



	Wet Season Total (inches)	X% of Annual Totals
1940-1969	34.2	63%
1970-1994	30.6	61%
1995-2009	34.4	66%
POR	34.0	64%

	Mean	Year Ending
Driest 2 yr mean annual	37.31	2007
Driest 3 yr mean annual	38.39	2008
Driest 4 yr mean annual	41.74	2009
Driest 5 yr mean annual	44.35	1988
Driest 10 year mean annual	47.04	1993

Wetest 2 yr mean annual	78.65	1960
Wetest 3 yr mean annual	73.04	1960
Wetest 4 yr mean annual	73.21	1960
Wetest 5 yr mean annual	67.83	1960
Wetest 10 year mean annual	60.54	1960



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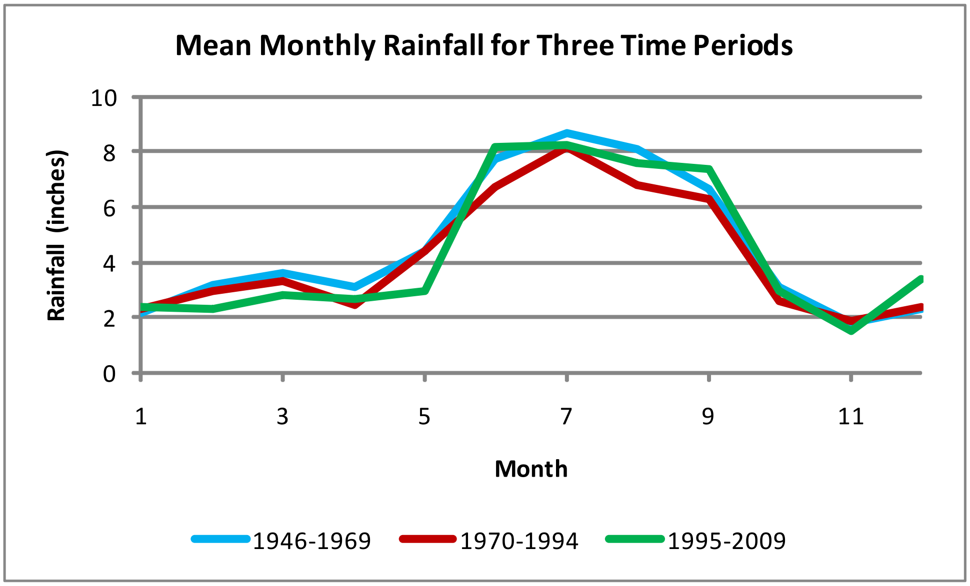
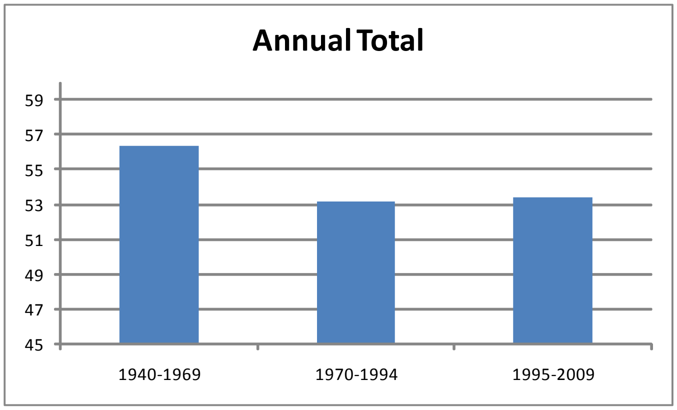
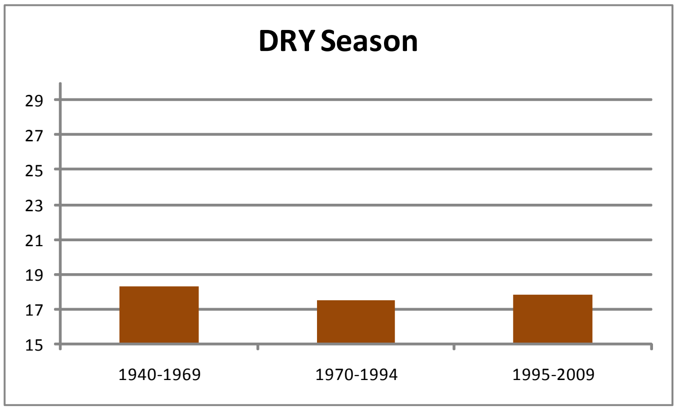


Month	1946-1969	1970-1994	1995-2009
1	2.20	2.30	2.41
2	3.21	2.99	2.30
3	3.62	3.34	2.82
4	3.10	2.43	2.64
5	4.43	4.39	2.98
6	7.74	6.75	8.18
7	8.65	8.18	8.25
8	8.09	6.78	7.57
9	6.64	6.29	7.37
10	3.07	2.62	2.99
11	1.80	1.87	1.54
12	2.33	2.37	3.38
Total	54.88	50.31	52.42

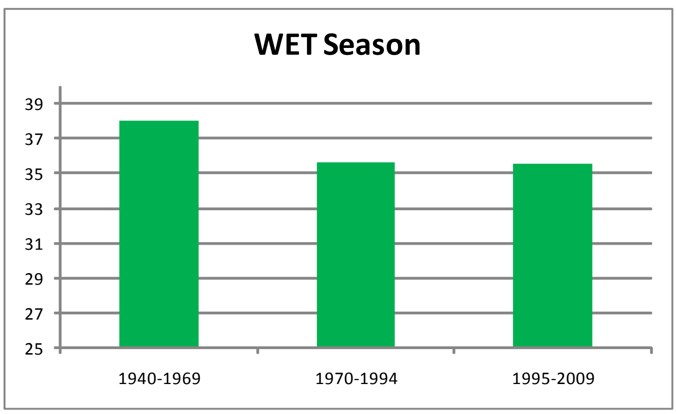
BRADENTON 5 ESE NWS



	Annual Total (inches)
1940-1969	56.3
1970-1994	53.1
1995-2009	53.4
POR	54.5

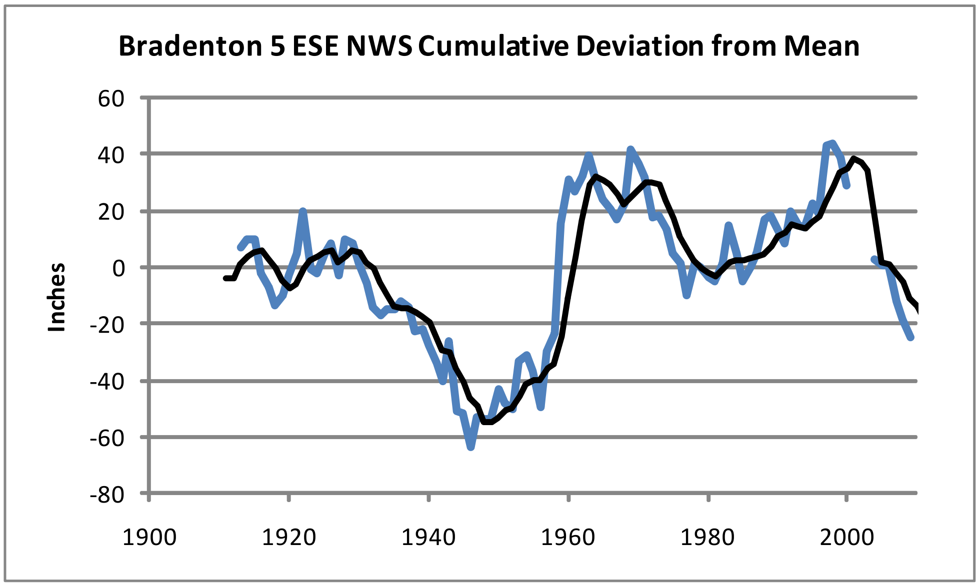


	Dry Season Total (inches)	X% of Annual Totals
1940-1969	18.3	32%
1970-1994	17.5	33%
1995-2009	17.8	32%
POR	17.9	33%



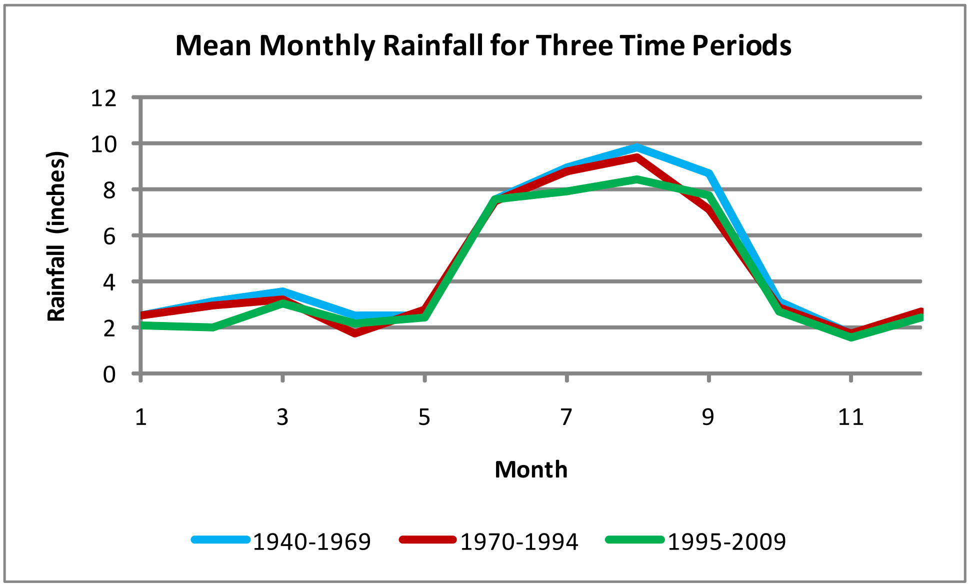
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	38.0	68%
1970-1994	35.6	67%
1995-2009	35.5	68%
POR	36.3	67%

	Mean	Year Ending
Driest 2 yr mean annual	41.67	1945
Driest 3 yr mean annual	41.79	1946
Driest 4 yr mean annual	47.14	1977
Driest 5 yr mean annual	47.91	1975
Driest 10 year mean annual	49.08	1946
Wetest 2 yr mean annual	81.38	1960
Wetest 3 yr mean annual	75.87	1959
Wetest 4 yr mean annual	74.27	1960
Wetest 5 yr mean annual	69.42	1961
Wetest 10 year mean annual	62.53	1962



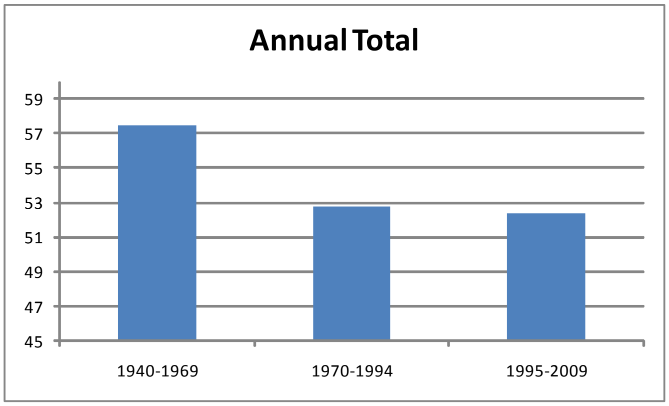
* years 2001-2003 deleted to high number of missing daily observations

BRADENTON 5 ESE NWS

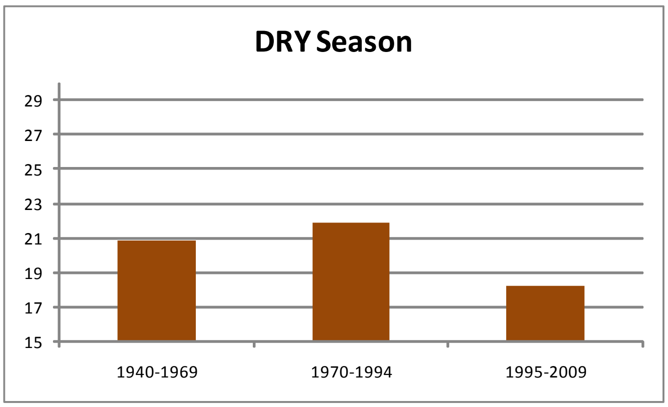


Month	1940-1969	1970-1994	1995-2009
1	2.52	2.53	2.06
2	3.11	2.97	1.96
3	3.52	3.22	3.02
4	2.53	1.74	2.20
5	2.50	2.78	2.44
6	7.55	7.43	7.58
7	8.92	8.76	7.92
8	9.79	9.38	8.45
9	8.64	7.15	7.73
10	3.11	2.89	2.64
11	1.72	1.69	1.56
12	2.50	2.64	2.44
Total	56.40	53.17	49.99

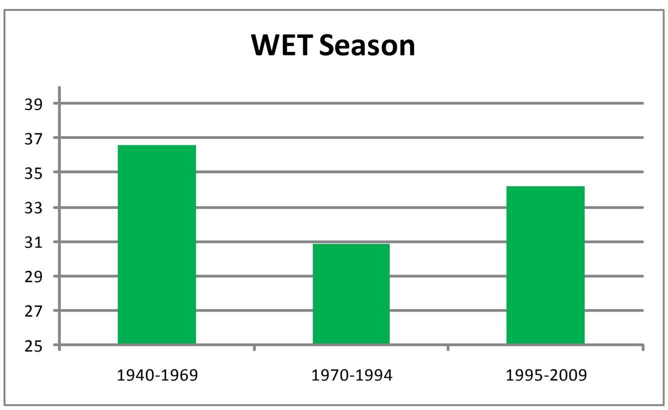
BROOKSVILLE CHINSEGUT HILL NWS



	Annual Total (inches)
1940-1969	57.5
1970-1994	52.8
1995-2009	52.4
POR	54.7

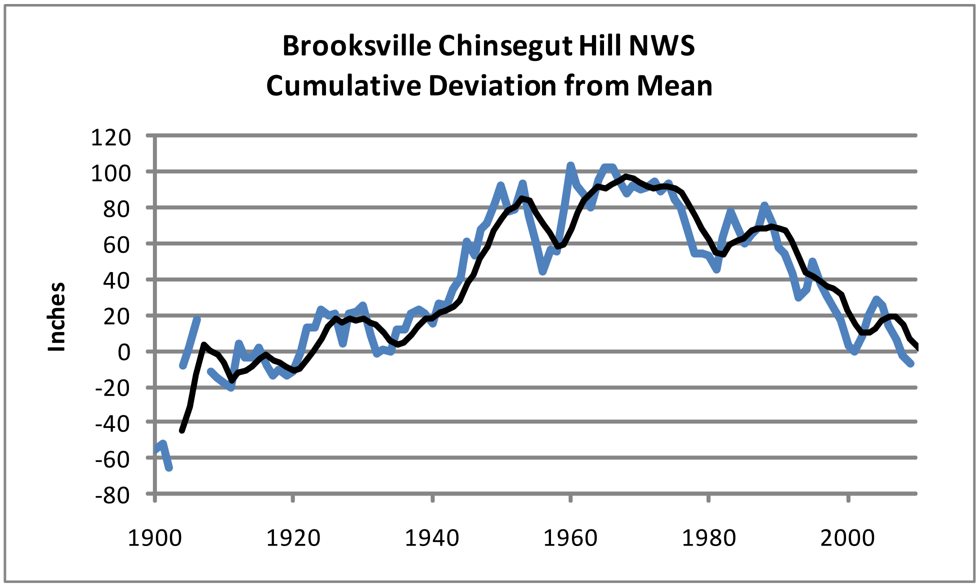


	Dry Season Total (inches)	X% of Annual Totals
1940-1969	20.9	37%
1970-1994	21.9	41%
1995-2009	18.2	35%
POR	20.3	38%

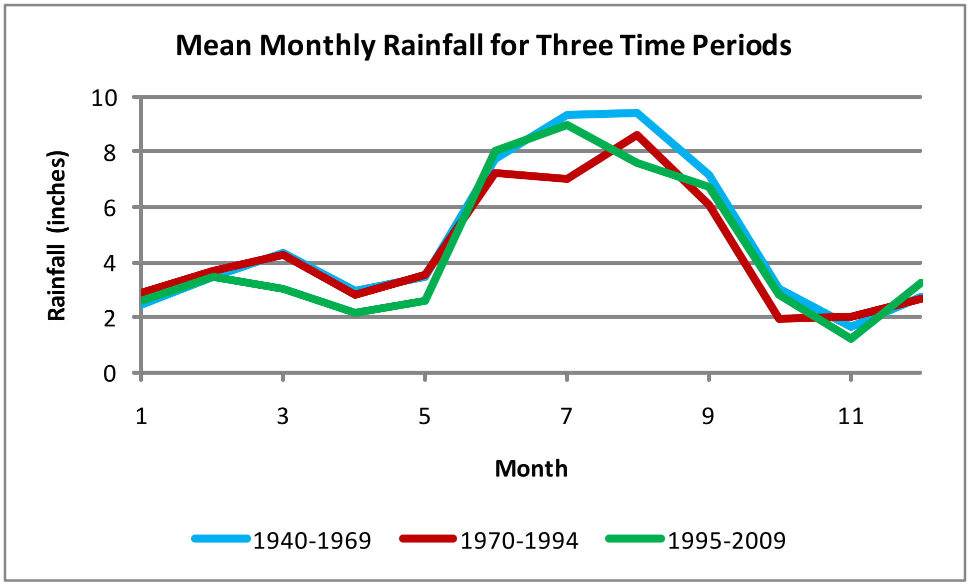


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	36.6	63%
1970-1994	30.9	59%
1995-2009	34.2	65%
POR	34.5	62%

	Mean	Year Ending
Driest 2 yr mean annual	37.77	1955
Driest 3 yr mean annual	38.88	1956
Driest 4 yr mean annual	44.62	1993
Driest 5 yr mean annual	44.67	1993
Driest 10 year mean annual	49.26	1998
Wetest 2 yr mean annual	78.83	1959
Wetest 3 yr mean annual	70.59	1959
Wetest 4 yr mean annual	69.74	1960
Wetest 5 yr mean annual	64.60	1961
Wetest 10 year mean annual	62.85	1950

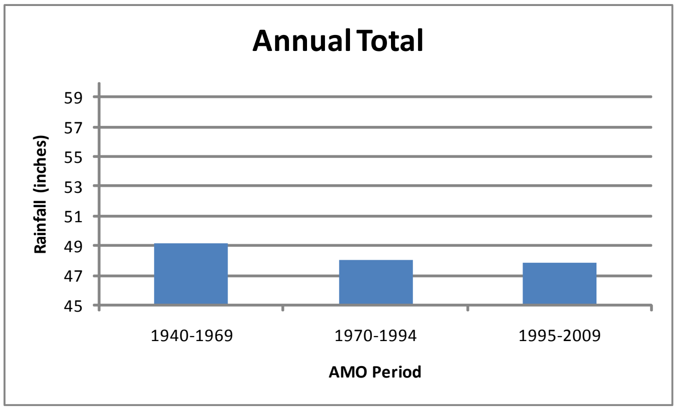


BROOKSVILLE CHINSEGUT HILL NWS

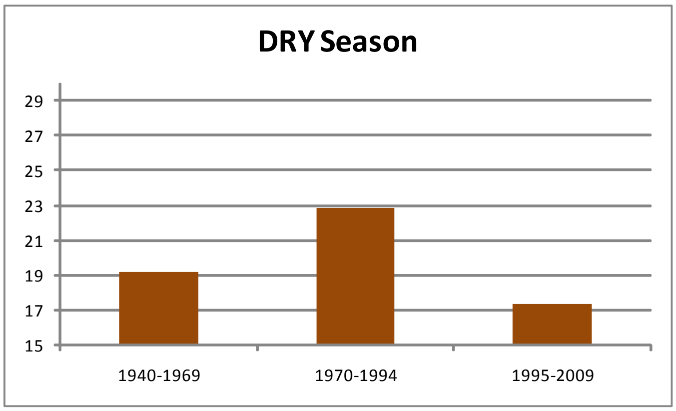


Month	1940-1969	1970-1994	1995-2009
1	2.43	2.92	2.56
2	3.49	3.65	3.47
3	4.37	4.25	3.04
4	2.92	2.83	2.19
5	3.44	3.55	2.63
6	7.72	7.24	8.06
7	9.31	7.02	8.97
8	9.41	8.61	7.61
9	7.14	6.07	6.70
10	3.02	1.96	2.82
11	1.69	2.03	1.25
12	2.73	2.68	3.22
Total	57.66	52.81	52.53

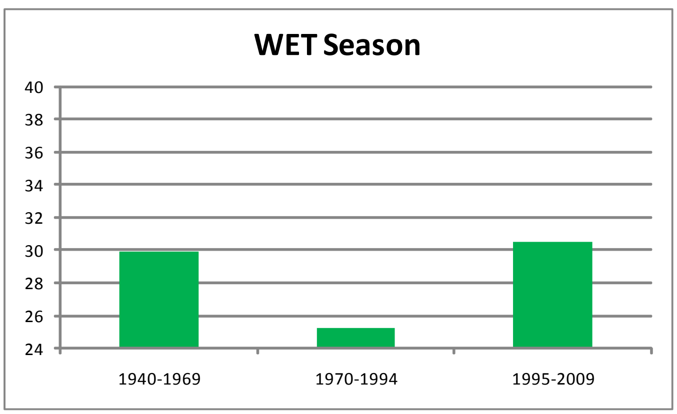
BURRELL LOCK NWS



	Annual Total (inches)
1940-1969	49.1
1970-1994	48.0
1995-2009	47.9
POR	48.2

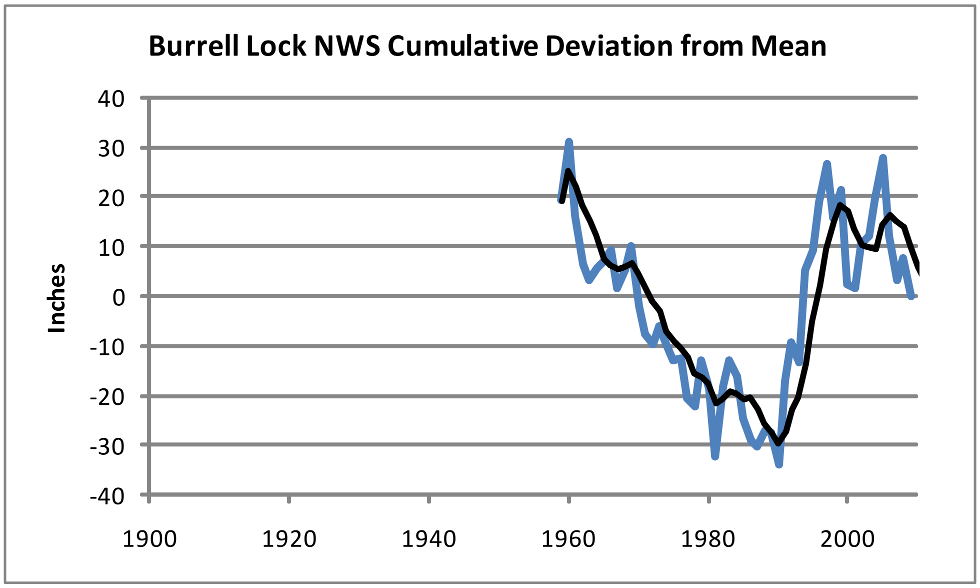


	Dry Season Total (inches)	X% of Annual Totals
1940-1969	19.2	39%
1970-1994	22.8	47%
1995-2009	17.4	36%
POR	20.4	42%



	Wet Season Total (inches)	X% of Annual Totals
1940-1969	29.9	61%
1970-1994	25.2	53%
1995-2009	30.5	64%
POR	27.8	58%

	Mean	Year Ending
Driest 2 yr mean annual	35.89	1962
Driest 3 yr mean annual	38.95	1963
Driest 4 yr mean annual	41.26	2009
Driest 5 yr mean annual	43.39	1965
Driest 10 year mean annual	44.93	1970
Wetest 2 yr mean annual	63.76	1959
Wetest 3 yr mean annual	58.97	1996
Wetest 4 yr mean annual	58.24	1994
Wetest 5 yr mean annual	56.85	1995
Wetest 10 year mean annual	53.92	1997



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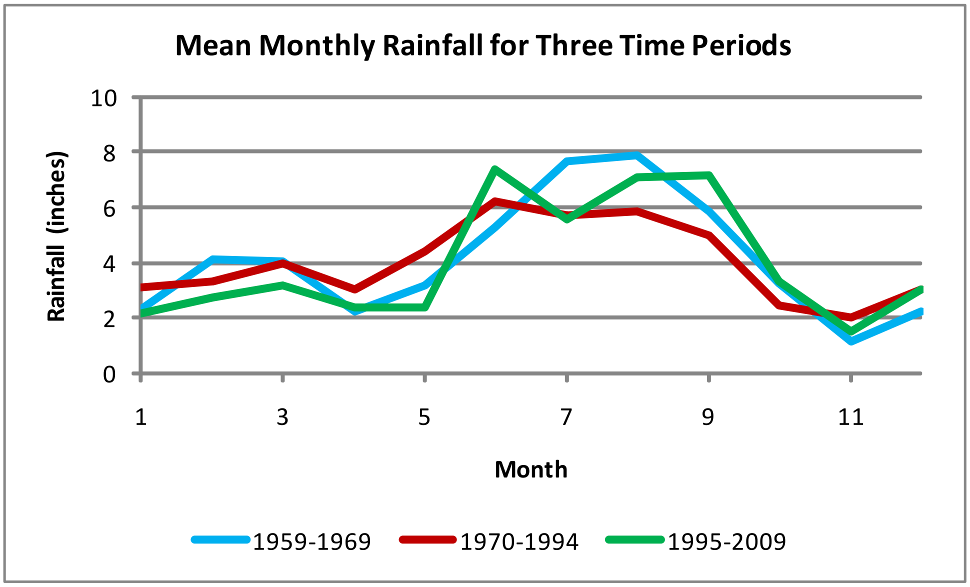
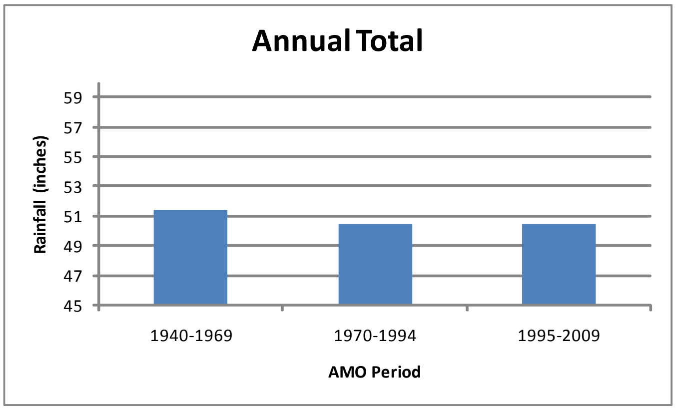
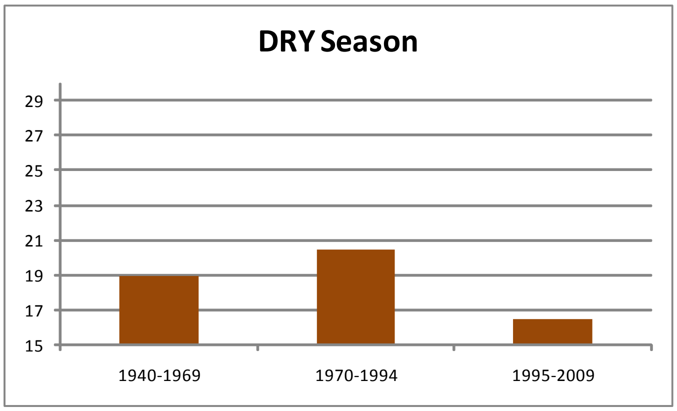


Month	1959-1969	1970-1994	1995-2009
1	2.32	3.11	2.18
2	4.12	3.34	2.70
3	4.06	4.01	3.19
4	2.22	3.02	2.41
5	3.15	4.39	2.37
6	5.31	6.20	7.39
7	7.67	5.70	5.55
8	7.89	5.85	7.06
9	5.85	5.01	7.15
10	3.22	2.44	3.33
11	1.13	2.00	1.50
12	2.26	3.03	3.05
Total	49.20	48.10	47.88

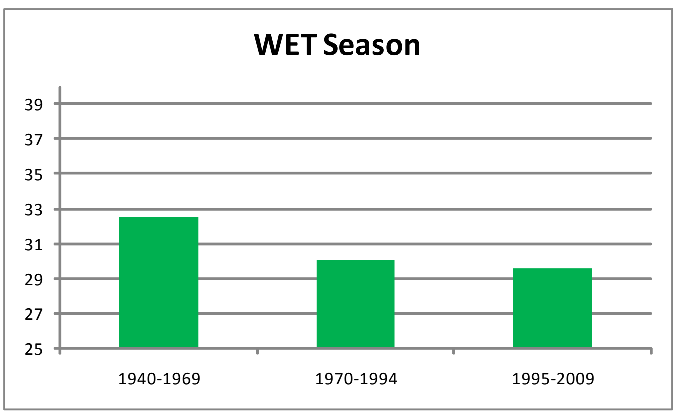
CLERMONT 9 S NWS



	Annual Total (inches)
1940-1969	51.4
1970-1994	50.5
1995-2009	50.5
POR	50.5

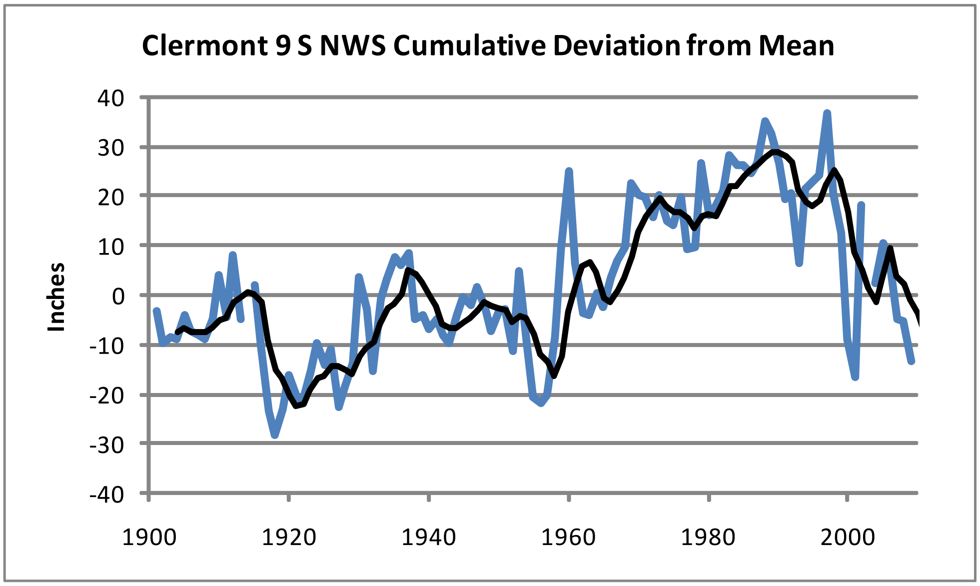


	Dry Season Total (inches)	X% of Annual Totals
1940-1969	18.9	37%
1970-1994	20.4	41%
1995-2009	16.5	33%
POR	18.6	37%

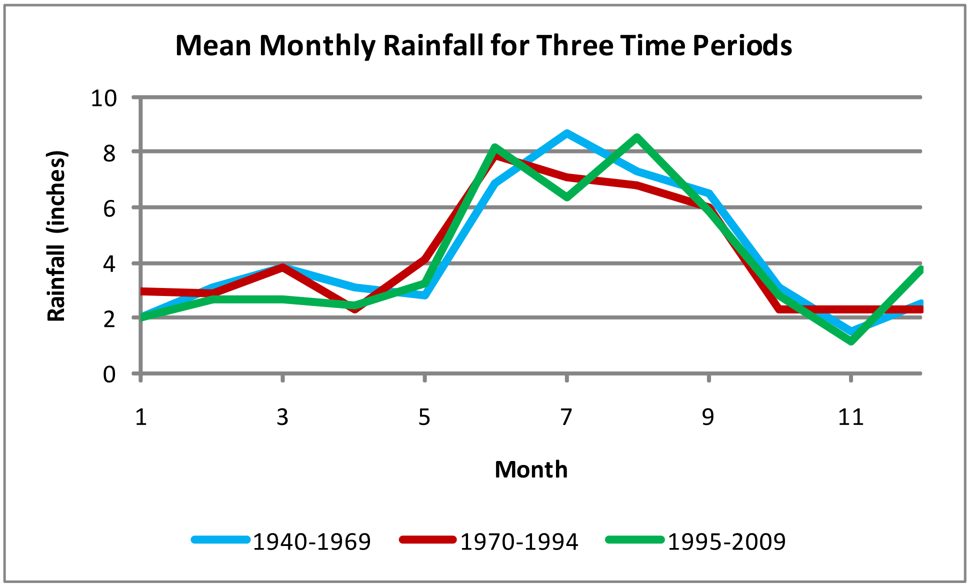


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	32.5	63%
1970-1994	30.1	59%
1995-2009	29.6	60%
POR	31.0	61%

	Mean	Year Ending
Driest 2 yr mean annual	35.79	2000
Driest 3 yr mean annual	35.35	2001
Driest 4 yr mean annual	37.29	2001
Driest 5 yr mean annual	42.45	2001
Driest 10 year mean annual	46.98	2001
Wetest 2 yr mean annual	67.18	1960
Wetest 3 yr mean annual	65.57	1960
Wetest 4 yr mean annual	62.19	1960
Wetest 5 yr mean annual	59.59	1960
Wetest 10 year mean annual	53.68	1960

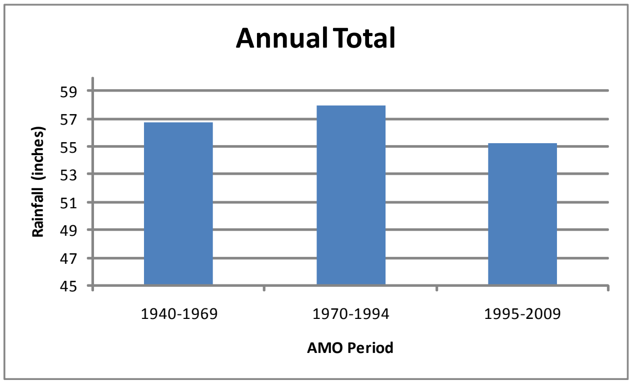


CLERMONT 9 S NWS

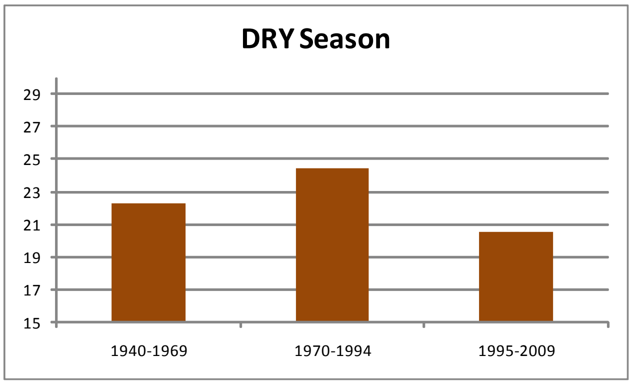


Month	1940-1969	1970-1994	1995-2009
1	2.04	2.93	2.03
2	3.10	2.90	2.66
3	3.85	3.85	2.65
4	3.12	2.28	2.44
5	2.84	4.10	3.22
6	6.90	7.90	8.17
7	8.69	7.07	6.35
8	7.33	6.78	8.54
9	6.53	6.02	5.87
10	3.08	2.30	2.78
11	1.53	2.28	1.17
12	2.54	2.29	3.74
Total	51.54	50.70	49.60

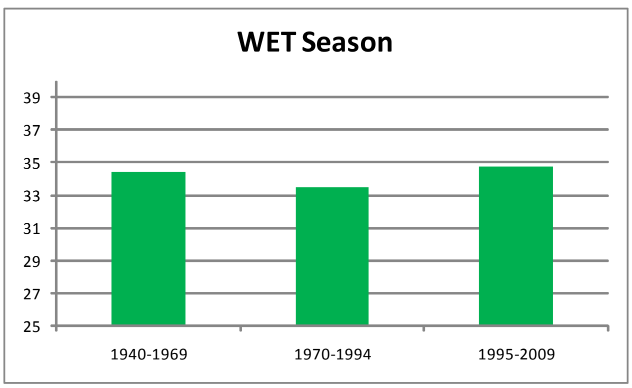
CROSS CITY 1 E NWS



	Annual Total (inches)
1940-1969	56.8
1970-1994	57.9
1995-2009	55.2
POR	57.0

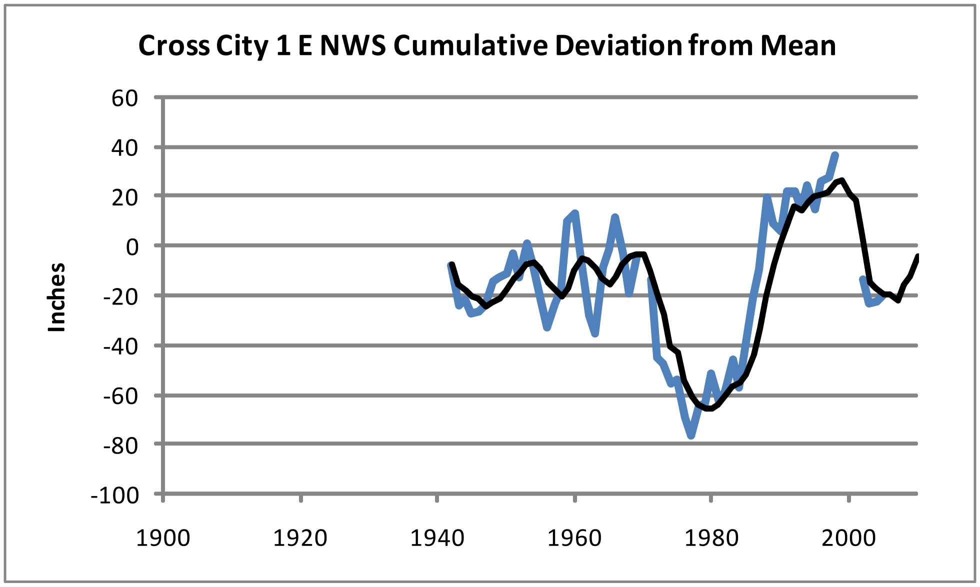


	Dry Season Total (inches)	X% of Annual Totals
1940-1969	22.3	39%
1970-1994	24.5	43%
1995-2009	20.5	37%
POR	22.9	40%

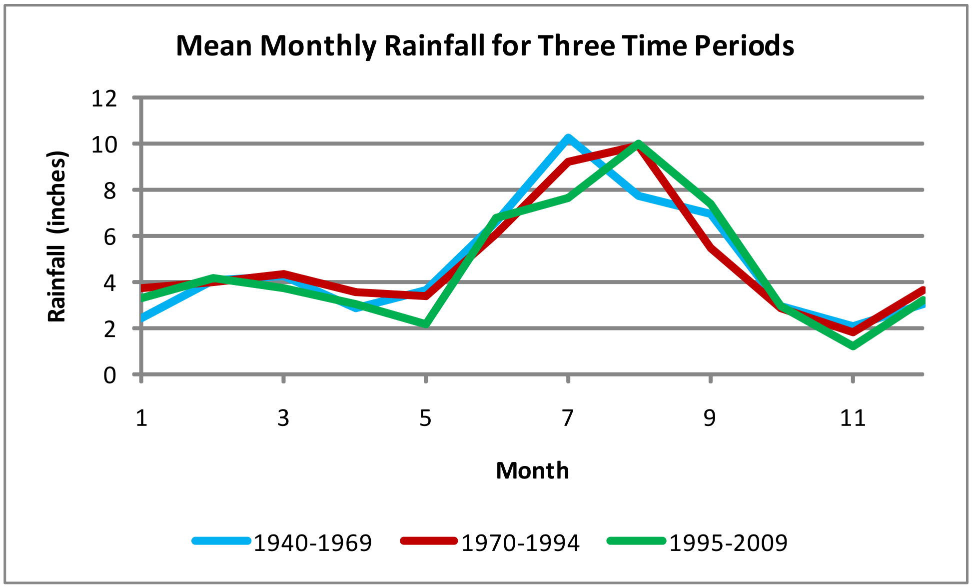


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	34.4	61%
1970-1994	33.5	57%
1995-2009	34.7	63%
POR	34.1	60%

	Mean	Year Ending
Driest 2 yr mean annual	34.41	1972
Driest 3 yr mean annual	40.82	1963
Driest 4 yr mean annual	43.10	1974
Driest 5 yr mean annual	45.70	1975
Driest 10 year mean annual	47.53	1976
Wetest 2 yr mean annual	76.91	1988
Wetest 3 yr mean annual	75.27	1988
Wetest 4 yr mean annual	75.87	1988
Wetest 5 yr mean annual	70.00	1987
Wetest 10 year mean annual	65.37	1991

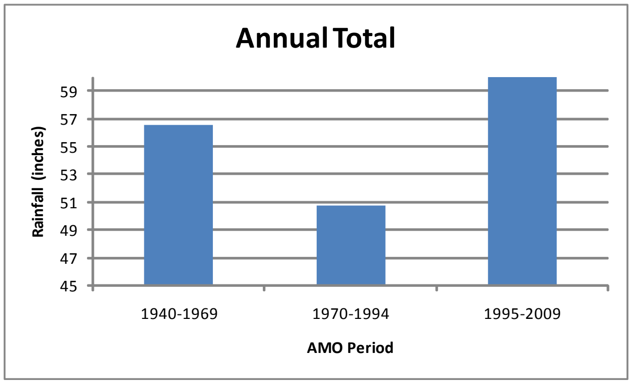


CROSS CITY 1 E NWS

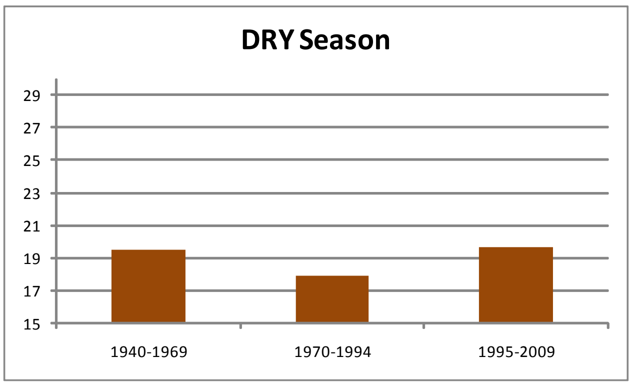


Month	1940-1969	1970-1994	1995-2009
1	2.45	3.75	3.27
2	4.11	3.94	4.19
3	4.22	4.35	3.73
4	2.85	3.57	3.01
5	3.65	3.35	2.12
6	6.58	6.09	6.76
7	10.27	9.21	7.68
8	7.71	9.86	9.98
9	6.97	5.47	7.39
10	2.90	2.83	2.91
11	2.04	1.85	1.18
12	3.06	3.65	3.24
Total	56.81	57.92	55.47

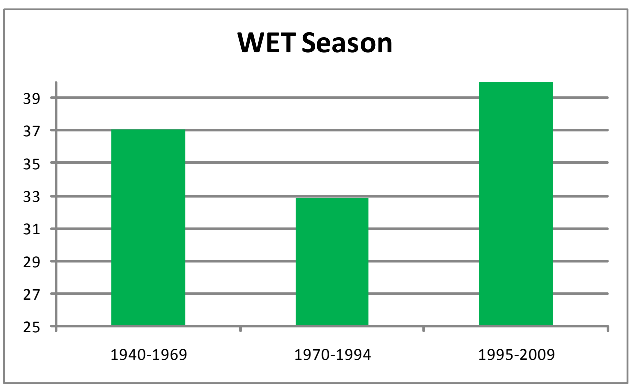
FORT GREEN 12 WSW NWS



	Annual Total (inches)
1940-1969	56.5
1970-1994	50.8
1995-2009	60.7
POR	55.0



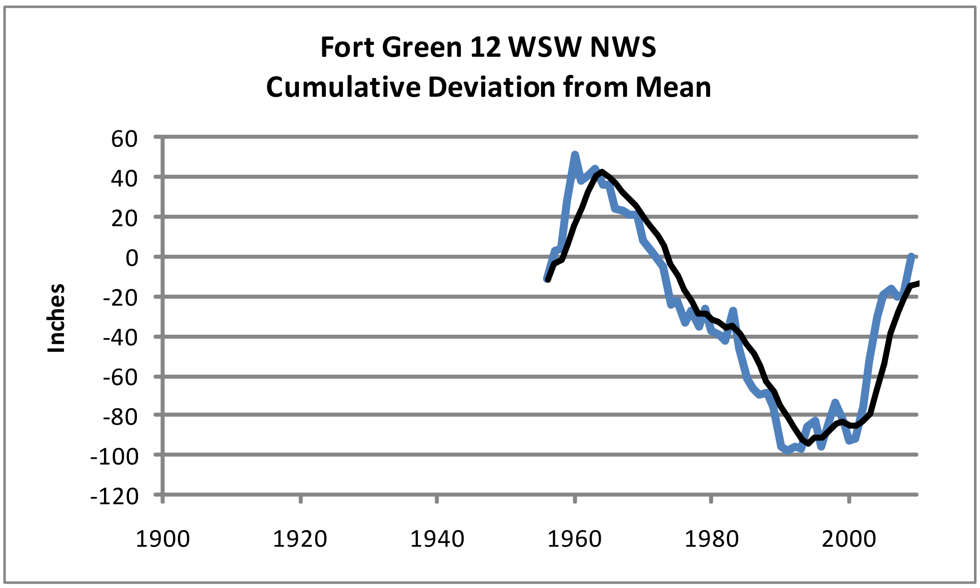
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	19.5	34%
1970-1994	17.9	35%
1995-2009	19.6	32%
POR	18.8	34%



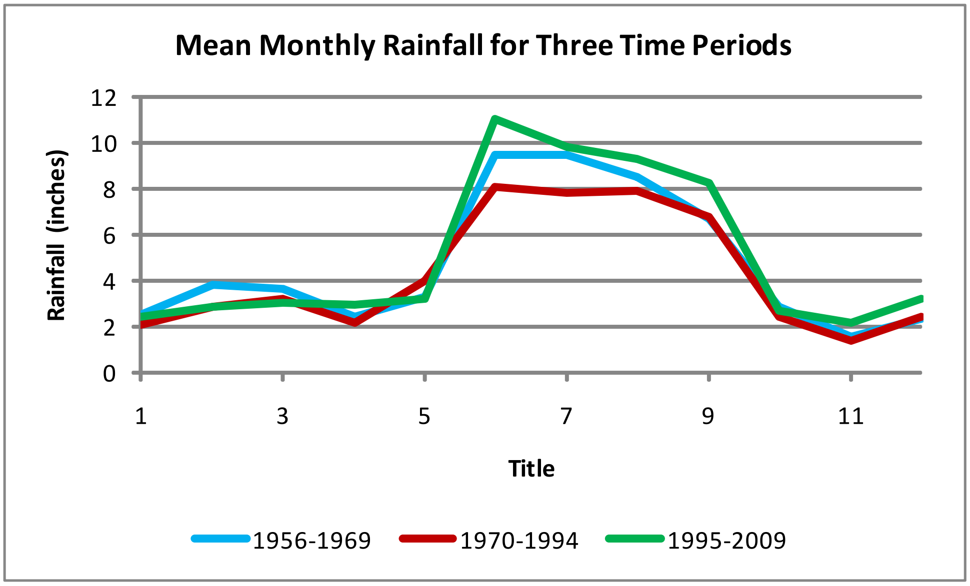
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	37.0	66%
1970-1994	32.9	65%
1995-2009	41.1	68%
POR	36.2	66%

	Mean	Year Ending
Driest 2 yr mean annual	38.00	1972
Driest 3 yr mean annual	41.94	1963
Driest 4 yr mean annual	44.43	1974
Driest 5 yr mean annual	46.05	1975
Driest 10 year mean annual	48.14	1976
Wetest 2 yr mean annual	78.83	1988
Wetest 3 yr mean annual	75.71	1988
Wetest 4 yr mean annual	73.31	1988
Wetest 5 yr mean annual	70.25	1989
Wetest 10 year mean annual	63.33	1991

Years deleted due to missing data:
1970, 1999, 2001, 2006, 2007

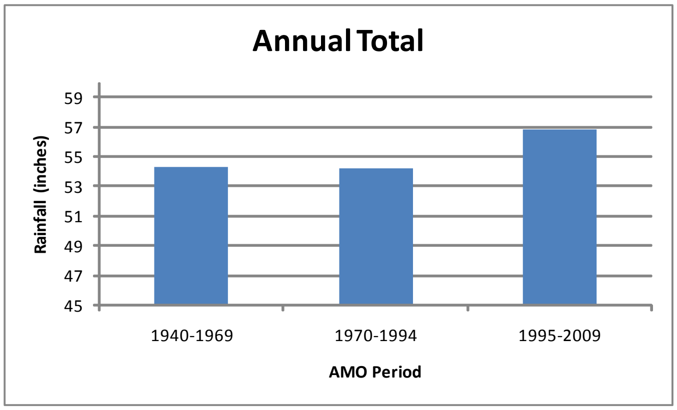


FORT GREEN 12 WSW NWS

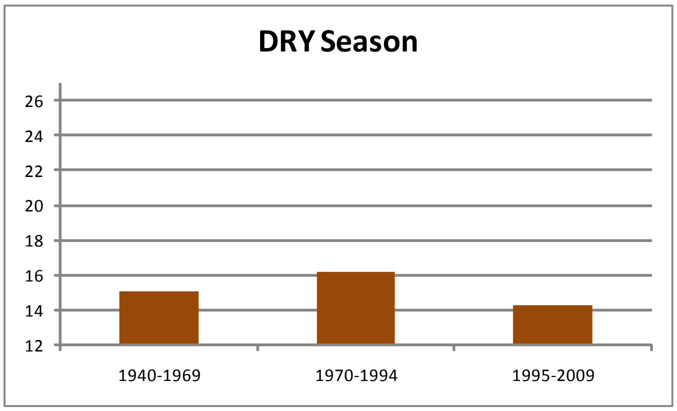


Month	1956-1969	1970-1994	1995-2009
1	2.51	2.04	2.45
2	3.80	2.87	2.86
3	3.65	3.19	3.06
4	2.46	2.13	2.98
5	3.26	3.97	3.18
6	9.45	8.08	11.07
7	9.49	7.79	9.80
8	8.51	7.90	9.31
9	6.72	6.74	8.24
10	2.87	2.38	2.68
11	1.58	1.38	2.16
12	2.31	2.46	3.22
Total	56.60	50.92	61.01

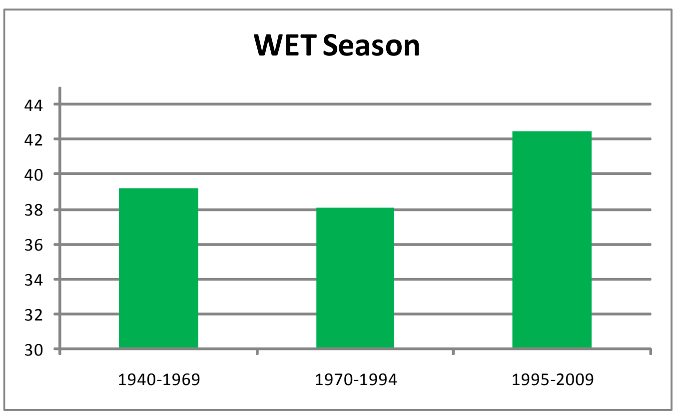
FORT MYERS PAGE FIELD AIRPORT NWS



	Annual Total (inches)
1940-1969	54.3
1970-1994	54.2
1995-2009	56.8
POR	54.1



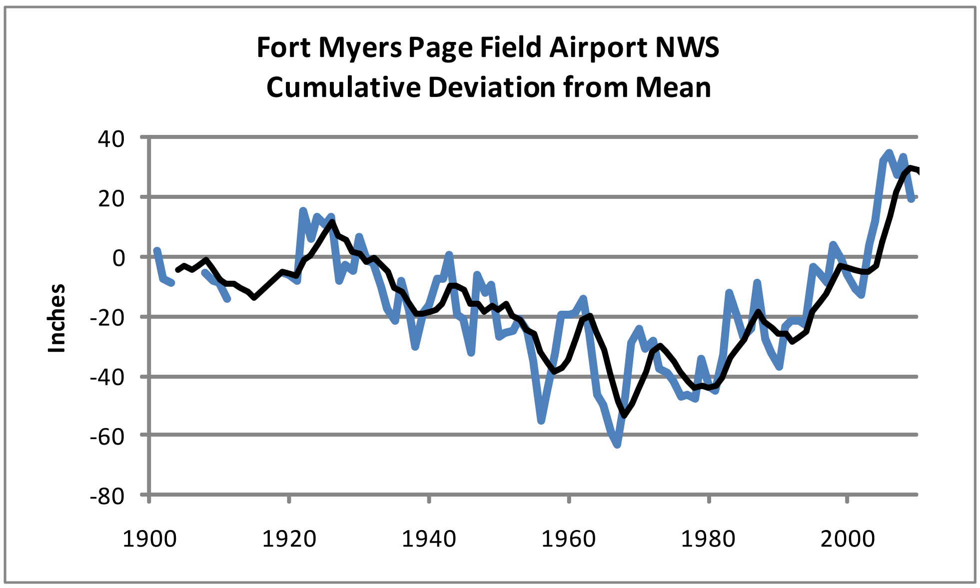
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	15.1	28%
1970-1994	16.2	29%
1995-2009	14.3	25%
POR	15.0	28%



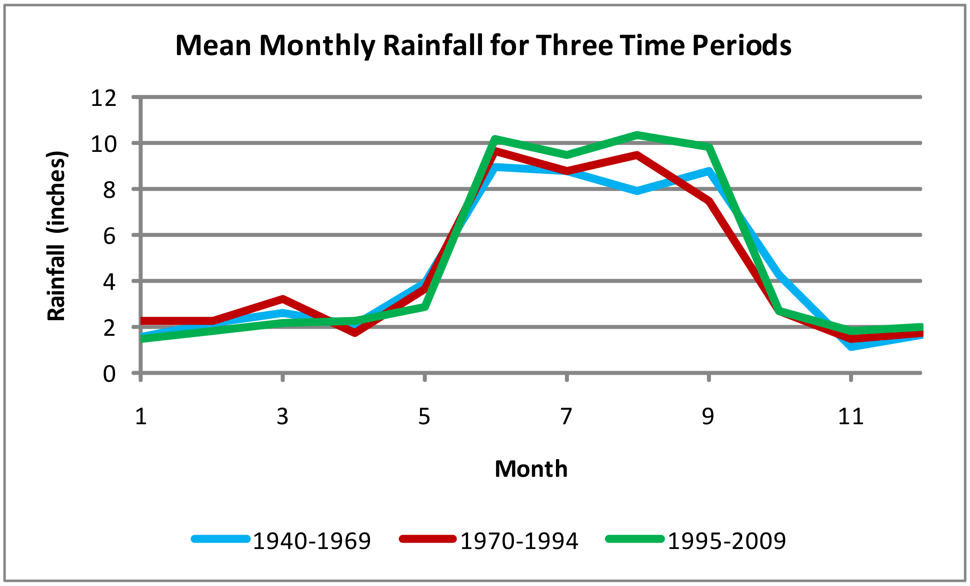
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	39.2	72%
1970-1994	38.1	71%
1995-2009	42.5	75%
POR	39.1	72%

	Mean	Year Ending
Driest 2 yr mean annual	37.87	1964
Driest 3 yr mean annual	42.19	1965
Driest 4 yr mean annual	42.89	1966
Driest 5 yr mean annual	44.19	1967
Driest 10 year mean annual	50.09	1957
Wetest 2 yr mean annual	71.12	1969
Wetest 3 yr mean annual	68.97	1005
Wetest 4 yr mean annual	65.80	2006
Wetest 5 yr mean annual	63.05	2006
Wetest 10 year mean annual	58.00	2006

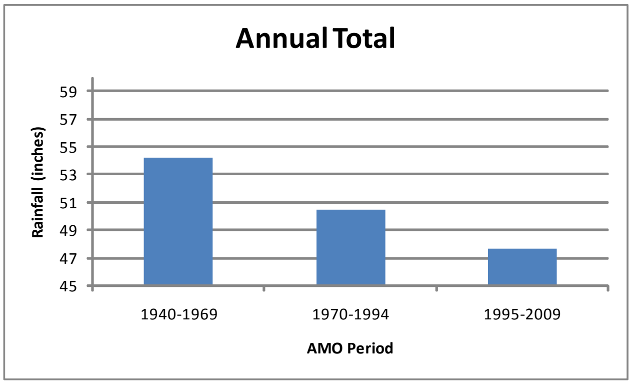
Complete record since 1919



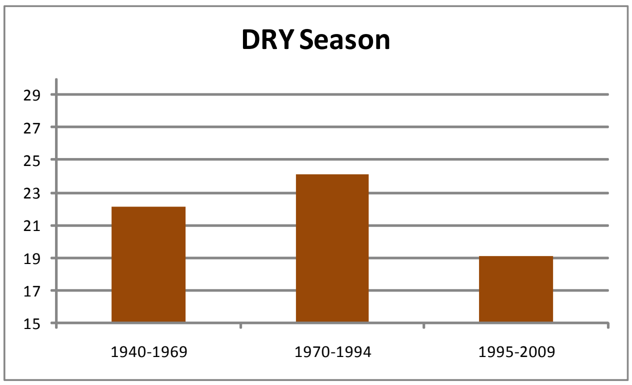
FORT MYERS PAGE FIELD AIRPORT NWS



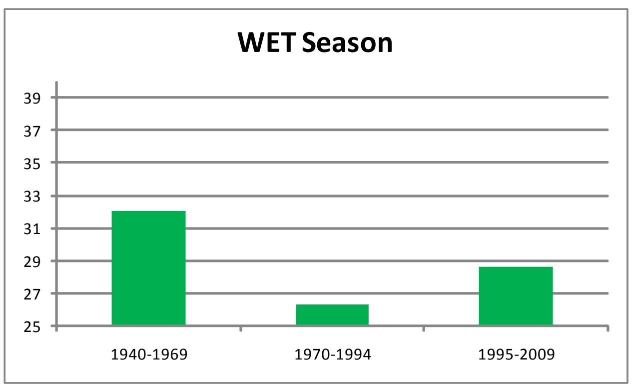
Month	1940-1969	1970-1994	1995-2009
1	1.51	2.27	1.48
2	2.18	2.28	1.82
3	2.58	3.21	2.12
4	2.10	1.74	2.29
5	3.86	3.60	2.87
6	8.95	9.67	10.17
7	8.80	8.78	9.48
8	7.87	9.51	10.30
9	8.78	7.45	9.85
10	4.29	2.66	2.67
11	1.14	1.42	1.83
12	1.67	1.71	2.01
Total	53.73	54.32	56.89



	Annual Total (inches)
1940-1969	54.2
1970-1994	50.4
1995-2009	47.7
POR	50.7



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	22.1	41%
1970-1994	24.1	48%
1995-2009	19.1	40%
POR	21.3	42%

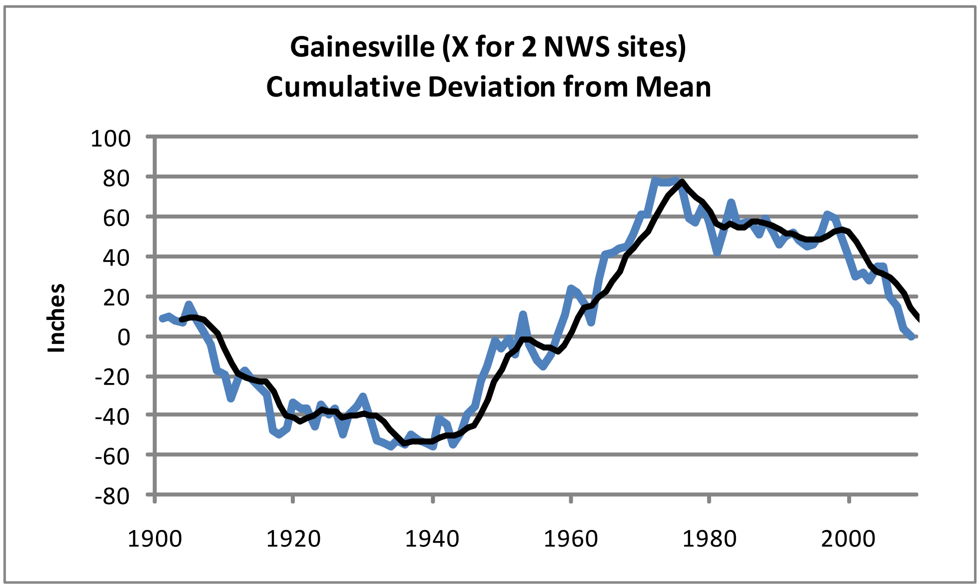


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	32.1	59%
1970-1994	26.3	52%
1995-2009	28.6	60%
POR	29.4	58%

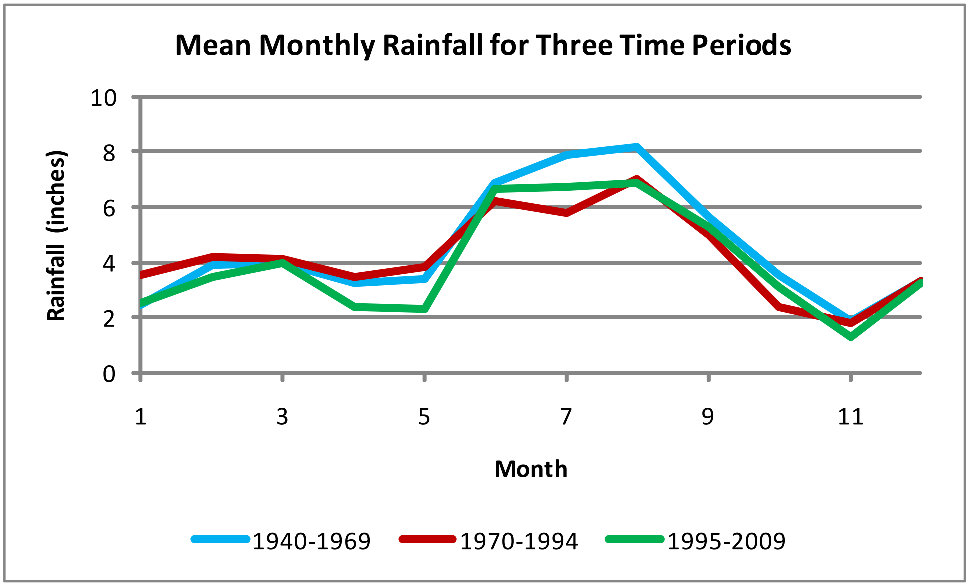
	Mean	Year Ending
Driest 2 yr mean annual	38.41	1981
Driest 3 yr mean annual	40.41	2008
Driest 4 yr mean annual	42.04	2009
Driest 5 yr mean annual	42.83	1911 (2009 2nd)
Driest 10 year mean annual	45.18	2008

Wetest 2 yr mean annual	67.81	1965
Wetest 3 yr mean annual	62.49	1966
Wetest 4 yr mean annual	60.33	1960
Wetest 5 yr mean annual	59.89	1941
Wetest 10 year mean annual	57.77	1973

Record complete since 1901 when use mean of two sites

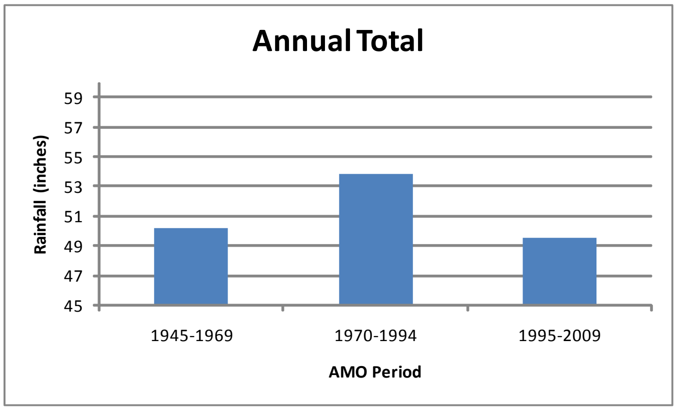


GainesvilleXfor2NWS_Sites

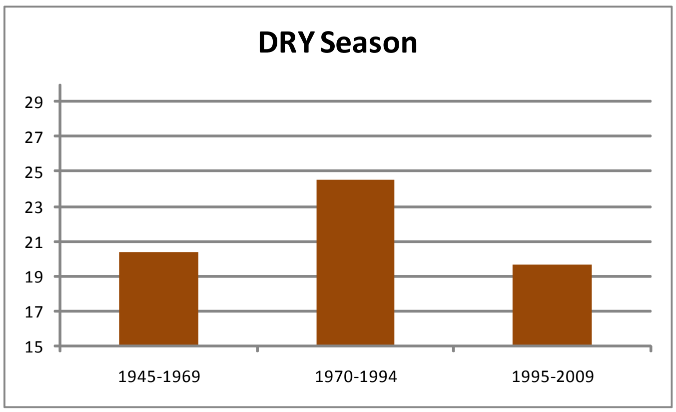


Month	1940-1969	1970-1994	1995-2009
1	2.46	3.53	2.53
2	3.90	4.22	3.49
3	4.00	4.11	3.99
4	3.25	3.46	2.38
5	3.38	3.83	2.29
6	6.85	6.25	6.67
7	7.86	5.80	6.73
8	8.20	6.98	6.88
9	5.63	4.95	5.26
10	3.56	2.35	3.07
11	1.85	1.83	1.32
12	3.29	3.30	3.22
Total	54.23	50.61	47.83

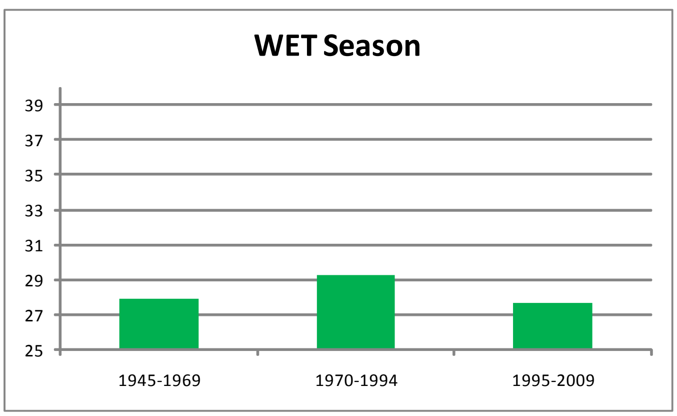
HIGH SPRINGS NWS



	Annual Total (inches)
1940-1969	50.2
1970-1994	53.8
1995-2009	49.5
POR	51.4



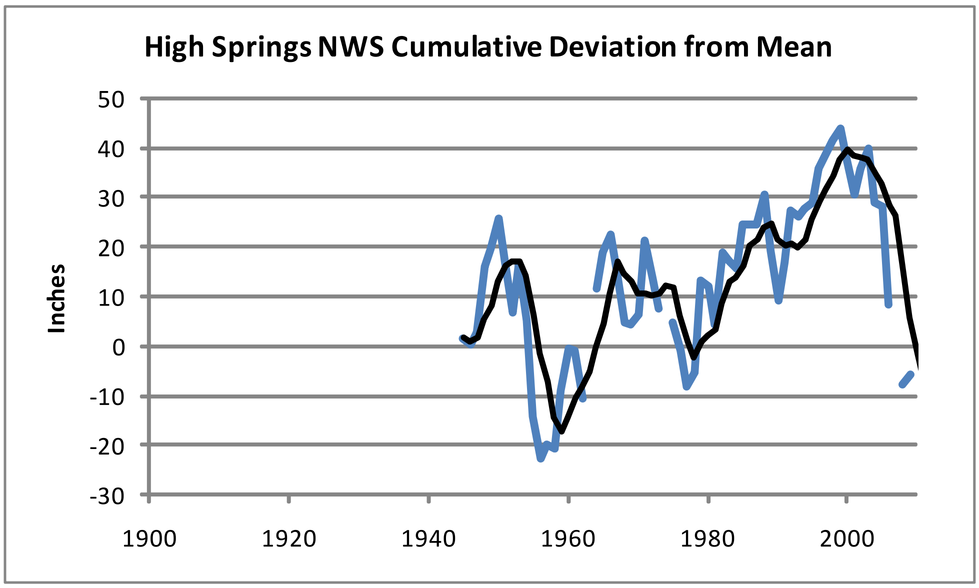
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	20.4	39%
1970-1994	24.5	46%
1995-2009	19.7	39%
POR	21.7	41%



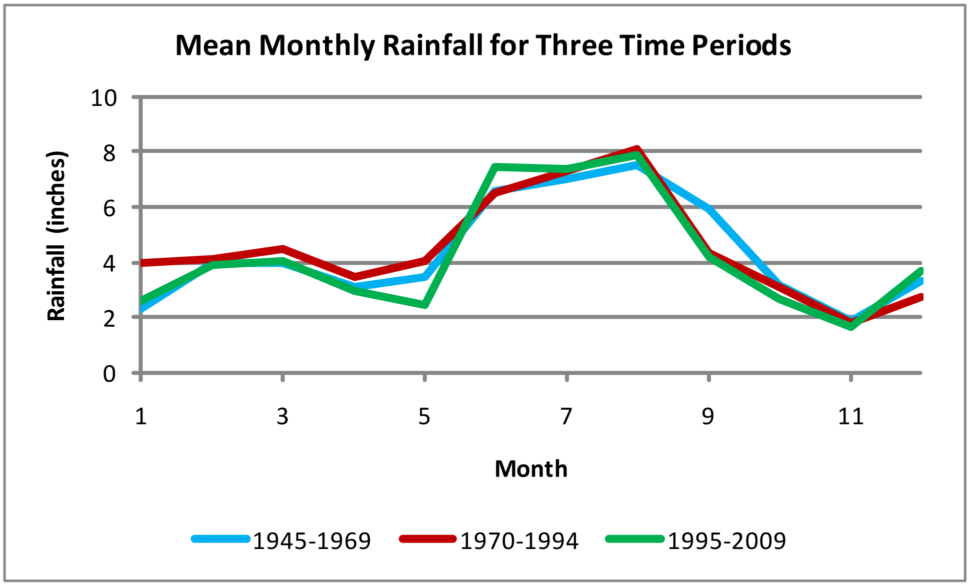
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	27.9	54%
1970-1994	29.3	54%
1995-2009	27.7	55%
POR	28.4	54%

	Mean	Year Ending
Driest 2 yr mean annual	37.02	1955
Driest 3 yr mean annual	39.44	1956
Driest 4 yr mean annual	43.39	1957
Driest 5 yr mean annual	44.52	1955
Driest 10 year mean annual	48.86	1958
Wetest 2 yr mean annual	63.27	1979
Wetest 3 yr mean annual	60.10	1950
Wetest 4 yr mean annual	58.83	1950
Wetest 5 yr mean annual	57.95	1982
Wetest 10 year mean annual	56.09	1988

Period of Record is from 1945 to present.
Years deleted due to missing data: 1963, 1974, 2007

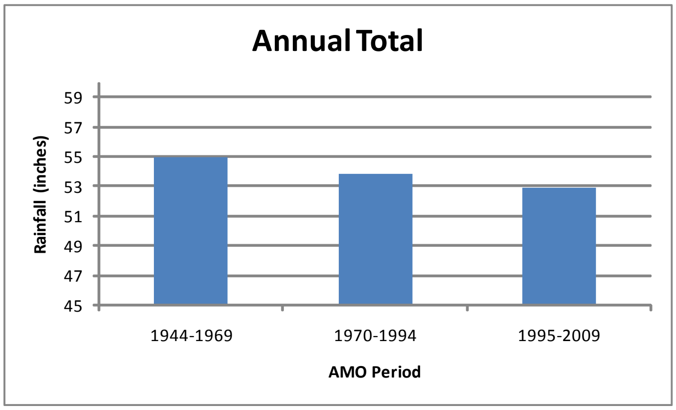


HIGH SPRINGS NWS

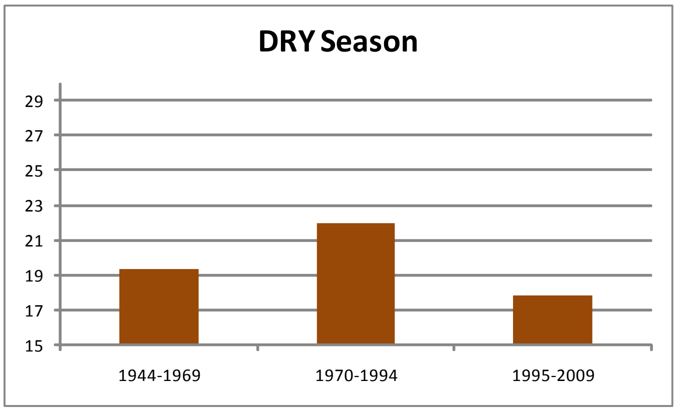


Month	1945-1969	1970-1994	1995-2009
1	2.29	3.97	2.61
2	3.99	4.15	3.93
3	4.00	4.48	4.02
4	3.09	3.44	2.96
5	3.48	4.05	2.45
6	6.60	6.48	7.42
7	6.99	7.29	7.41
8	7.50	8.10	7.89
9	5.93	4.34	4.22
10	3.18	3.09	2.69
11	1.88	1.78	1.66
12	3.36	2.74	3.68
Total	52.28	53.91	50.93

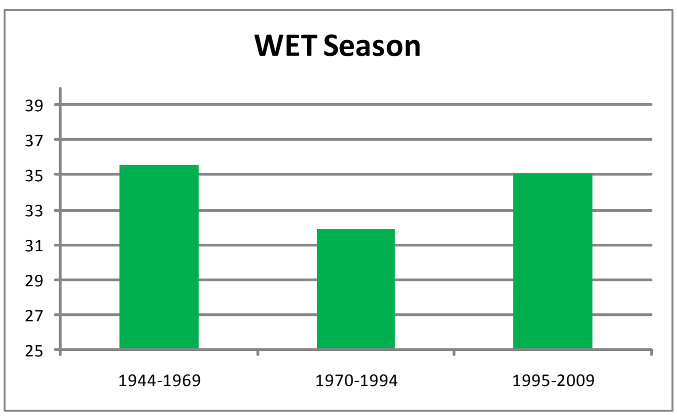
HILLSBOROUGH RIVER STATE PARK NWS



	Annual Total (inches)
1940-1969	54.9
1970-1994	53.9
1995-2009	52.9
POR	54.0



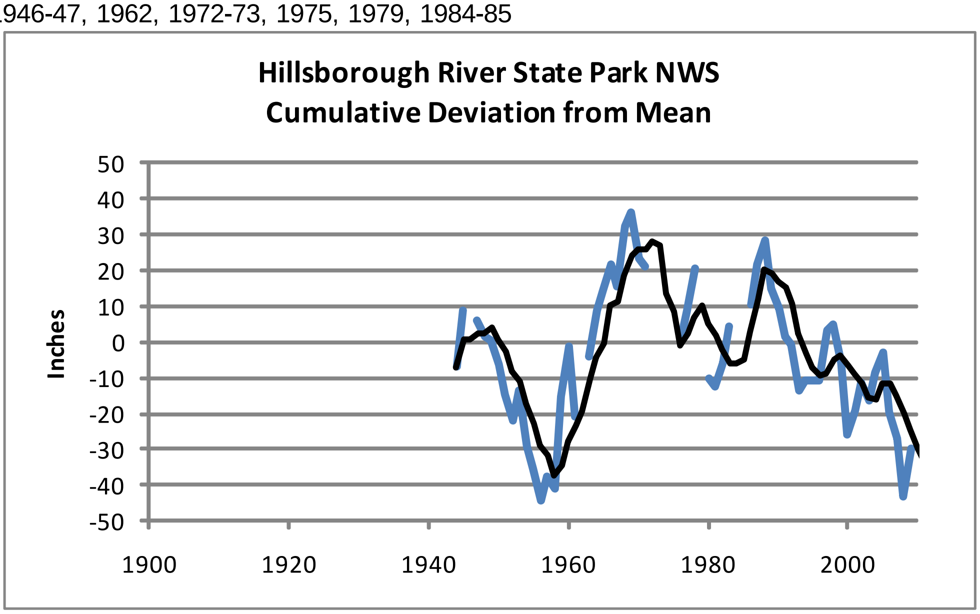
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	19.3	35%
1970-1994	22.0	41%
1995-2009	17.8	33%
POR	19.8	37%



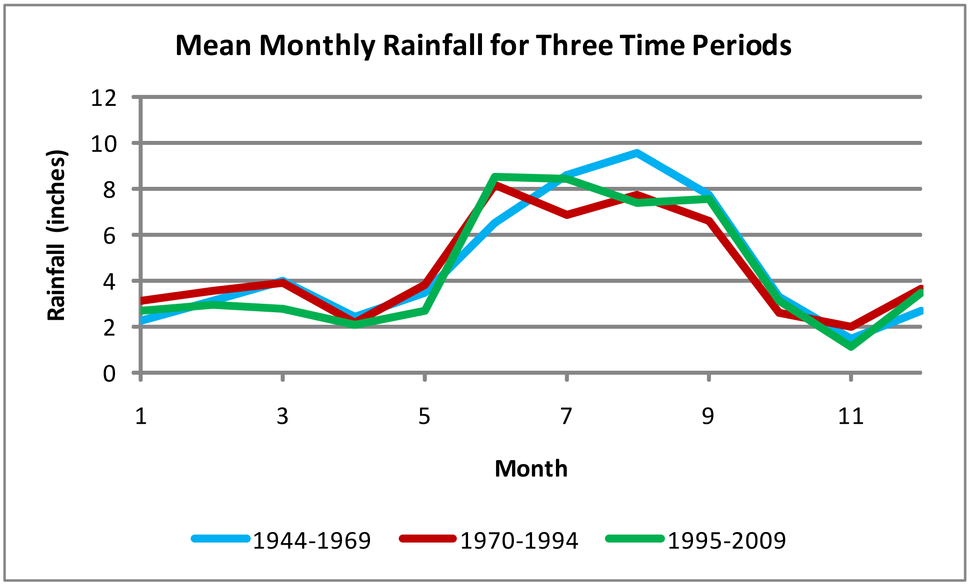
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	35.6	65%
1970-1994	31.9	59%
1995-2009	35.0	67%
POR	34.2	63%

	Mean	Year Ending
Driest 2 yr mean annual	38.80	2000
Driest 3 yr mean annual	40.54	2008
Driest 4 yr mean annual	45.34	2008
Driest 5 yr mean annual	45.65	1993
Driest 10 year mean annual	49.31	2008
Wetest 2 yr mean annual	73.81	1960
Wetest 3 yr mean annual	66.12	1960
Wetest 4 yr mean annual	64.82	1960
Wetest 5 yr mean annual	61.40	1968
Wetest 10 year mean annual	54.92	

Period of Record from 1944 to 2009
Years deleted due to missing data:
1946-47, 1962, 1972-73, 1975, 1979, 1984-85

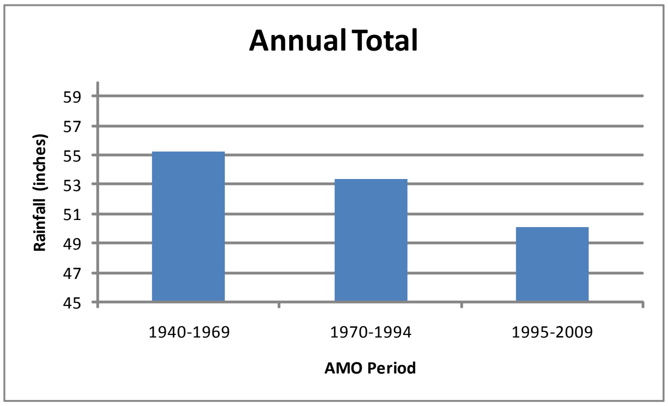


HILLSBOROUGH RIVER STATE PARK NWS

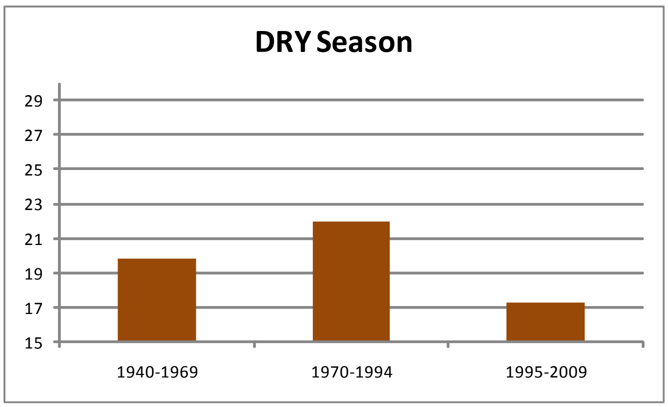


Month	1944-1969	1970-1994	1995-2009
1	2.21	3.10	2.71
2	3.13	3.51	2.97
3	4.02	3.94	2.80
4	2.42	2.19	2.07
5	3.47	3.84	2.70
6	6.47	8.15	8.47
7	8.57	6.83	8.44
8	9.53	7.76	7.42
9	7.69	6.58	7.59
10	3.33	2.55	3.13
11	1.45	1.98	1.15
12	2.71	3.63	3.50
Total	55.00	54.06	52.95

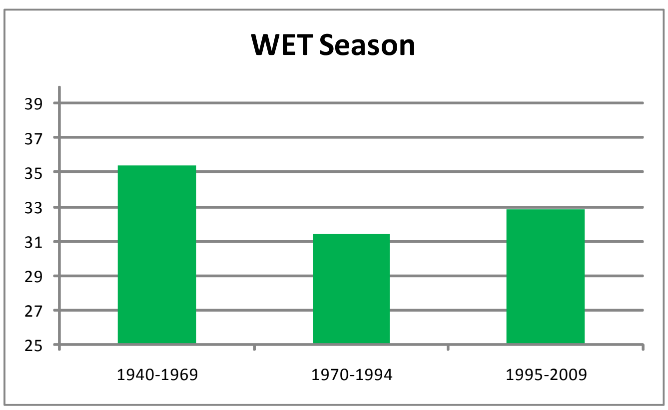
INVERNESS 3 SE NWS



	Annual Total (inches)
1940-1969	55.3
1970-1994	53.3
1995-2009	50.1
POR	52.8



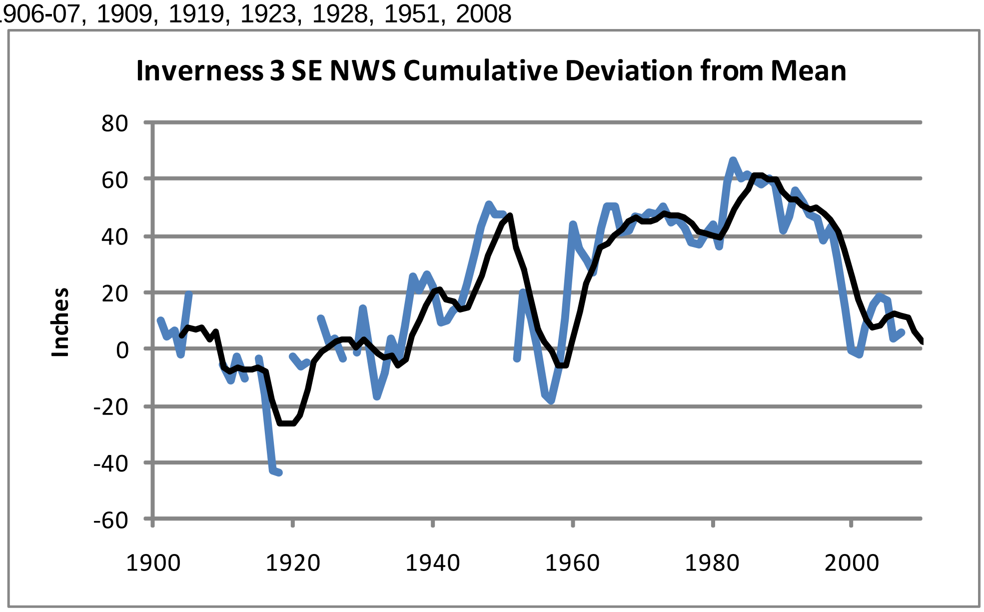
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	19.8	36%
1970-1994	22.0	41%
1995-2009	17.3	35%
POR	19.6	37%



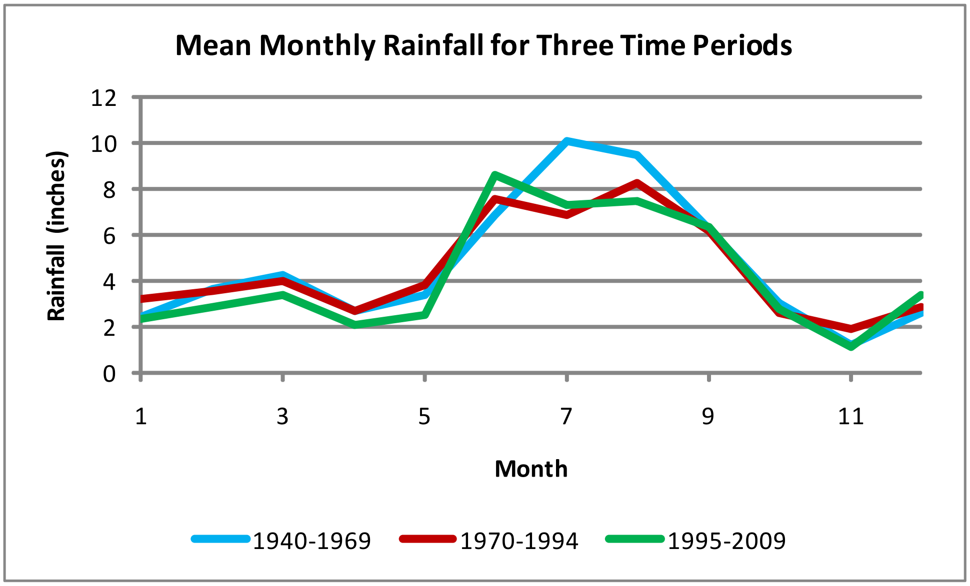
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	35.4	64%
1970-1994	31.4	59%
1995-2009	32.8	65%
POR	33.2	63%

	Mean	Year Ending
Driest 2 yr mean annual	33.75	1917 (2000 2nd)
Driest 3 yr mean annual	38.70	2000
Driest 4 yr mean annual	42.06	2001
Driest 5 yr mean annual	43.99	2000
Driest 10 year mean annual	48.48	2001
Wetest 2 yr mean annual	78.39	1960
Wetest 3 yr mean annual	74.00	1960
Wetest 4 yr mean annual	68.40	1960
Wetest 5 yr mean annual	63.57	1961
Wetest 10 year mean annual	59.94	1966

Period of Record fm 1901 to 2009
Years due to missing data:
1906-07, 1909, 1919, 1923, 1928, 1951, 2008

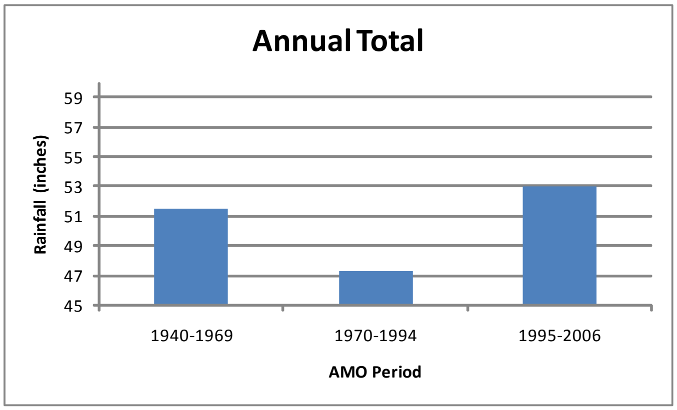


INVERNESS 3 SE NWS

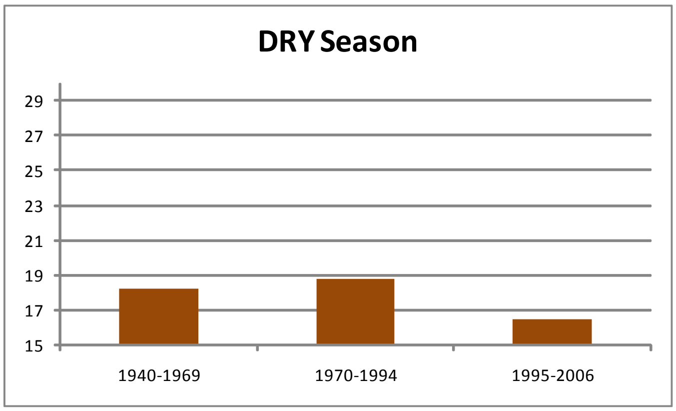


Month	1940-1969	1970-1994	1995-2009
1	2.45	3.20	2.36
2	3.59	3.57	2.89
3	4.28	3.99	3.41
4	2.69	2.65	2.09
5	3.38	3.85	2.51
6	6.87	7.56	8.60
7	10.06	6.88	7.31
8	9.51	8.21	7.48
9	6.26	6.16	6.34
10	3.01	2.58	2.76
11	1.16	1.92	1.09
12	2.55	2.82	3.35
Total	55.82	53.41	50.19

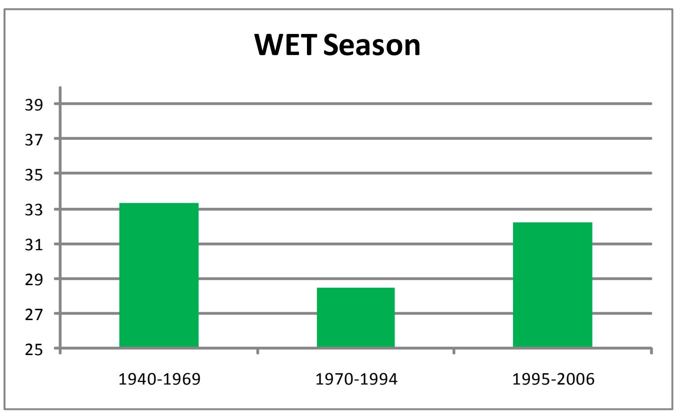
KISSIMMEE 2 NWS



	Annual Total (inches)
1940-1969	51.5
1970-1994	47.3
1995-2009	53.0
POR	49.8



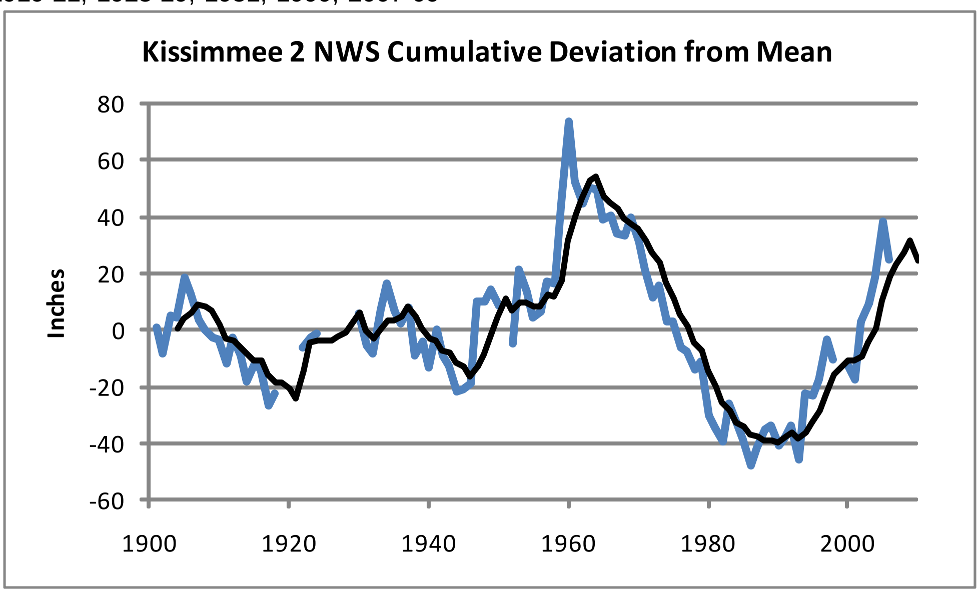
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	18.2	35%
1970-1994	18.8	40%
1995-2009	16.5	31%
POR	18.2	37%



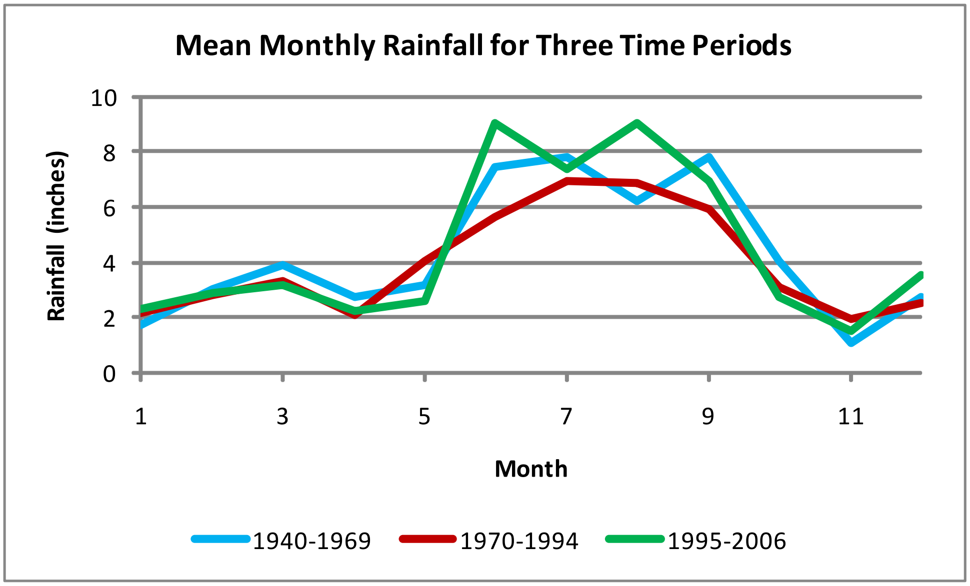
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	33.3	65%
1970-1994	28.5	60%
1995-2009	32.2	61%
POR	31.0	62%

	Mean	Year Ending
Driest 2 yr mean annual	35.30	1962
Driest 3 yr mean annual	40.46	1972
Driest 4 yr mean annual	42.58	1974
Driest 5 yr mean annual	42.44	1974
Driest 10 year mean annual	43.58	1980
Wetest 2 yr mean annual	78.37	1960
Wetest 3 yr mean annual	68.64	1960
Wetest 4 yr mean annual	66.49	1960
Wetest 5 yr mean annual	63.67	1960
Wetest 10 year mean annual	57.94	1960

Period of Record is 1901 to 2006
Years deleted due to missing data:
1919-21, 1925-29, 1951, 1999, 2007-09

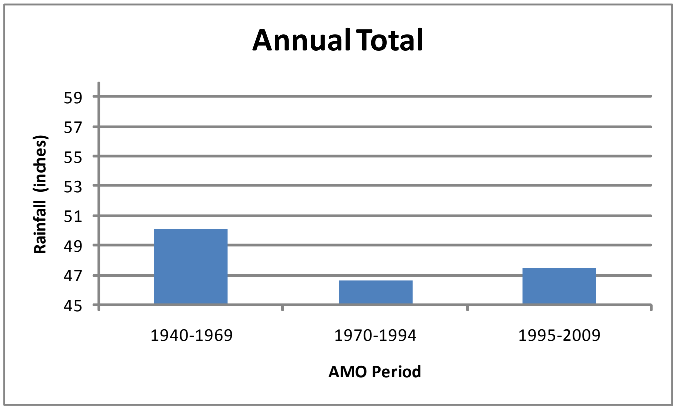


KISSIMMEE 2 NWS

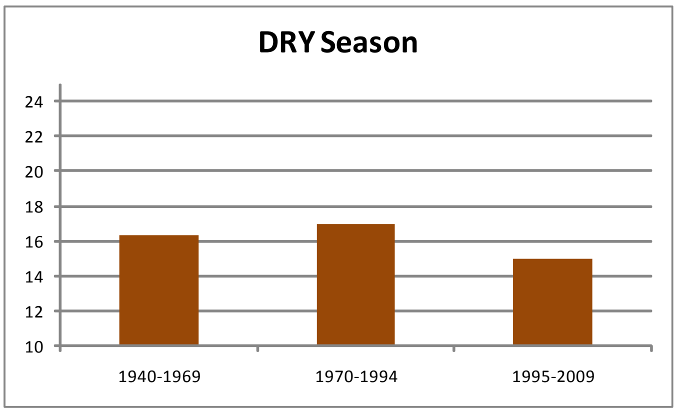


Month	1940-1969	1970-1994	1995-2006
1	1.73	2.13	2.27
2	3.03	2.81	2.89
3	3.90	3.35	3.15
4	2.74	2.12	2.21
5	3.21	4.01	2.62
6	7.44	5.62	9.08
7	7.79	6.97	7.40
8	6.22	6.89	9.02
9	7.81	5.92	6.95
10	4.05	3.09	2.72
11	1.11	1.97	1.47
12	2.70	2.51	3.52
Total	51.72	47.40	53.30

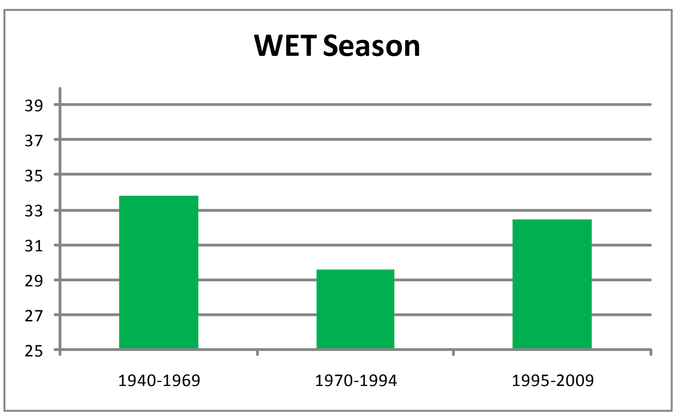
MOORE HAVEN LOCK 1 NWS



	Annual Total (inches)
1940-1969	50.1
1970-1994	46.6
1995-2009	47.4
POR	48.4



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	16.3	32%
1970-1994	17.0	36%
1995-2009	15.0	32%
POR	15.7	33%

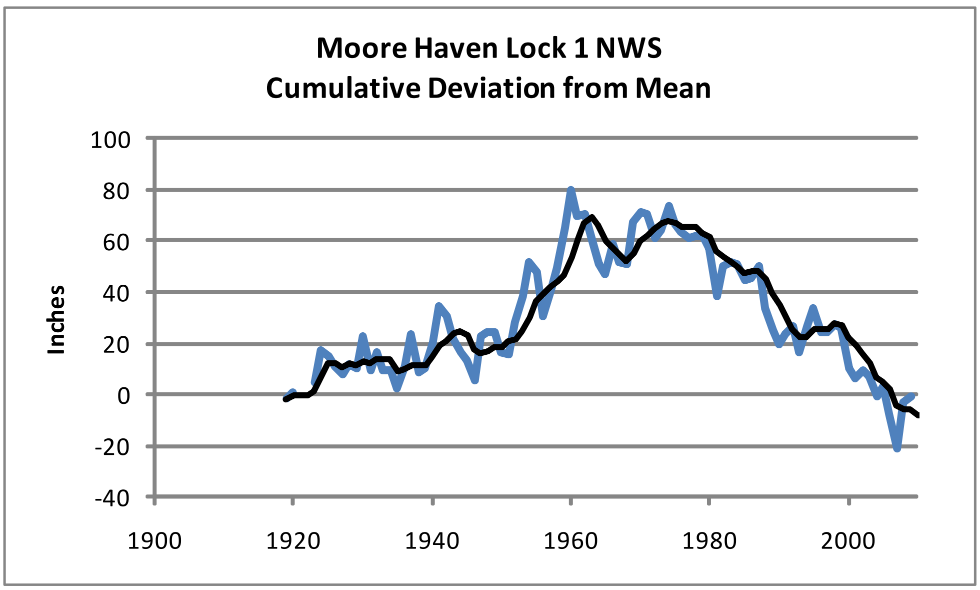


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	33.8	68%
1970-1994	29.6	64%
1995-2009	32.4	68%
POR	32.2	67%

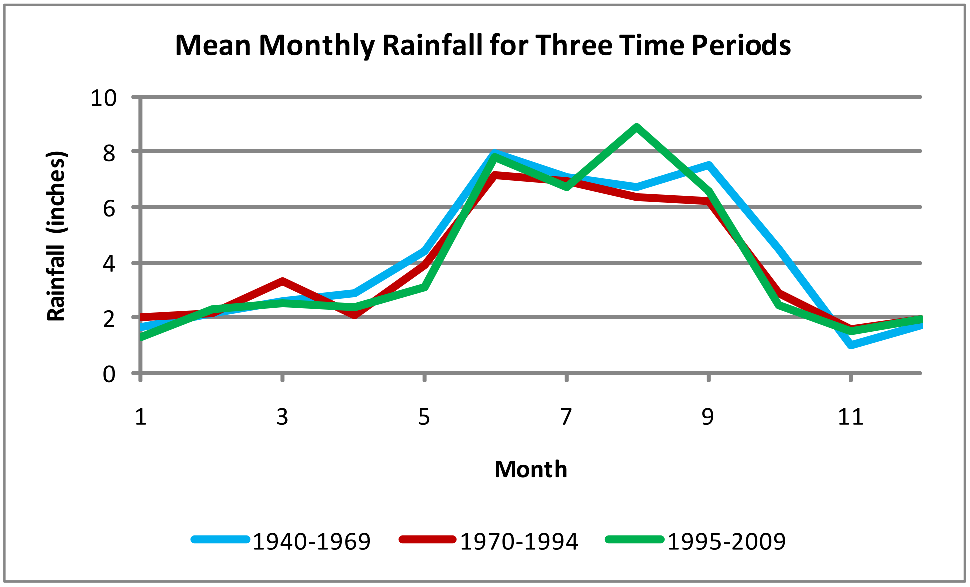
	Mean	Year Ending
Driest 2 yr mean annual	35.88	1989
Driest 3 yr mean annual	37.96	1990
Driest 4 yr mean annual	40.88	1964
Driest 5 yr mean annual	41.61	1965
Driest 10 year mean annual	43.68	2007

Wetest 2 yr mean annual	63.58	1960
Wetest 3 yr mean annual	61.37	1960
Wetest 4 yr mean annual	60.59	1960
Wetest 5 yr mean annual	56.00	1961
Wetest 10 year mean annual	54.62	1960

Period of Record 1919 to 2009
Years deleted due to missing data:
1921-22, 2001, 2007

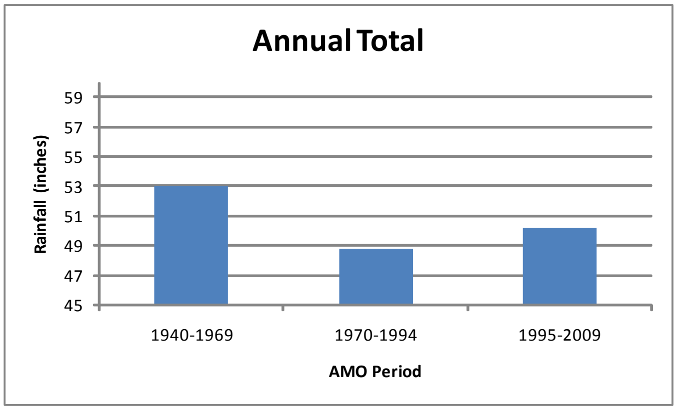


MOORE HAVEN LOCK 1 NWS

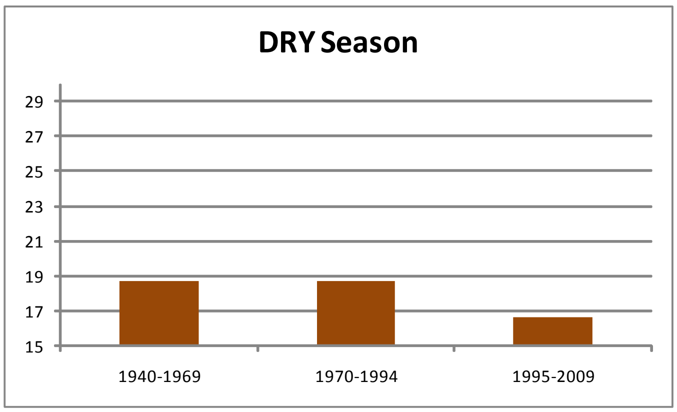


Month	1940-1969	1970-1994	1995-2009
1	1.62	2.03	1.32
2	2.17	2.15	2.28
3	2.61	3.31	2.53
4	2.86	2.11	2.36
5	4.38	3.89	3.11
6	7.94	7.15	7.78
7	7.12	6.98	6.70
8	6.69	6.36	8.92
9	7.53	6.22	6.58
10	4.49	2.90	2.45
11	1.01	1.61	1.47
12	1.76	1.96	1.97
Total	50.20	46.65	47.48

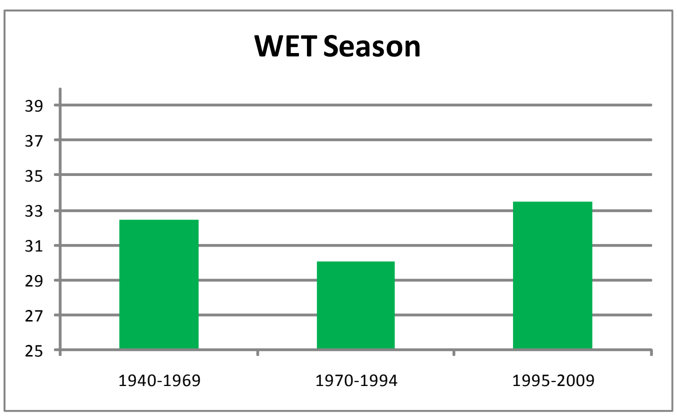
MOUNTAIN LAKE NWS



	Annual Total (inches)
1940-1969	53.0
1970-1994	48.8
1995-2009	50.2
POR	50.9



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	18.7	35%
1970-1994	18.7	38%
1995-2009	16.7	33%
POR	18.3	36%

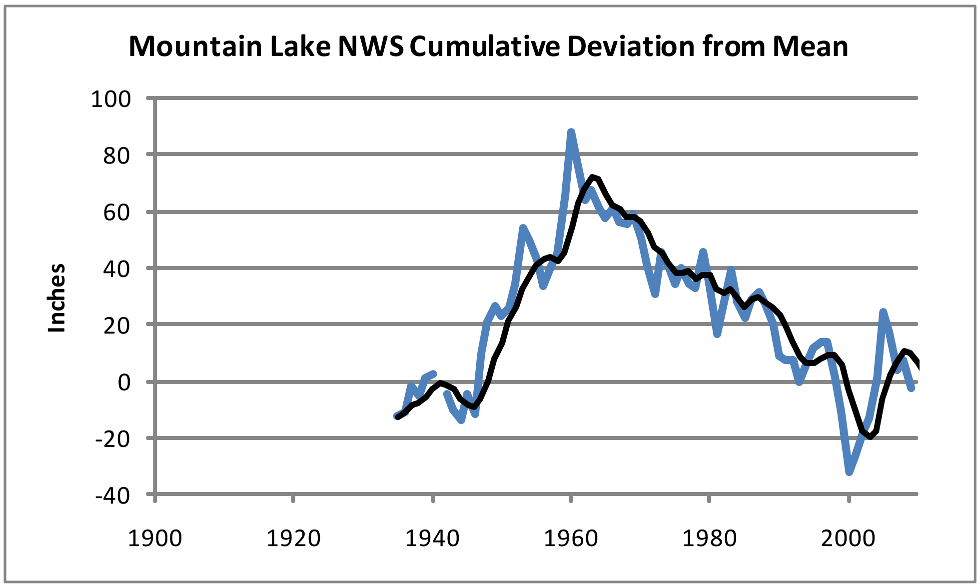


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	32.4	61%
1970-1994	30.1	62%
1995-2009	33.5	67%
POR	31.9	63%

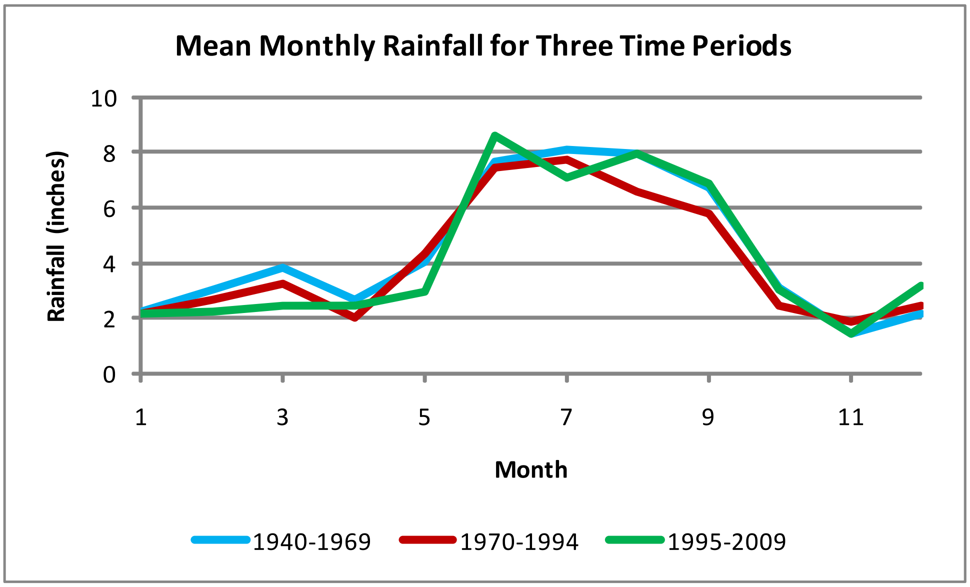
	Mean	Year Ending
Driest 2 yr mean annual	34.31	2000
Driest 3 yr mean annual	35.55	2000
Driest 4 yr mean annual	39.37	2000
Driest 5 yr mean annual	42.12	2000
Driest 10 year mean annual	46.73	2000
Wetest 2 yr mean annual	72.22	1960
Wetest 3 yr mean annual	66.51	1960
Wetest 4 yr mean annual	64.44	1960
Wetest 5 yr mean annual	62.14	2005
Wetest 10 year mean annual	57.29	1960

Period of Record 1935 to 2009

Years deleted due to missing data: 1941

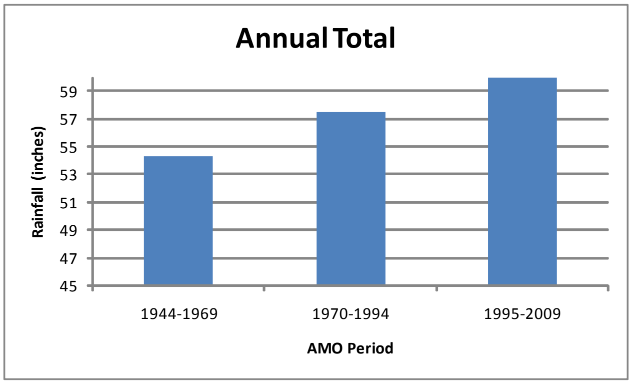


MOUNTAIN LAKE NWS

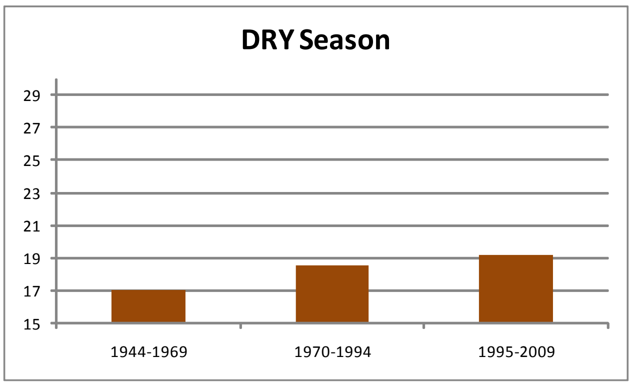


Month	1940-1969	1970-1994	1995-2009
1	2.26	2.18	2.16
2	3.05	2.69	2.25
3	3.80	3.28	2.45
4	2.69	2.02	2.43
5	4.01	4.32	2.97
6	7.70	7.48	8.59
7	8.07	7.72	7.07
8	7.98	6.58	7.98
9	6.70	5.80	6.86
10	3.10	2.47	3.02
11	1.45	1.84	1.43
12	2.16	2.46	3.14
Total	52.96	48.85	50.35

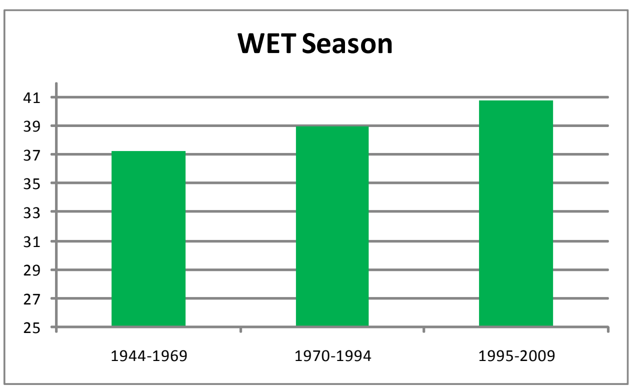
MYAKKA RIVER STATE PARK NWS



	Annual Total (inches)
1940-1969	54.3
1970-1994	57.5
1995-2009	60.0
POR	56.8



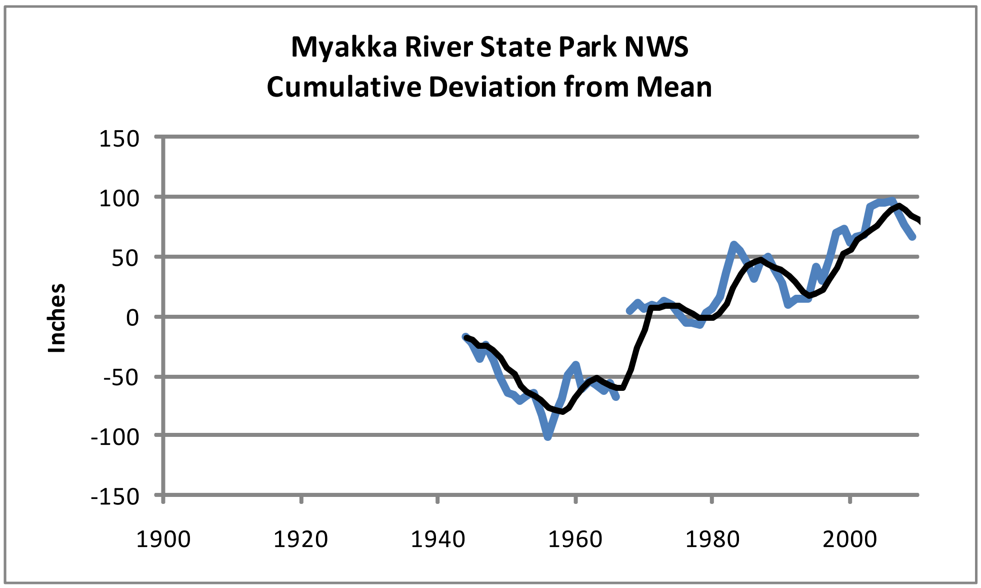
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	17.1	31%
1970-1994	18.6	32%
1995-2009	19.2	32%
POR	18.1	32%



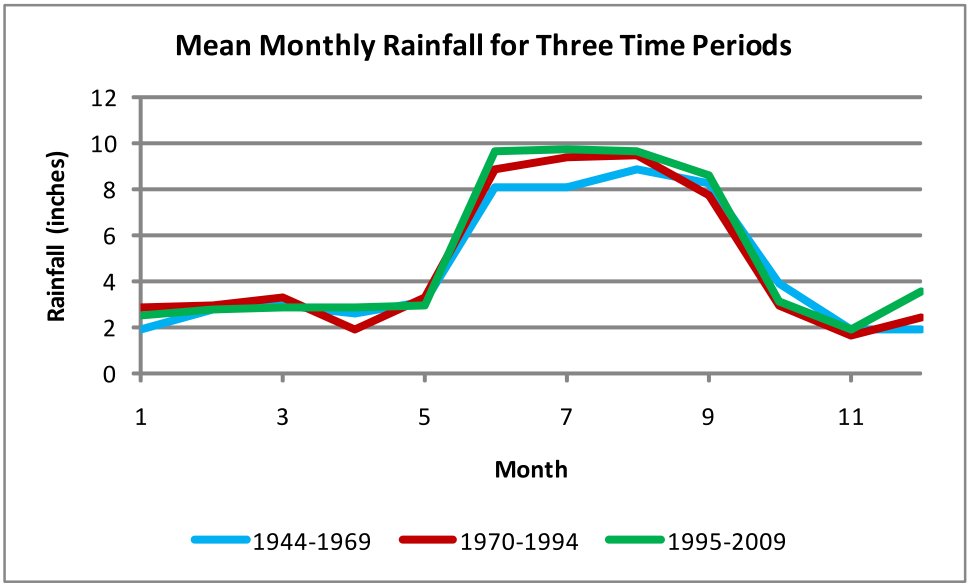
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	37.2	69%
1970-1994	38.9	68%
1995-2009	40.8	68%
POR	38.7	68%

	Mean	Year Ending
Driest 2 yr mean annual	38.20	1956
Driest 3 yr mean annual	43.19	1991
Driest 4 yr mean annual	46.30	1951
Driest 5 yr mean annual	47.41	1952
Driest 10 year mean annual	49.90	1953
Wetest 2 yr mean annual	78.54	1983
Wetest 3 yr mean annual	74.88	1983
Wetest 4 yr mean annual	71.31	1960
Wetest 5 yr mean annual	70.02	1985
Wetest 10 year mean annual	64.56	2004

Period of Record from 1944 to 2009
Years deleted due to missing data: 1967

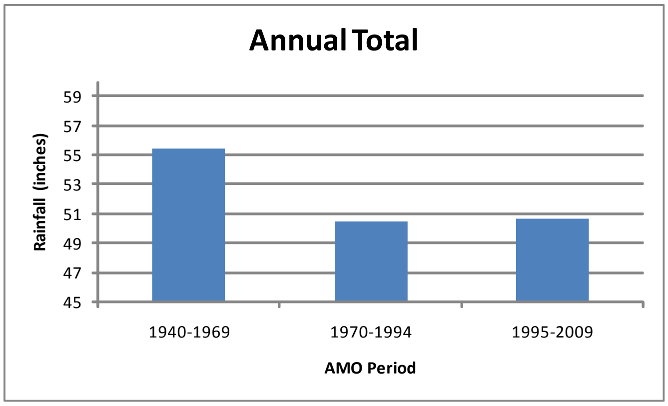


MYAKKA RIVER STATE PARK NWS

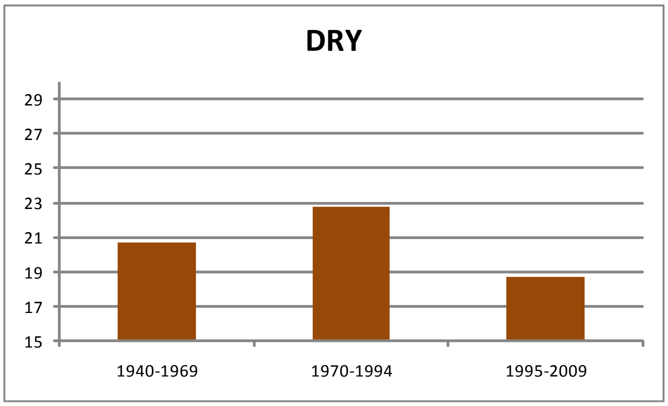


Month	1944-1969	1970-1994	1995-2009
1	1.89	2.87	2.49
2	2.77	2.96	2.80
3	2.95	3.31	2.86
4	2.61	1.91	2.89
5	3.11	3.29	2.92
6	8.11	8.88	9.65
7	8.11	9.35	9.75
8	8.85	9.43	9.65
9	8.24	7.74	8.62
10	3.91	2.97	3.12
11	1.85	1.67	1.88
12	1.93	2.38	3.51
Total	54.33	56.77	60.14

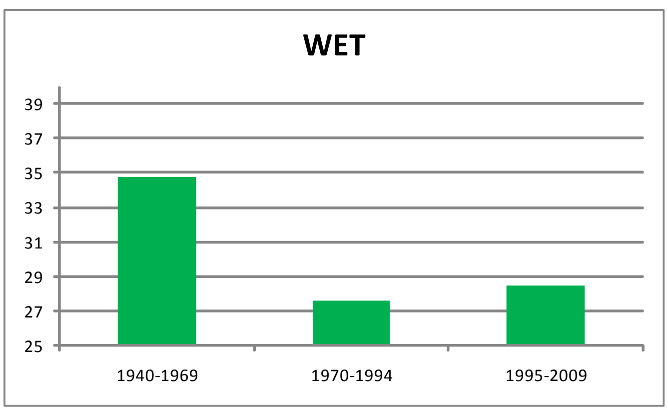
OCALA NWS RAINFALL



	Annual Total (inches)
1940-1969	55.5
1970-1994	50.4
1995-2009	50.7
POR	52.8



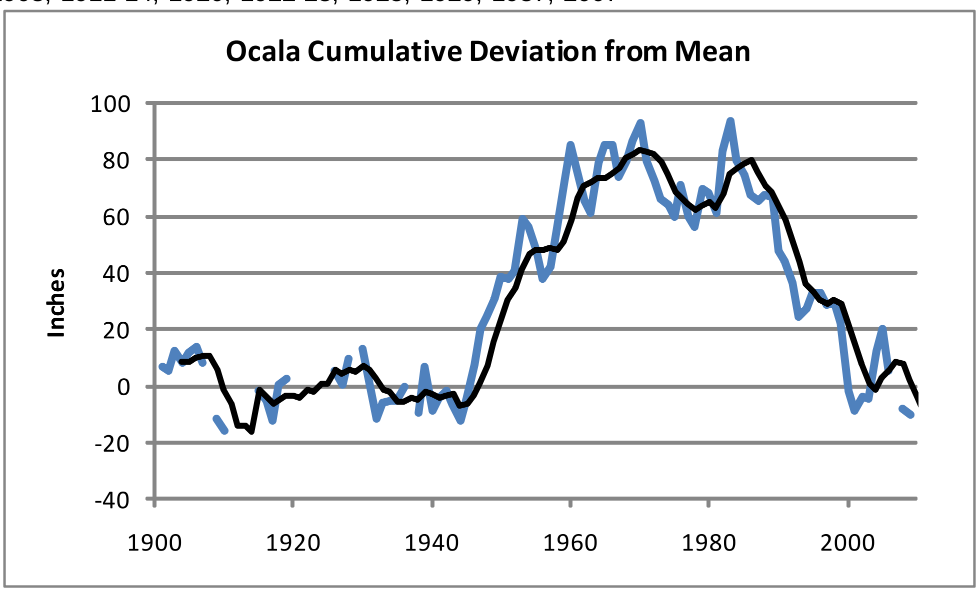
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	20.7	37%
1970-1994	22.8	45%
1995-2009	18.7	37%
POR	20.5	39%



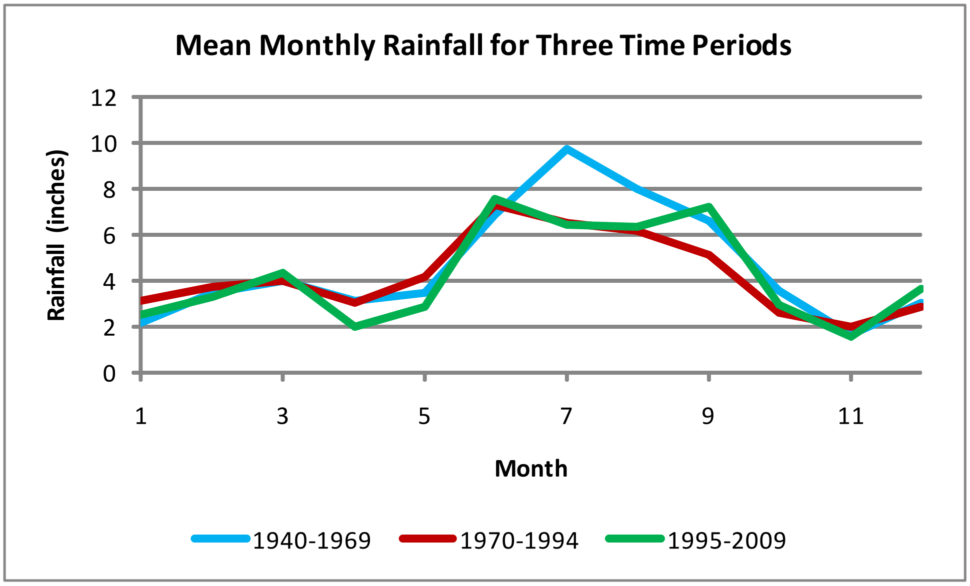
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	34.8	63%
1970-1994	27.6	55%
1995-2009	28.5	57%
POR	30.7	58%

	Mean	Year Ending
Driest 2 yr mean annual	37.10	2000
Driest 3 yr mean annual	40.13	2001
Driest 4 yr mean annual	42.16	1993
Driest 5 yr mean annual	44.11	1993
Driest 10 year mean annual	45.90	1993
Wetest 2 yr mean annual	68.82	1983
Wetest 3 yr mean annual	67.06	1960
Wetest 4 yr mean annual	64.66	1960
Wetest 5 yr mean annual	61.46	1949
Wetest 10 year mean annual	59.70	1954

Period of Record is from 1901 to 2009
Years deleted due to missing values:
1908, 1911-14, 1920, 1922-23, 1925, 1929, 1937, 2007

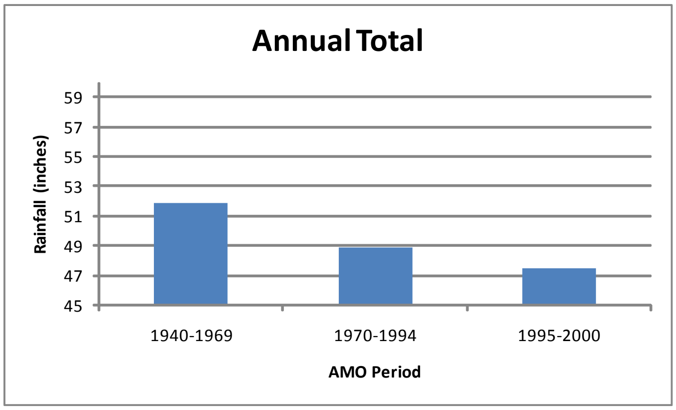


OCALA NWS RAINFALL

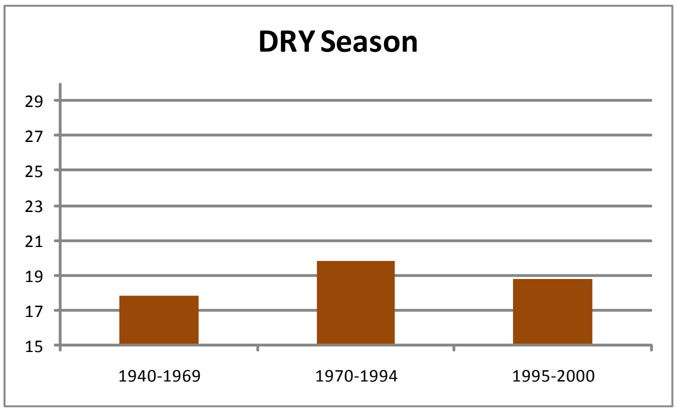


Month	1940-1969	1970-1994	1995-2009
1	2.19	3.15	2.53
2	3.48	3.69	3.29
3	4.01	3.95	4.31
4	3.14	3.04	2.01
5	3.47	4.16	2.87
6	6.85	7.30	7.51
7	9.70	6.48	6.46
8	8.02	6.18	6.32
9	6.61	5.12	7.22
10	3.57	2.55	2.97
11	1.60	2.01	1.53
12	3.02	2.84	3.64
Total	55.67	50.47	50.65

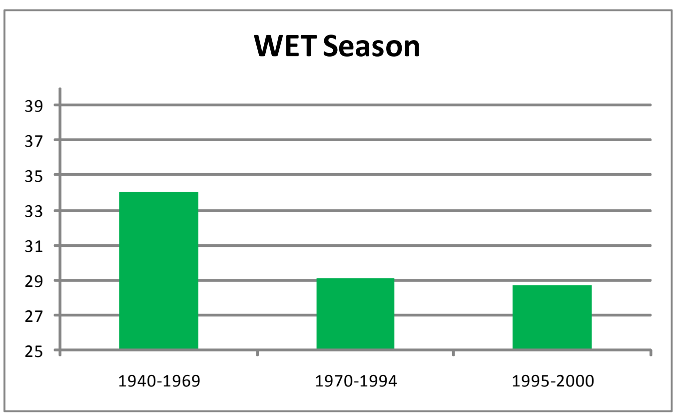
ORLANDO HERNDON AIRPORT NWS



	Annual Total (inches)
1940-1969	51.8
1970-1994	48.9
1995-2009	47.5
POR	51.0



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	17.8	34%
1970-1994	19.8	40%
1995-2009	18.8	38%
POR	18.7	37%

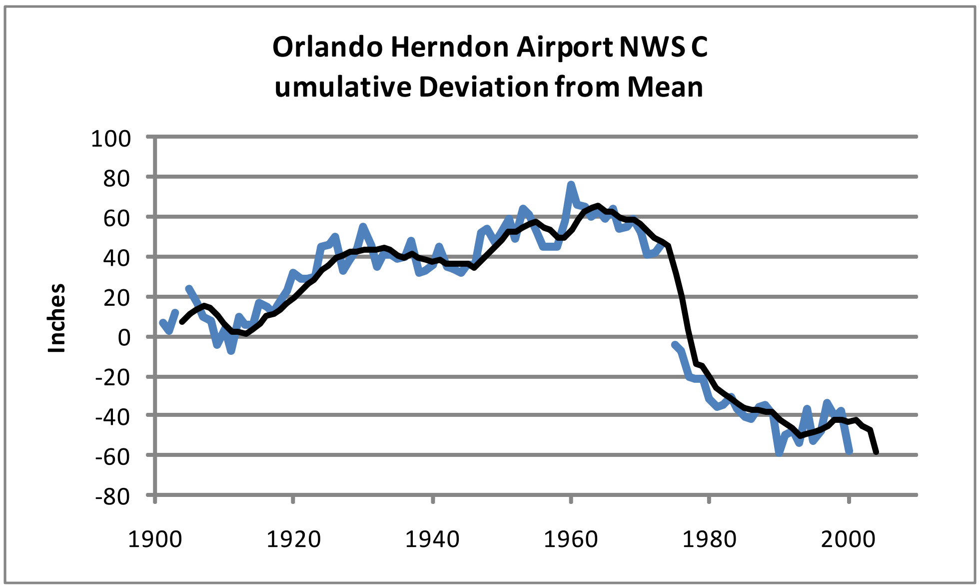


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	34.0	66%
1970-1994	29.1	60%
1995-2009	28.7	62%
POR	32.3	63%

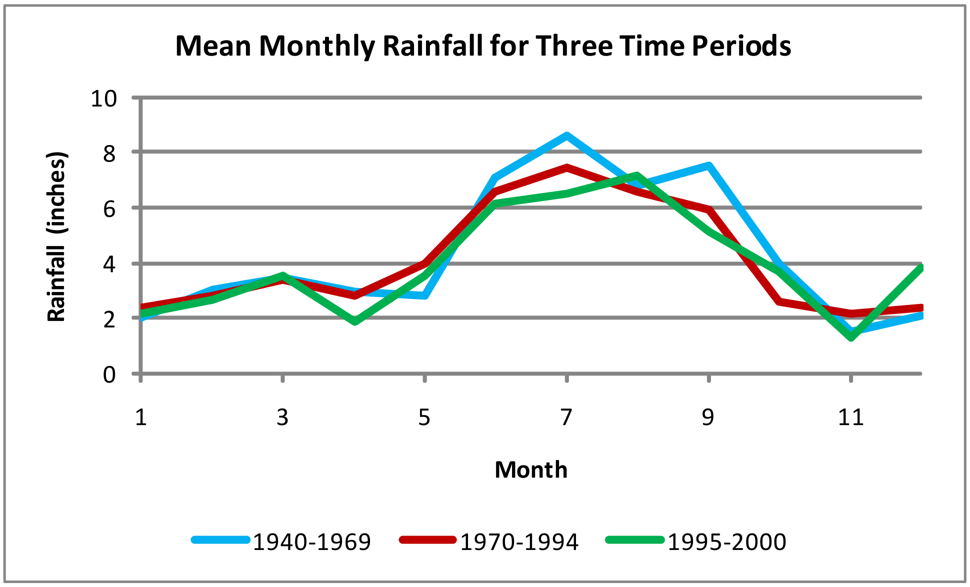
	Mean	Year Ending
Driest 2 yr mean annual	38.67	1990
Driest 3 yr mean annual	42.98	2000
Driest 4 yr mean annual	43.93	1998
Driest 5 yr mean annual	45.45	1980
Driest 10 year mean annual	47.29	1984
Wetest 2 yr mean annual	66.18	1960
Wetest 3 yr mean annual	61.18	1960
Wetest 4 yr mean annual	58.62	1960
Wetest 5 yr mean annual	55.68	1960
Wetest 10 year mean annual	54.88	1924

Period of Record from 1901 to 2000

Years deleted due to missing data: 1904, 1974

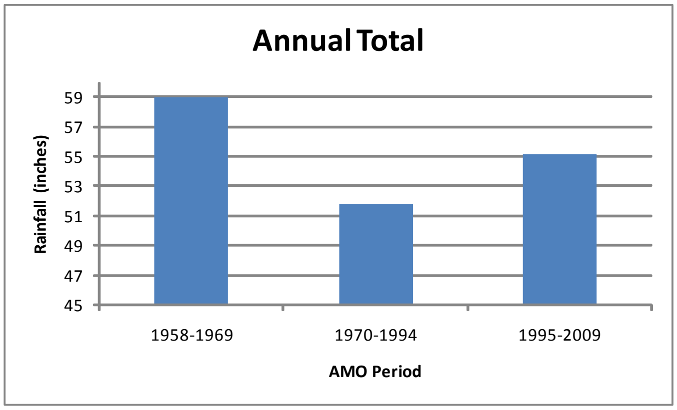


ORLANDO HERNDON AIRPORT NWS

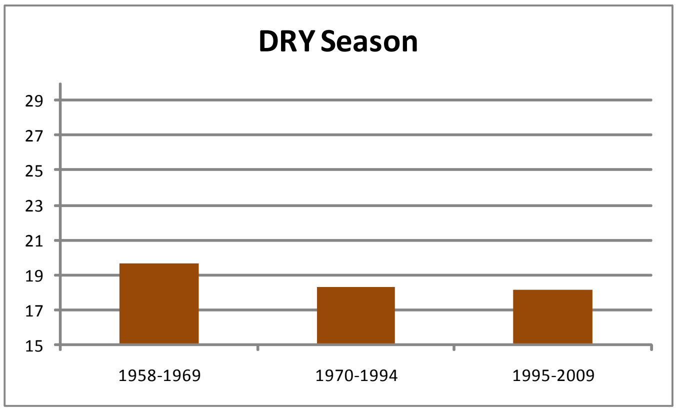


Month	1940-1969	1970-1994	1995-2000
1	2.03	2.39	2.14
2	3.01	2.85	2.66
3	3.49	3.39	3.55
4	2.96	2.78	1.84
5	2.84	3.96	3.56
6	7.12	6.59	6.13
7	8.58	7.43	6.53
8	6.83	6.55	7.17
9	7.51	5.92	5.15
10	3.98	2.61	3.71
11	1.48	2.18	1.29
12	2.11	2.36	3.86
Total	51.93	49.00	47.58

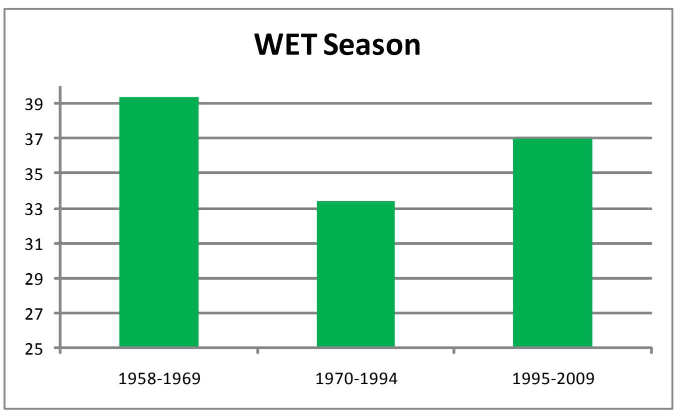
PARRISH NWS



	Annual Total (inches)
1940-1969	59.0
1970-1994	51.8
1995-2009	55.1
POR	54.4



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	19.7	33%
1970-1994	18.3	36%
1995-2009	18.1	32%
POR	18.6	34%



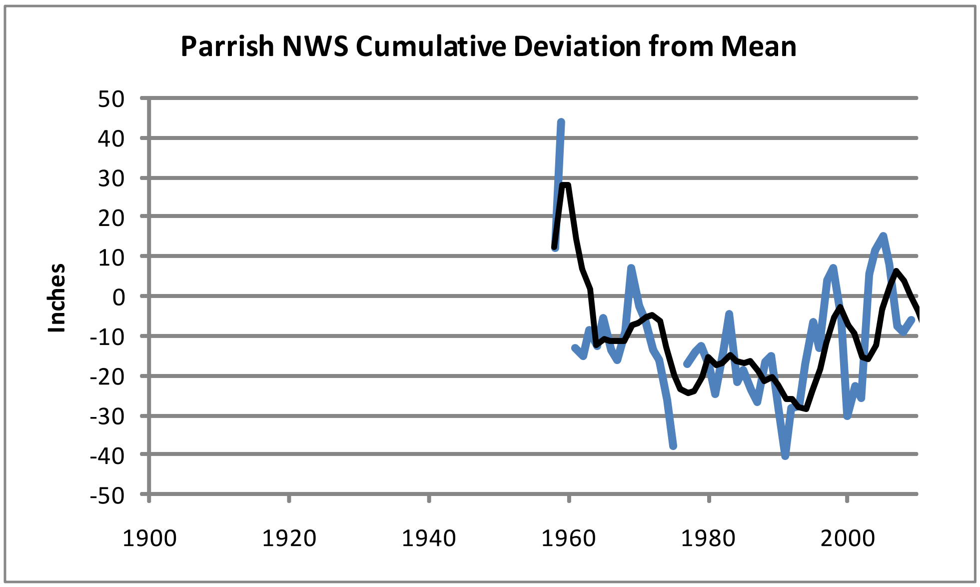
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	39.3	67%
1970-1994	33.4	64%
1995-2009	37.0	68%
POR	35.8	66%

	Mean	Year Ending
Driest 2 yr mean annual	35.88	2000
Driest 3 yr mean annual	42.94	2000
Driest 4 yr mean annual	46.13	2003
Driest 5 yr mean annual	47.27	1975
Driest 10 year mean annual	insufficient data	

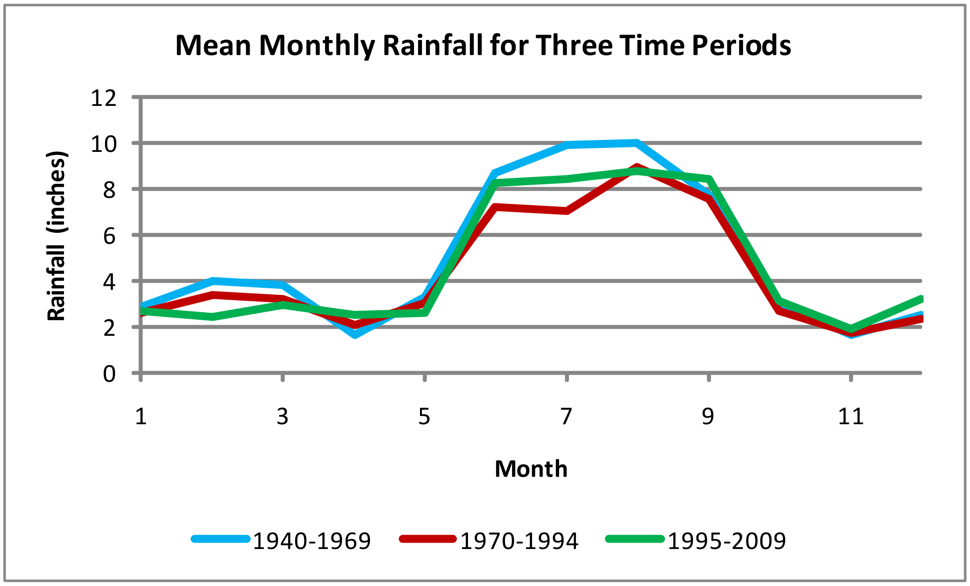
Wetest 2 yr mean annual	76.28	1959
Wetest 3 yr mean annual	68.05	2005
Wetest 4 yr mean annual	64.74	2004
Wetest 5 yr mean annual	63.38	2005
Wetest 10 year mean annual	insufficient data	

Period of Record is 1958 to 2009

Years deleted due to missing data: 1960, 1976

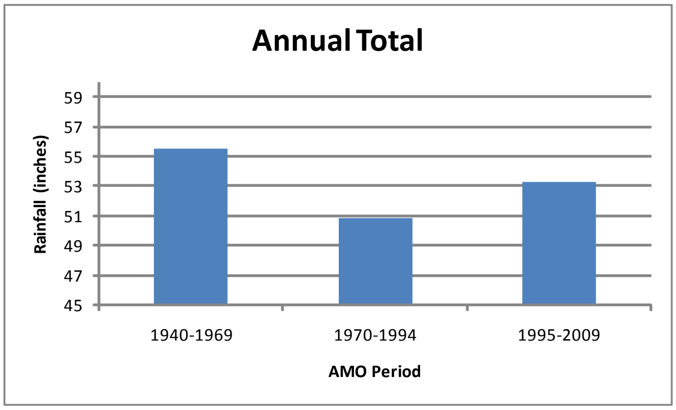


PARRISH NWS

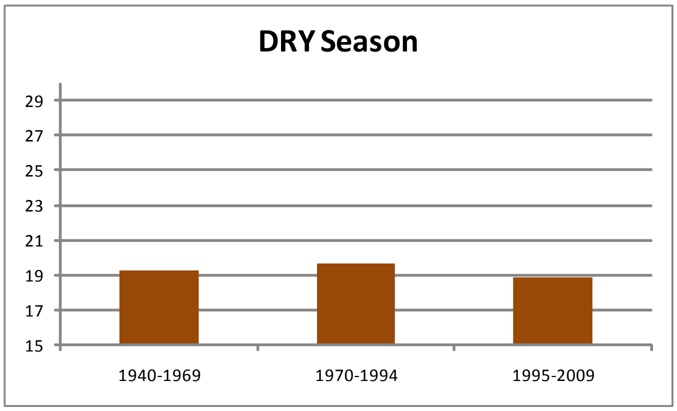


Month	1940-1969	1970-1994	1995-2009
1	2.88	2.59	2.69
2	3.96	3.42	2.45
3	3.80	3.20	2.94
4	1.64	2.09	2.53
5	3.31	3.04	2.57
6	8.70	7.24	8.27
7	9.91	7.06	8.42
8	9.97	8.90	8.74
9	7.71	7.54	8.40
10	3.04	2.70	3.15
11	1.60	1.74	1.91
12	2.54	2.29	3.19
Total	59.06	51.81	55.26

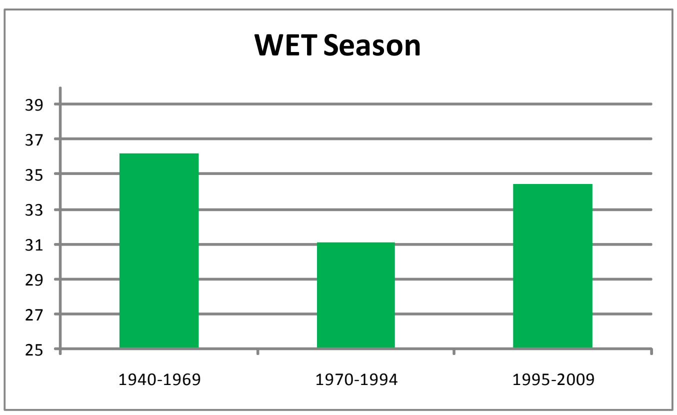
PLANT CITY NWS



	Annual Total (inches)
1940-1969	55.5
1970-1994	50.8
1995-2009	53.3
POR	53.6



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	19.3	35%
1970-1994	19.7	39%
1995-2009	18.9	35%
POR	19.5	36%

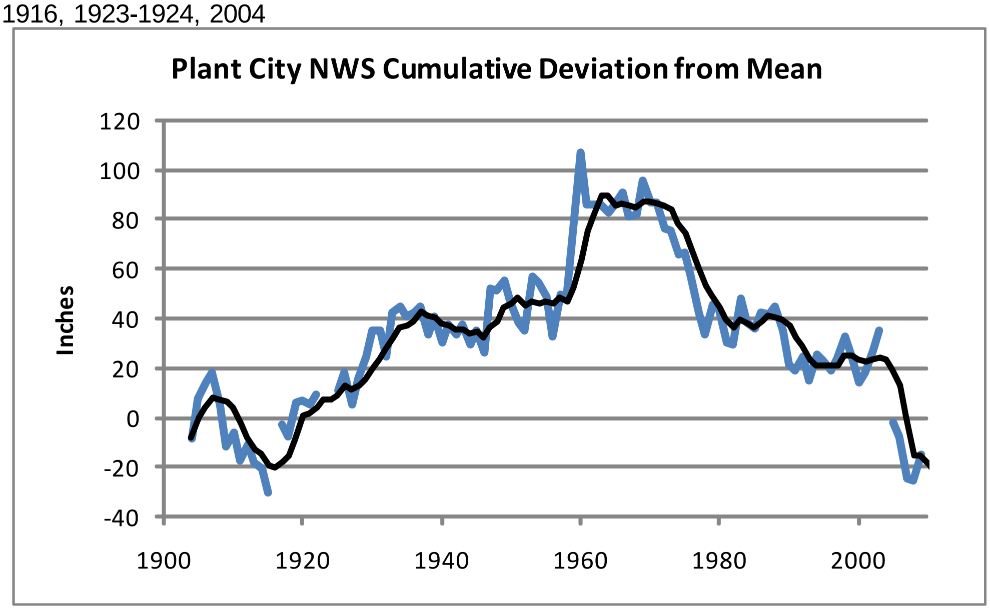


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	36.2	65%
1970-1994	31.1	61%
1995-2009	34.4	65%
POR	34.1	64%

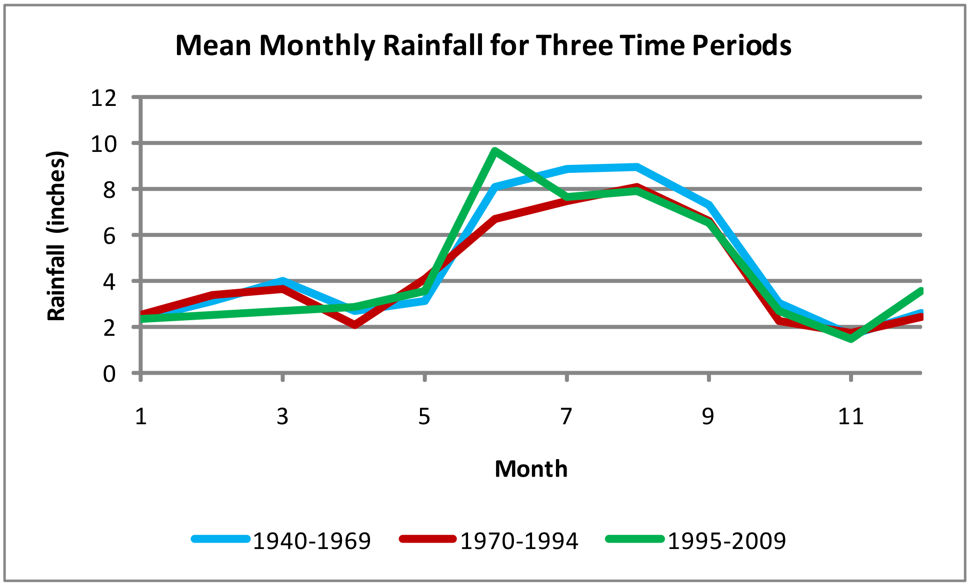
	Mean	Year Ending
Driest 2 yr mean annual	38.43	1909 (1978 2nd)
Driest 3 yr mean annual	42.60	1979
Driest 4 yr mean annual	44.74	1911 (1978 2nd)
Driest 5 yr mean annual	45.22	1978
Driest 10 year mean annual	47.97	1981

Wetest 2 yr mean annual	82.47	1960
Wetest 3 yr mean annual	72.58	1960
Wetest 4 yr mean annual	72.10	1960
Wetest 5 yr mean annual	65.13	1960
Wetest 10 year mean annual	59.62	1960

Period of Record from 1904 to 2009
Years deleted due to missing data:
1916, 1923-1924, 2004

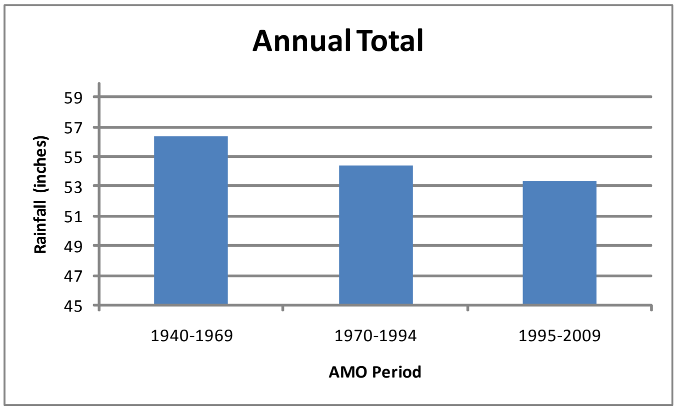


PLANT CITY NWS

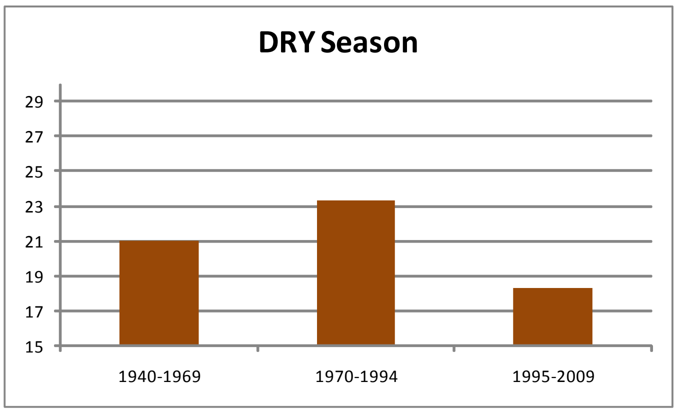


Month	1940-1969	1970-1994	1995-2009
1	2.36	2.47	2.37
2	3.08	3.34	2.49
3	4.01	3.62	2.67
4	2.66	2.06	2.89
5	3.13	4.09	3.58
6	8.03	6.70	9.61
7	8.89	7.43	7.66
8	8.98	8.11	7.92
9	7.28	6.62	6.54
10	3.00	2.28	2.71
11	1.63	1.73	1.45
12	2.56	2.44	3.58
Total	55.62	50.89	53.47

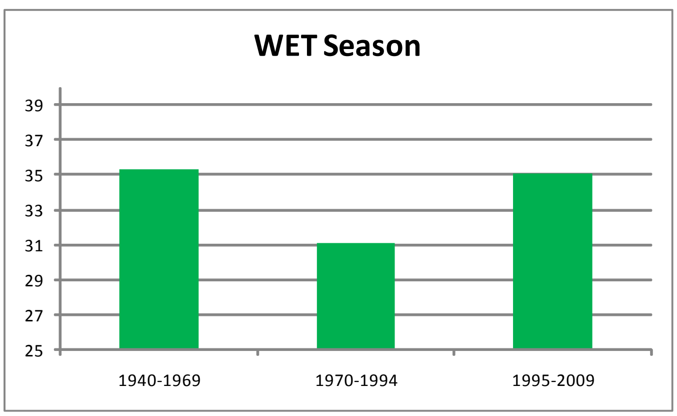
SAINT LEO NWS



	Annual Total (inches)
1940-1969	56.4
1970-1994	54.4
1995-2009	53.4
POR	54.7



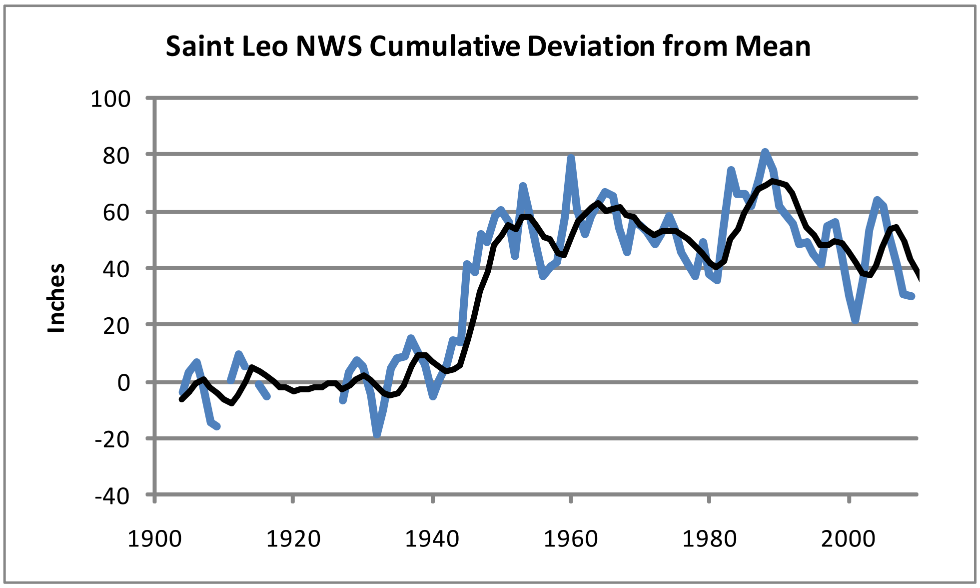
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	21.0	37%
1970-1994	23.3	43%
1995-2009	18.3	34%
POR	20.2	38%



	Wet Season Total (inches)	X% of Annual Totals
1940-1969	35.3	63%
1970-1994	31.1	57%
1995-2009	35.1	66%
POR	34.0	62%

	Mean	Year Ending
Driest 2 yr mean annual	41.26	2000
Driest 3 yr mean annual	43.06	2001
Driest 4 yr mean annual	46.33	2001
Driest 5 yr mean annual	47.93	2009
Driest 10 year mean annual	50.95	2001
Wetest 2 yr mean annual	74.17	1983
Wetest 3 yr mean annual	68.75	2004
Wetest 4 yr mean annual	65.17	1960
Wetest 5 yr mean annual	63.92	1947
Wetest 10 year mean annual	61.23	1950

Period of Record from 1902 to 2009
Years deleted due to missing data:
1903, 1910, 1914, 1917, 1919, 1921-22, 1924, 1926



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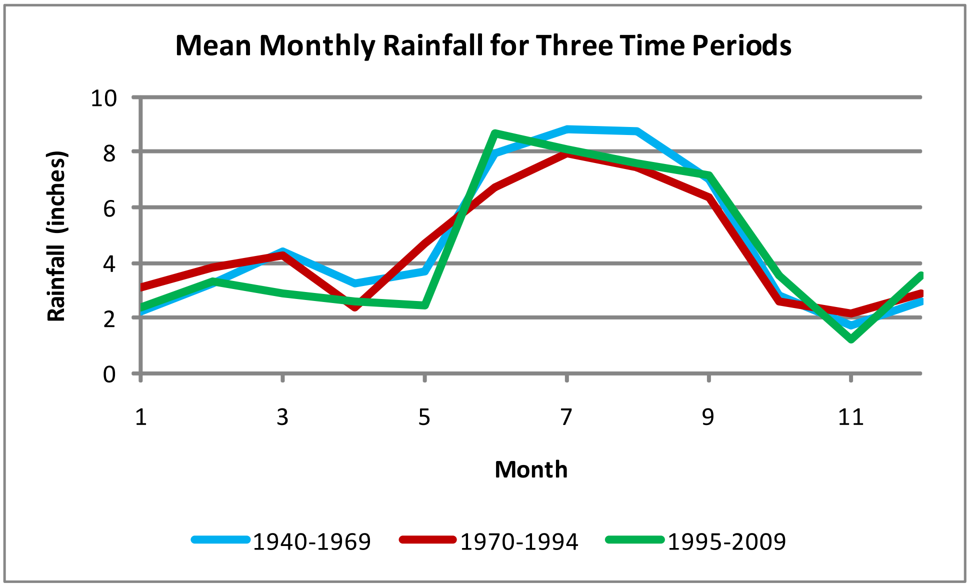
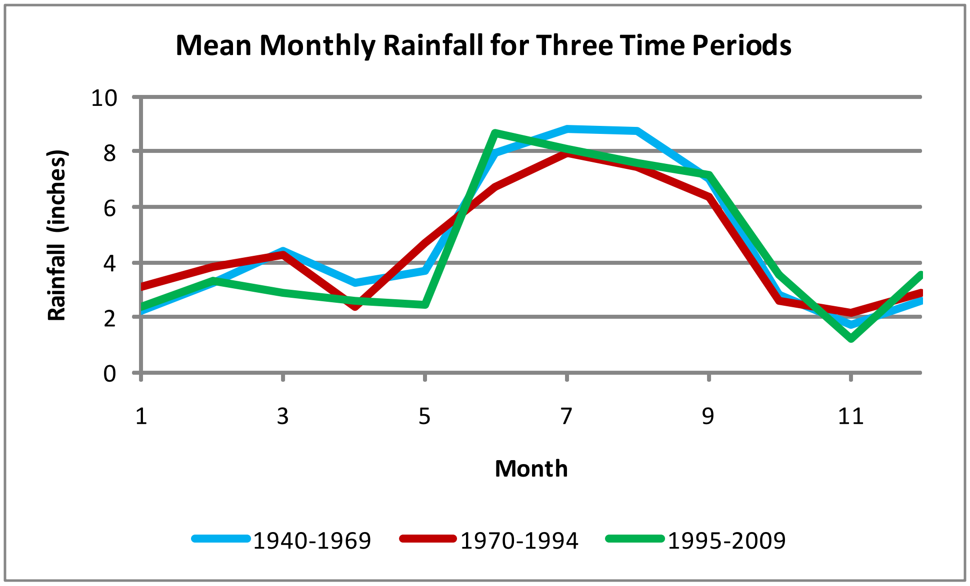


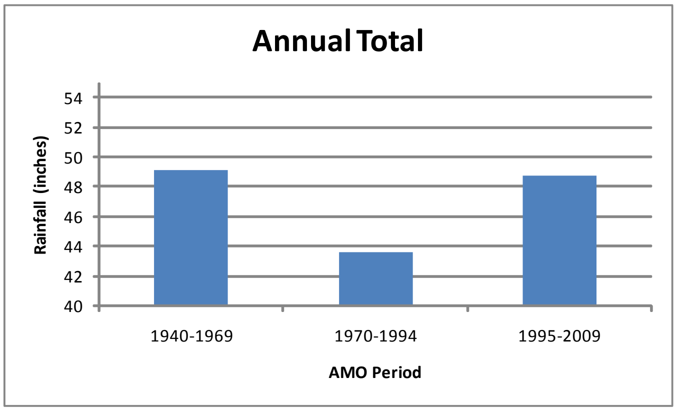
Month	1940-1969	1970-1994	1995-2009
1	2.22	3.13	2.37
2	3.28	3.83	3.30
3	4.41	4.27	2.85
4	3.27	2.40	2.63
5	3.67	4.68	2.46
6	7.95	6.72	8.69
7	8.82	7.93	8.08
8	8.72	7.48	7.61
9	7.04	6.38	7.14
10	2.79	2.57	3.57
11	1.74	2.17	1.25
12	2.60	2.89	3.55
Total	56.51	54.45	53.50

SAINT LEO NWS

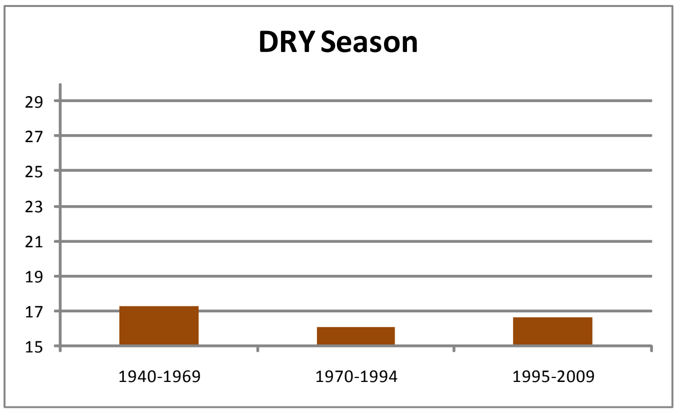


Month	1940-1969	1970-1994	1995-2009
1	2.22	3.13	2.37
2	3.28	3.83	3.30
3	4.41	4.27	2.85
4	3.27	2.40	2.63
5	3.67	4.68	2.46
6	7.95	6.72	8.69
7	8.82	7.93	8.08
8	8.72	7.48	7.61
9	7.04	6.38	7.14
10	2.79	2.57	3.57
11	1.74	2.17	1.25
12	2.60	2.89	3.55
Total	56.51	54.45	53.50

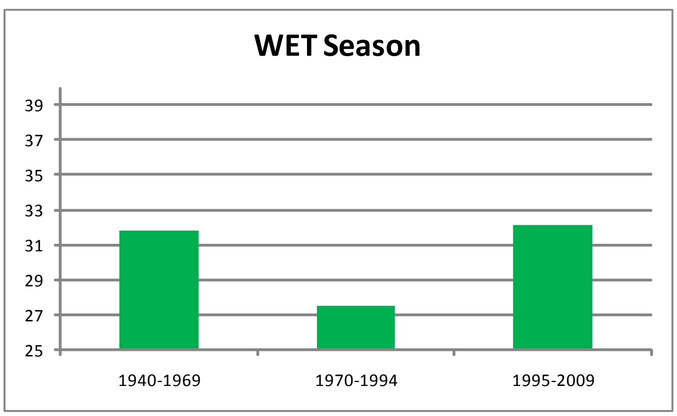
TAMPA INTERNATIONAL AIRPORT NWS



	Annual Total (inches)
1940-1969	49.1
1970-1994	43.6
1995-2009	48.7
POR	47.4



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	17.3	35%
1970-1994	16.1	37%
1995-2009	16.6	33%
POR	16.5	35%



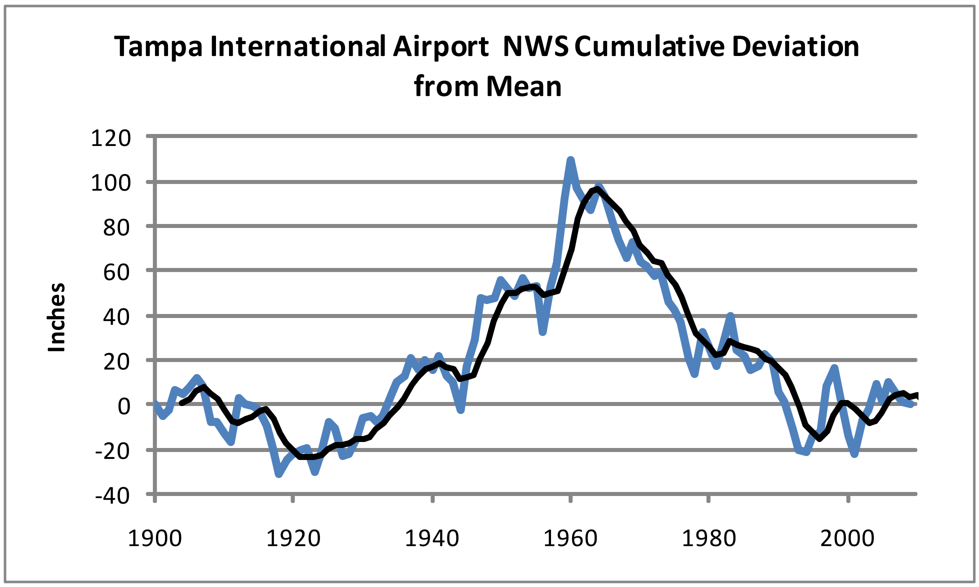
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	31.8	65%
1970-1994	27.5	63%
1995-2009	32.1	67%
POR	30.8	65%

	Mean	Year Ending
Driest 2 yr mean annual	32.09	2000
Driest 3 yr mean annual	34.64	2001
Driest 4 yr mean annual	37.52	1993
Driest 5 yr mean annual	38.19	1978
Driest 10 year mean annual	41.36	1993

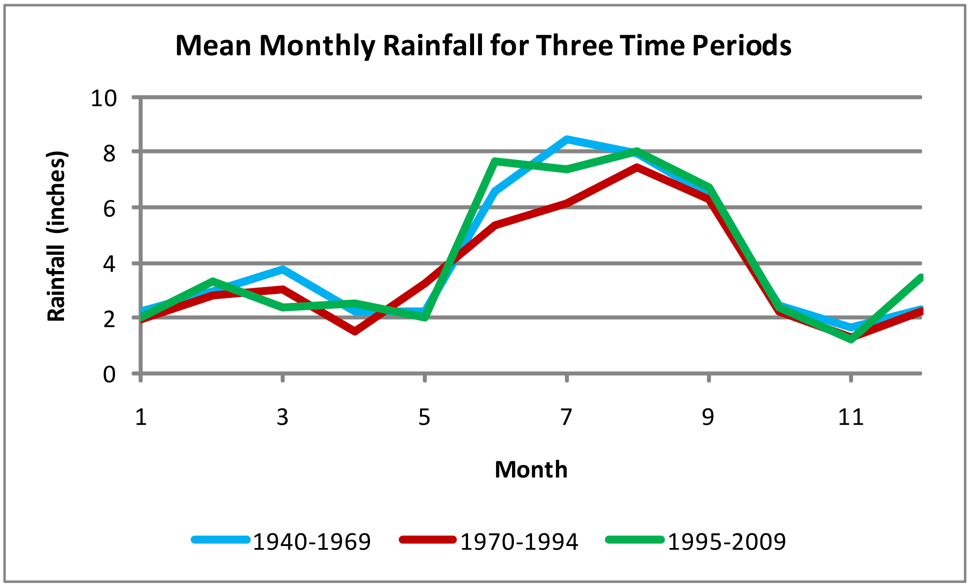
Wetest 2 yr mean annual	70.21	1960
Wetest 3 yr mean annual	67.12	1959
Wetest 4 yr mean annual	66.43	1960
Wetest 5 yr mean annual	60.15	1961
Wetest 10 year mean annual	52.76	1954

Period of Record from 1901 to 2009

Years deleted due to missing data: None

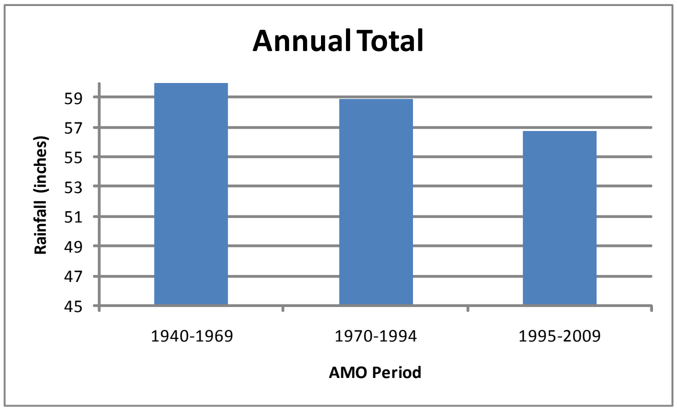


TAMPA INTERNATIONAL AIRPORT NWS

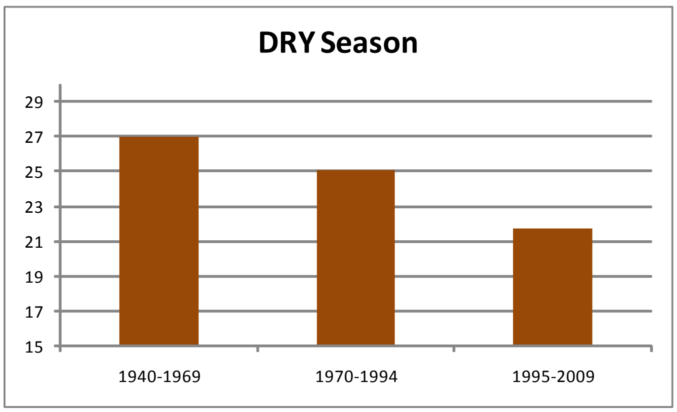


Month	1940-1969	1970-1994	1995-2009
1	2.21	1.94	2.00
2	2.94	2.81	3.29
3	3.76	3.05	2.38
4	2.21	1.54	2.50
5	2.27	3.28	2.05
6	6.56	5.34	7.67
7	8.45	6.16	7.37
8	7.95	7.48	8.04
9	6.44	6.32	6.69
10	2.44	2.23	2.35
11	1.64	1.32	1.21
12	2.29	2.21	3.44
Total	49.16	43.68	48.99

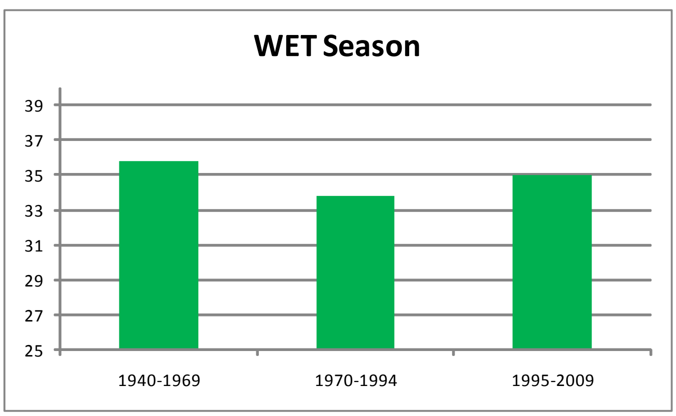
USHER TOWER NWS



	Annual Total (inches)
1940-1969	62.8
1970-1994	58.9
1995-2009	56.7
POR	59.2



	Dry Season Total (inches)	X% of Annual Totals
1940-1969	27.0	43%
1970-1994	25.1	43%
1995-2009	21.7	38%
POR	24.6	41%

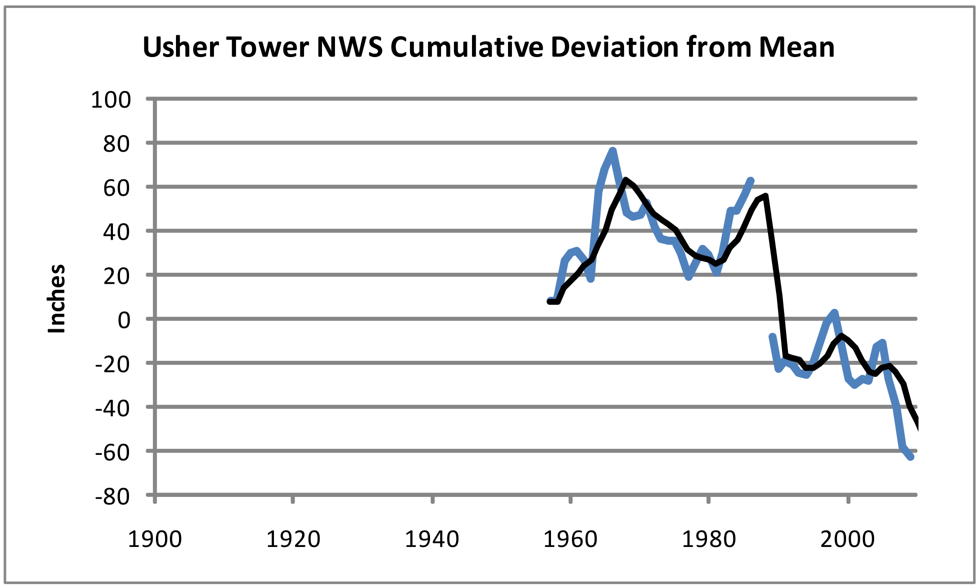


	Wet Season Total (inches)	X% of Annual Totals
1940-1969	35.8	57%
1970-1994	33.8	57%
1995-2009	35.0	62%
POR	34.7	59%

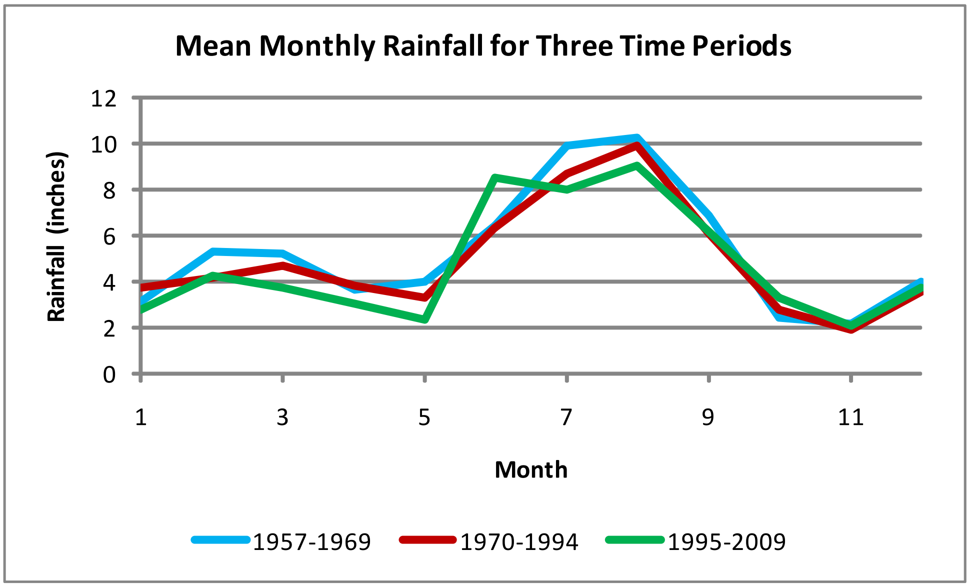
	Mean	Year Ending
Driest 2 yr mean annual	43.88	2008
Driest 3 yr mean annual	43.60	2008
Driest 4 yr mean annual	46.33	2009
Driest 5 yr mean annual	49.26	2009
Driest 10 year mean annual	53.20	2008
Wetest 2 yr mean annual	84.23	1965
Wetest 3 yr mean annual	78.68	1966
Wetest 4 yr mean annual	71.80	1966
Wetest 5 yr mean annual	68.34	1966
Wetest 10 year mean annual	66.89	1966

Period of Record from 1957 to 2009

Years deleted due to missing data: 1987-88

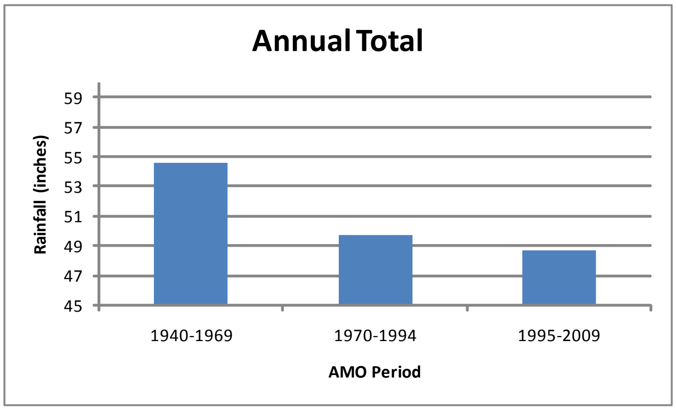


USHER TOWER NWS

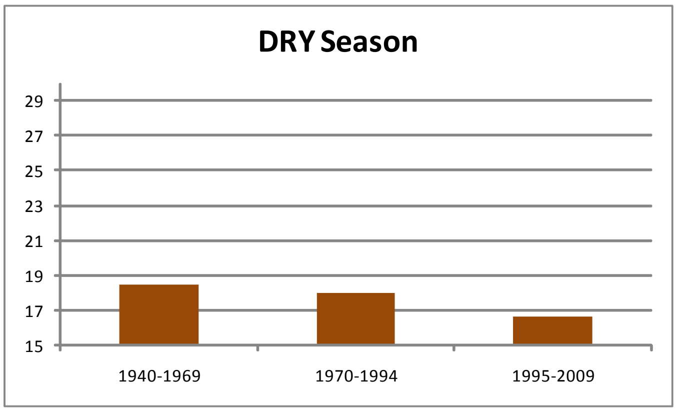


Month	1957-1969	1970-1994	1995-2009
1	3.12	3.70	2.76
2	5.30	4.13	4.26
3	5.21	4.65	3.75
4	3.59	3.80	3.05
5	3.98	3.30	2.30
6	6.44	6.33	8.49
7	9.87	8.72	7.98
8	10.24	9.87	9.06
9	6.83	6.10	6.19
10	2.42	2.76	3.27
11	2.15	1.93	2.04
12	3.95	3.59	3.72
Total	63.11	58.88	56.88

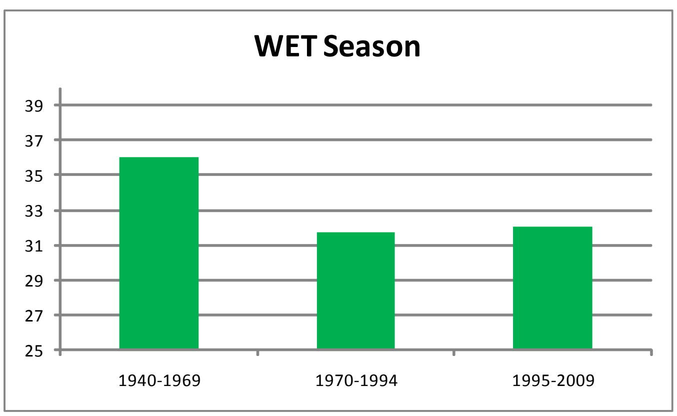
WAUCHULA NWS



	Annual Total (inches)
1940-1969	54.6
1970-1994	49.7
1995-2009	48.7
POR	51.8



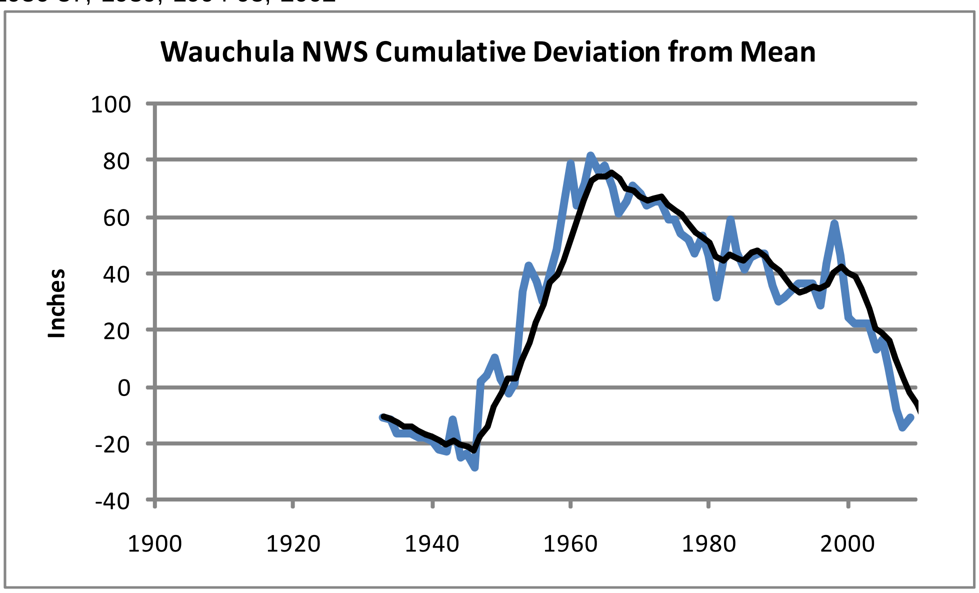
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	18.5	34%
1970-1994	18.0	36%
1995-2009	16.6	33%
POR	17.9	34%



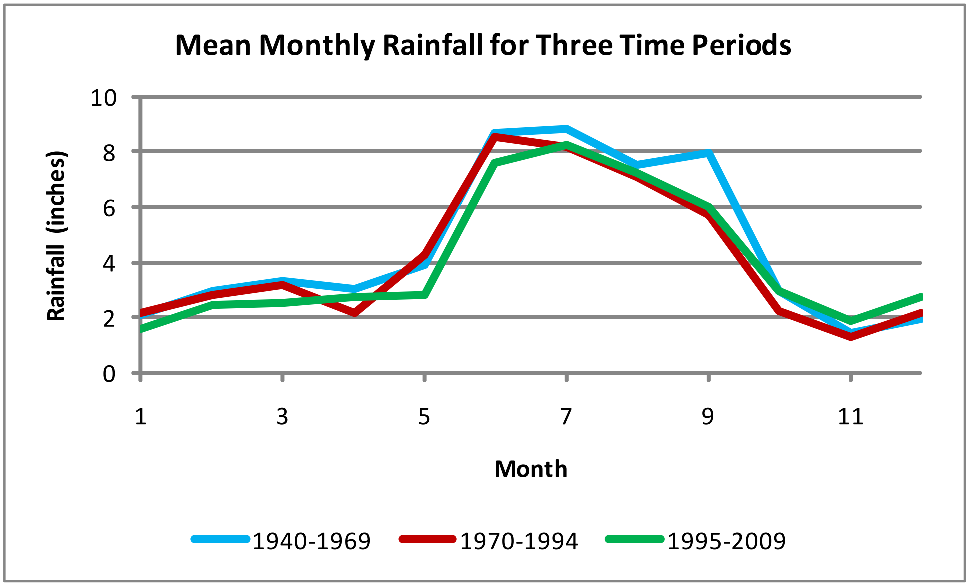
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	36.1	66%
1970-1994	31.8	64%
1995-2009	32.0	67%
POR	33.9	66%

	Mean	Year Ending
Driest 2 yr mean annual	34.92	2000
Driest 3 yr mean annual	39.77	2001
Driest 4 yr mean annual	43.94	2007
Driest 5 yr mean annual	44.30	2008
Driest 10 year mean annual	48.37	1981
Wetest 2 yr mean annual	72.14	1954
Wetest 3 yr mean annual	66.55	1954
Wetest 4 yr mean annual	63.74	1960
Wetest 5 yr mean annual	59.83	1960
Wetest 10 year mean annual	59.20	1960

Period of Record from 1934 to 2009
Years deleted due to missing data:
1936-37, 1939, 1994-95, 2002

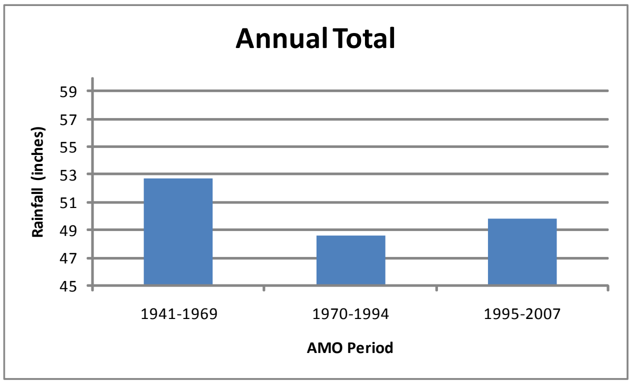


WAUCHULA NWS

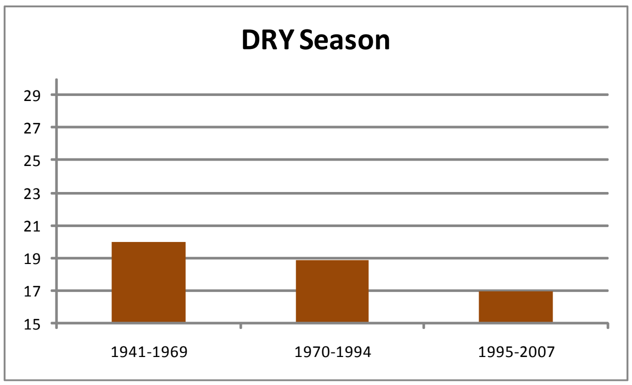


Month	1940-1969	1970-1994	1995-2009
1	2.07	2.16	1.56
2	2.99	2.78	2.43
3	3.31	3.16	2.50
4	3.04	2.19	2.75
5	3.87	4.26	2.83
6	8.69	8.56	7.58
7	8.86	8.20	8.24
8	7.56	7.06	7.26
9	7.98	5.68	6.03
10	2.98	2.27	2.93
11	1.46	1.32	1.85
12	1.98	2.15	2.71
Total	54.79	49.78	48.68

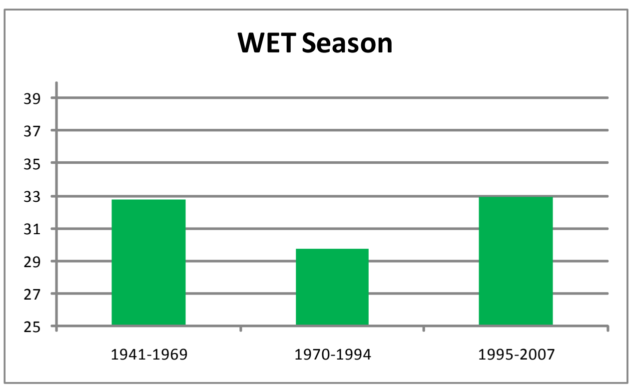
WINTER HAVEN NWS



	Annual Total (inches)
1940-1969	52.7
1970-1994	48.6
1995-2009	49.8
POR	50.6



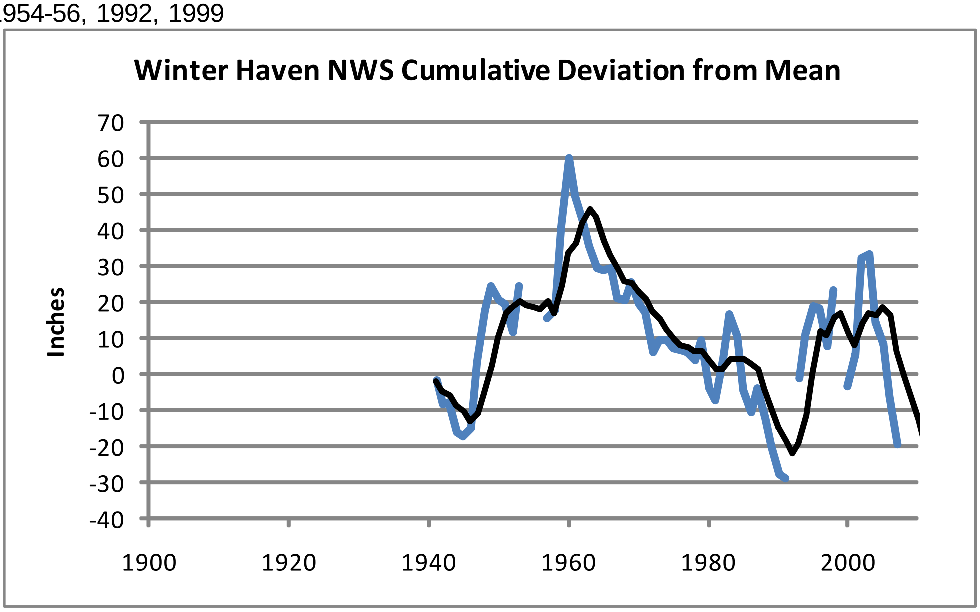
	Dry Season Total (inches)	X% of Annual Totals
1940-1969	20.0	38%
1970-1994	18.9	39%
1995-2009	16.9	34%
POR	18.9	37%



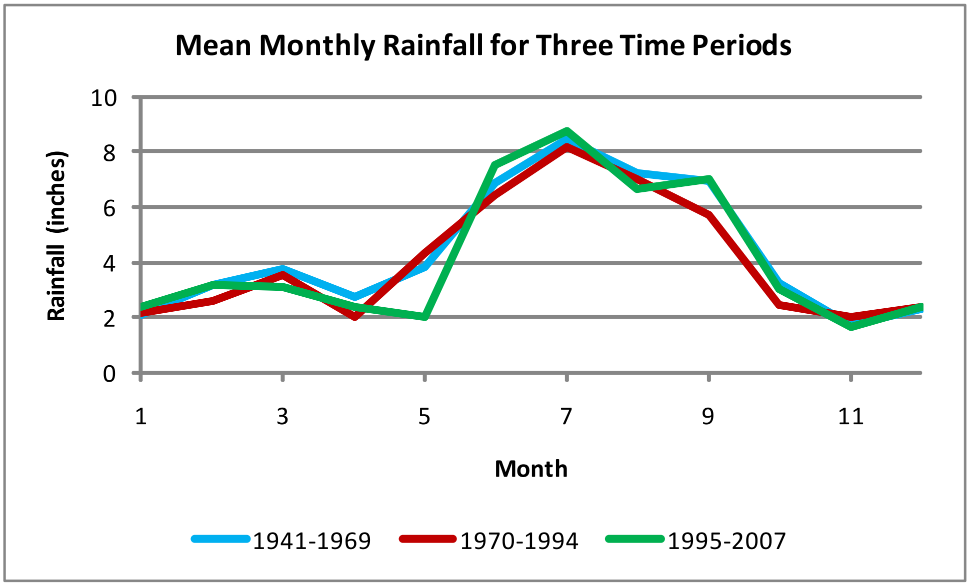
	Wet Season Total (inches)	X% of Annual Totals
1940-1969	32.8	62%
1970-1994	29.7	61%
1995-2009	32.9	66%
POR	31.6	63%

	Mean	Year Ending
Driest 2 yr mean annual	36.83	2007
Driest 3 yr mean annual	37.42	2006
Driest 4 yr mean annual	37.38	2007
Driest 5 yr mean annual	40.21	2007
Driest 10 year mean annual	46.35	1970
Wetest 2 yr mean annual	71.45	1960
Wetest 3 yr mean annual	65.21	1960
Wetest 4 yr mean annual	65.39	1960
Wetest 5 yr mean annual	60.27	1961
Wetest 10 year mean annual	53.63	1953

Period of Record from 1941 to 2007
Years deleted due to missing data:
1954-56, 1992, 1999



WINTER HAVEN NWS



Month	1941-1969	1970-1994	1995-2007
1	2.08	2.18	2.41
2	3.15	2.61	3.18
3	3.78	3.51	3.08
4	2.71	2.04	2.36
5	3.86	4.32	2.04
6	6.88	6.41	7.51
7	8.49	8.19	8.76
8	7.25	7.00	6.64
9	6.92	5.69	6.99
10	3.27	2.42	3.01
11	1.71	1.99	1.64
12	2.33	2.36	2.35
Total	52.42	48.73	49.96

PHABSIM Appendix

IFIM/PHABSIM PROTOCOL - Withlacoochee River

Started with IFG4 deck/file containing all transects and all calibration sets. These were entered from downstream to upstream with a dummy transect.

Nine (9) sets of transects were created:

- Little Withlacoochee River at River Junction at 5.608 cfs, 11.502 cfs, and 33.567 cfs (simulated range: 2.25 cfs – 220 cfs).
- Withlacoochee River above 476 at 26.212 cfs, 135.848 cfs, and 333.956 cfs (simulated range: 10.5 cfs – 650 cfs).
- Withlacoochee River at Trilby at 59.377 cfs, 140.84 cfs, and 443.17 cfs (simulated range: 23.75 cfs – 850 cfs).
- Withlacoochee River at Green Swamp West at 3.2 cfs, 124.16 cfs, and 264.321 cfs (simulated range: 1.25 cfs – 540 cfs)
- Withlacoochee River at Holder at 77.47 cfs, 333.69 cfs, and 926.96 cfs (simulated range: 30 cfs – 1800 cfs).
- Withlacoochee River at River Road at 7.886 cfs, 42.338 cfs, and 409.406 cfs (simulated range: 3.1 cfs – 860 cfs).
- Withlacoochee River near Croom at 65.94 cfs, 373.52 cfs, and 572.727 cfs (simulated range: 26 cfs – 1225 cfs)
- Withlacoochee River at 48 at 53.195 cfs, 411.03 cfs, and 472.28 cfs (simulated range: 21 cfs – 990 cfs)
- Withlacoochee River at Turner Fish Camp at 62.81 cfs, 559.72 cfs, and 668.34 cfs (simulated range: 25 cfs – 1350 cfs)

The simulated flow ranges did not encompass all low flows in the historical records available, in some instances, and did not encompass a few of the highest flows. An appropriate regression (usually first- or second-order polynomial or piece-wise linear regression) was used during time-series analysis to create WUA values for the very low and high flows. Since these flow values occurred less than 5% of the time in the historical record, they are unlikely to affect the overall estimate of MFL's at a 15% habitat loss.

The following codes were entered on the N/S lines:

CODE	DESCRIPTION
0	**Delimiter**
1	No cover and silt **or** terrestrial vegetation
2	No cover and sand
3	No cover and gravel
4	No cover and cobble
5	No cover and small boulder
6	No cover and boulder, angled bedrock, or woody debris
7	No cover and mud or flat bedrock
8	Overhead vegetation and terrestrial vegetation
9	Overhead vegetation and gravel
10	Overhead vegetation and cobble
11	Overhead vegetation and small boulder, boulder, angled bedrock, or woody debris
12	Instream cover and cobble
13	Instream cover and small boulder, boulder, angled bedrock, or woody debris
14	Proximal instream cover and cobble
15	Proximal instream cover and small boulder, boulder, angled bedrock, or woody debris
16	Instream cover or proximal instream cover and gravel
17	Overhead vegetation or instream cover or proximal instream cover and silt or sand
18	Aquatic Vegetation – macrophytes
100	**Delimiter**

The IFG4 predicted WSL's were placed in a (hand-made) table to be compared with observed WSL's for the given discharges on the CAL lines. The predicted WSL's were all within 0.2 ft of the observed values [accepted surveying error for the "tourch" technique] and IFG4 was considered to be an adequate predictor.

A second discharge is added to each CAL line (see A.51 from the PHABSIM user's manual). This second discharge is the calculated flow for that transect using the velocities measured. This is used as a secondary adjustment factor when predicting velocities and roughness coefficients.

The IFG4 input decks/files were then converted to several IFG4 input decks/files, each with a single velocity set, corresponding to measured calibration sets. The simulated discharges overlap but encompass the measured discharge for that calibration set.

	Little Withlacoochee at River Junction RIVJA. in4	Little Withlacoochee at River Junction RIVJB.in4	Little Withlacoochee at River Junction RIVJC.in4
Simulated Discharge Range	2.2 – 7.2 cfs	6.4 – 13 cfs	12 – 70 cfs

	Withlacoochee above 476 AB476A. in4	Withlacoochee above 476 AB476B.in4	Withlacoochee above 476 AB476C.in4
Simulated Discharge Range	10.5 – 31 cfs	27 – 140 cfs	120 – 650 cfs

	Withlacoochee River at Trilby TRILA. in4	Withlacoochee River at Trilby TRILB.in4	Withlacoochee River at Trilby TRILC.in4
Simulated Discharge Range	23.75 – 68 cfs	60 – 175 cfs	155 – 850 cfs

	Withlacoochee River at Green Swamp West GSWA. in4	Withlacoochee River at Green Swamp West GSWB.in4	Withlacoochee River at Green Swamp West GSWC.in4
Simulated Discharge Range	1.25 – 170 cfs	130 – 295 cfs	275 – 540 cfs

	Withlacoochee River at Holder HOLDERA. in4	Withlacoochee River at Holder HOLDERB.in4	Withlacoochee River at Holder HOLDERC.in4
Simulated Discharge Range	30 – 400 cfs	300 – 830 cfs	790 – 1800 cfs

	Withlacoochee River at River Road RIVRDA. in4	Withlacoochee River at River Road RIVRDB.in4	Withlacoochee River at River Road RIVRDC.in4
Simulated Discharge Range	3.1 – 30 cfs	10 – 375 cfs	275 – 860 cfs

	Withlacoochee River near Croom CROOMA. in4	Withlacoochee River near Croom CROOMB.in4	Withlacoochee River near Croom CROOMC.in4
Simulated Discharge Range	26 – 325 cfs	225 – 620 cfs	580 – 1225 cfs

	Withlacoochee River at Turner Fish Camp TFCA. in4	Withlacoochee River at Turner Fish Camp TFCB.in4	Withlacoochee River at Turner Fish Camp TFCC.in4
Simulated Discharge Range	25 – 100 cfs	80 – 650 cfs	610 – 1350 cfs

	Withlacoochee River at 48 UP48A. in4	Withlacoochee River at 48 UP48B.in4	Withlacoochee River at 48 UP48C.in4
Simulated Discharge Range	21 – 70 cfs	62 – 500 cfs	400 – 990 cfs

For each *.IN4 model, an IFG4 run was made. VAF (Velocity Adjustment Factor) values are checked. The slope of the VAF values must be positive. The VAF value at the discharge for which the velocity set is given should be between 0.85 and 1.15. Ideally, such a tight fit allows expansion of the simulation beyond .4 x the lowest discharge and 2 x the highest discharge. Where these criteria were not met, the simulation could not be expanded beyond the range of discharges and were considered to be poor predictors.

- Where VAF slope was a problem for a particular transect, WSL's are adjusted up or down [usually lowering WSL increases VAF value and increasing WSL decreases VAF value for given discharge] (based upon the range of WSL's [right bank, center, and left bank] measured in the field).

In all cases, VAF values were found to be acceptable, since all slopes were positive; although, some sites performed better than others; the Elfers site having the tightest predictive reliability and the Waterfall site having the least reliability.

	RIVJA. in4	RIVJB.in4	RIVJC.in4
VAF Range • Tr 1 • Tr 2 • Tr 3	1.113 – 0.643 0.98 – 0.658 1.003 – 4.527	0.783 – 0.799 0.831 – .836 0.504 – 2.581	0.987 – 0.997 0.907 – 915 0.215 – 0.907

	AB476A. in4	AB476B.in4	AB476C.in4
VAF Range • Tr 1 • Tr 2 • Tr 3	1.038 – 4.512 1.202 – 6.928 1.143 – 4.336	0.294 – 1.31 0.261 – 1.442 0.279 – 1.601	0.227 – 1.066 0.187 – 1.062 0.182 – 1.041

	TRILBYA. in4	TRILBYB.in4	TRILBYC.in4
VAF Range • Tr 1 • Tr 2 • Tr 3	1.043 – 1.787 0.974 – 2.013 ***	0.645 – 1.349 0.718 – 1.430 ***	0.559 – 1.029 0.576 – 0.997 ***

*** The simulation was unable to create an adequate stage-discharge relationship for transect 3 (simulating water surface elevations 350 feet above sea level at historical high flows). Therefore, this simulation was created with only transects 1 and 2.

	GSWA. in4	GSWB.in4	GSWC.in4
VAF Range • Tr 1 • Tr 2 • Tr 3	0.963 – 1.455 1.011 – 9.194 0.955 – 6.868	0.591 – 0.759 0.127 – 1.123 0.167 – 1.081	0.967 – 1.204 0.123 – 1.145 0.162 – 1.122

	HOLDERA. in4	HOLDERB.in4	HOLDERC.in4
VAF Range • Tr 1 • Tr 2	1.150 – 1.689	0.682 – 0.867	1.036 – 1.150

• Tr 3	0.995 – 1.083 1.049 – 3.535	0.466 – 1.135 1.36 – 1.273	0.399 – 1.075 0.246 – 1.097

	RIVRDA. in4	RIVRDB.in4	RIVRDC.in4
VAF Range • Tr 1 • Tr 2 • Tr 3	1.044 – 1.819 0.940 – 12.745 0.694 – 5.425	0.956 – 1.207 0.282 – 3.643 0.241 – 4.834	0.479 – 1.024 0.065 – 1.024 0.048 – 0.999

	CROOMA. in4	CROOMB.in4	CROOMC.in4
VAF Range • Tr 1 • Tr 2 • Tr 3	1.002 – 2.375 0.999 – 3.050 1.003 – 4.056	0.641 – 1.165 0.427 – 1.236 0.317 – 1.266	0.449 – 1.004 0.334 – 1.002 0.234 – 1.015

	TFCA. in4	TFCB.in4	TFCC.in4
VAF Range • Tr 1 • Tr 2 • Tr 3	1.127 – 3.468 *** ***	0.223 – 0.903 *** ***	0.319 – 1.15 *** ***

*** The simulation was unable to create an adequate stage-discharge relationship for transects 2 and 3 (simulating water surface elevations 1500 feet above sea level at historical high flows). Therefore, this simulation was created with only transect 1 and a dummy transect.

	UP48A. in4	UP48B.in4	UP48C.in4
VAF Range • Tr 1 • Tr 2 • Tr 3	0.996 – 5.796 *** 0.906 – 1.093	0.183 – 1.070 *** 0.202 – 1.107	0.185 – 1.052 *** 0.168 – 0.916

*** The simulation was unable to create an adequate stage-discharge relationship for transect 2 (appeared to have unrealistic channel geometry and could not predict adequate velocities with any WSL method). Therefore, this simulation was created with only transects 1 and 3.

[Note: the table of VAF values is presented after adjustment of Manning's "n" values for some data points}

After each *.IN4 file/model was calibrated to produce the best VAF's possible, the roughness values ("n") **calculated by IFG4** for each transect was checked. Those with values greater than 0.2 are chosen for adjustment. For each transect with some "n" values greater than 0.2, the mean value for "n" is calculated. Those "n" values above the median value are replaced with the mean value on the NS lines of the *.IN4 deck/file. This approach tries to adjust the worst problems without making drastic changes in WSL predictions and it is transect-specific [as compared to creating an NMAX line]. Professional judgment was also used, in some cases, to adjust other "n" values, where appropriate.

After "n" adjustments, IFG4 was run, again, with the adjusted roughness values and particular attention was placed on the predictions of velocities at the highest discharges. Each IFG4 output was checked for velocity "hot spots" at the high discharge simulations. Where predicted velocities exceeded 4.5 fps in a single cell **and** adjacent cells had low velocities, higher "n" values for that vertical/cell were added to the NS lines in the *.IN4 deck/file. This inserted "n" value was usually derived from the "n" values predicted by IFG4 for adjacent cells. When several contiguous cells had velocities that ranged from 3 to 6 fps (especially at high discharges), they were considered to be acceptable (i.e., **not** hot spots).

HABTAV was run with the appropriate HSI models for the "A", "B", "C", etc., models and the ZHAQF output files were examined. These contained habitat (WUA) versus discharge relationships for overlapping discharge ranges.

The overlapping ZHAQF values were combined on a spreadsheet (XCEL or SigmaPlot) into a single habitat versus discharge relationship. Weighted averages were used to combine the overlapping WUA values (these were different since different VAF values to adjust predicted velocities were not the same for comparable discharges in different runs). When an abrupt "jump" in the relationship occured, a plot of WUA/Q values is created and a curve smoothing routine (usually a third or fourth-order polynomial regression in SigmaPlot) was used for those values.

The WAU / Discharge results were prepared for the final report of WUA and Discharge and were the values used for time-series analysis.

Time-Series Analysis

Two sets of simulations were assessed, using southern river Wet AMO Years (1955 – 1969 plus 1995 – 2006) and Dry AMO Years (1970 – 1999).

LOCATION	FLOW FILE USED
Withlacoochee above 476	Croom (1955-1969 and 1970-1999)
Withlacoochee at Trilby	Trilby (1955-1969 and 1970-1999)
Withlacoochee at Turner Fish Camp	Holder (1955-1969 and 1970-1999)
Withlacoochee at Green Swamp West	Dade City (1984-2008)
Withlacoochee at Holder	Holder (1955-1969 and 1970-1999)
Withlacoochee at River Road	Dade City (1984-2008)

Withlacoochee at Croom	Croom (1955-1969 and 1970-1999)
Withlacoochee at 48	Floral City (1984-2008)
Little Withlacoochee at River Junction	Little Withlacoochee (1955-1969 and 1970-1999)

The TSLIB (time-series library) from the USGS Mid-Continent Research Laboratories was used to conduct the analysis.

Monthly discharge files were created for existing conditions, 10% monthly flow reductions, 20% monthly flow reductions, 30% monthly flow reductions, and 40% monthly flow reductions. For each set of discharge conditions, a monthly time-series was created as the amount of habitat (WUA) available for each discharge for each month. HAQ files (habitat availability) were created for the high discharge events by linear (first-order regression) or curvilinear (second-order polynomial regression) fits. Duration analysis was then accomplished through the percentage of time that the average and median habitat values were met or exceeded for each month over the period of record. Comparisons to existing conditions were made to evaluate the amount of habitat gain or loss under conditions of reduced flow.

During this analysis, habitat suitability curves for both “catalog” (USGS Blue Books of habitat suitability) and locally derived HIS’s were compared. Although the catalog and locally derived curves were quite similar, there was sufficient difference in at least one category of local preference (usually in substrate/cover preference, more often than not) that the predicted amount of available habitat was an order of magnitude less for Florida curves as opposed to catalog curves. This result supports conclusions by Gore and Nestler (1988) and Gore et al. (2001) who have indicated that habitat-specific derivations of suitability curves are the most appropriate application for this type of analysis.

Since predictions of less initial habitat availability are predicted in the PHABSIM runs for Florida curves, losses in smaller amounts of habitat result in larger incremental gains or losses in habitat. [For example if the catalog curves predict 2350 square feet of habitat under existing conditions (per 1000 linear feet of river) and the time series predicts a loss of 50 square feet of habitat, this results in a 3% habitat loss; however, if Florida curves for the same species predict only 235 square feet of habitat under existing conditions and the time series predicts only a loss of 20 square feet of habitat, the result is a 9% loss]. It should not be surprising, then, that some habitat gain / loss analyses are dramatically different using locally derived habitat information where a much lower initial habitat availability is predicted.

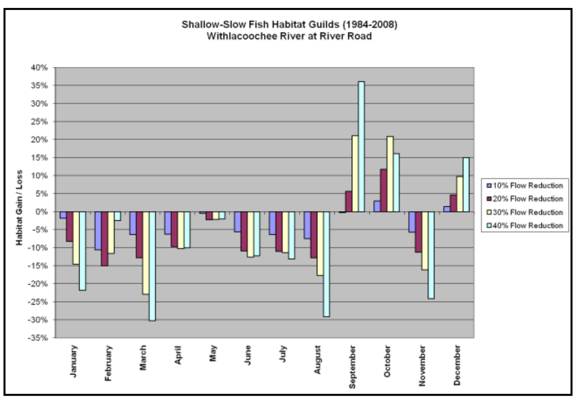
References:

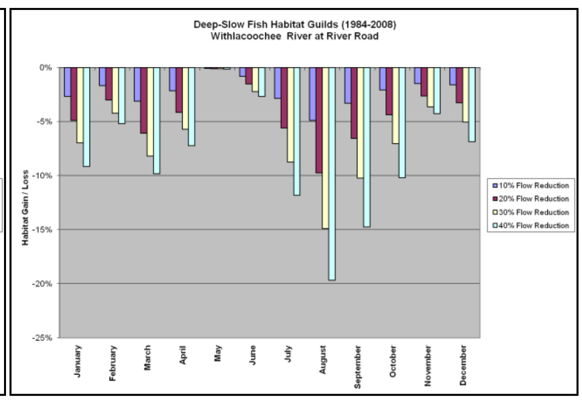
Gore, J.A., and J.M. Nestler. 1988. Instream flow studies in perspective. *Regulated Rivers* 2: 93-101.

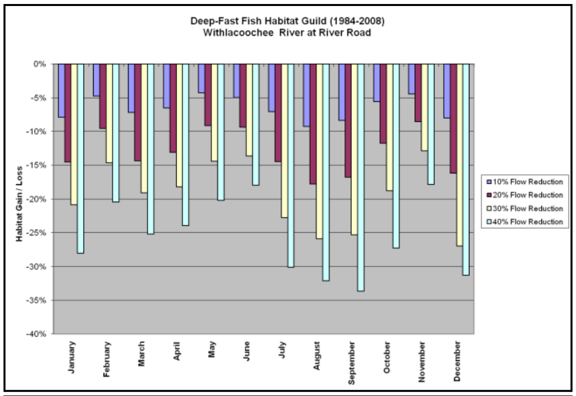
Gore, J.A., J.B. Layzer, and J. Mead. 2001. Macroinvertebrate instream flow studies after 20 years: a role in stream and river restoration. *Regulated Rivers* 17: 527-542.

Below are graphics generated for visual inspection of PHABSIM output. They are arranged from upstream to downstream.

Withlacoochee River at River Road (near Dade City)






Deep-Fast Fish Habitat Guild (1984-2008)
Withlacoochee River at River Road
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
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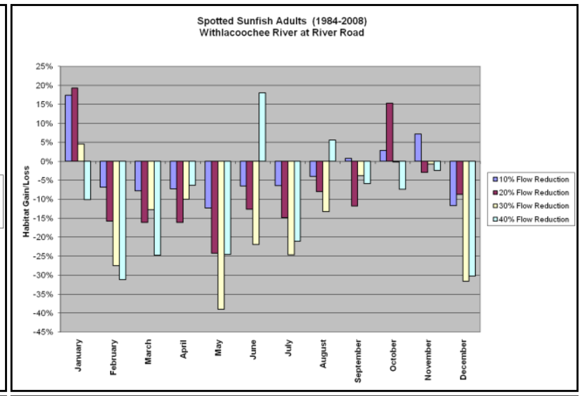
Spotted Sunfish Adults (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
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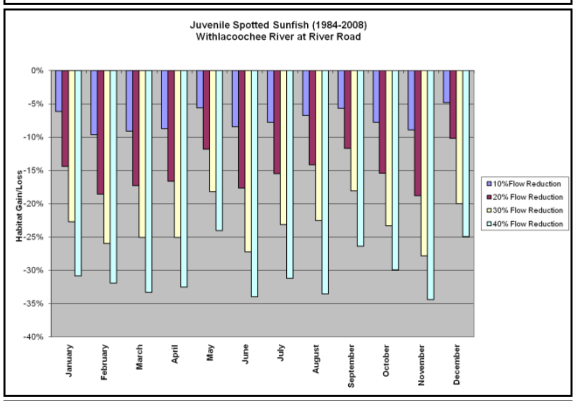
Juvenile Spotted Sunfish (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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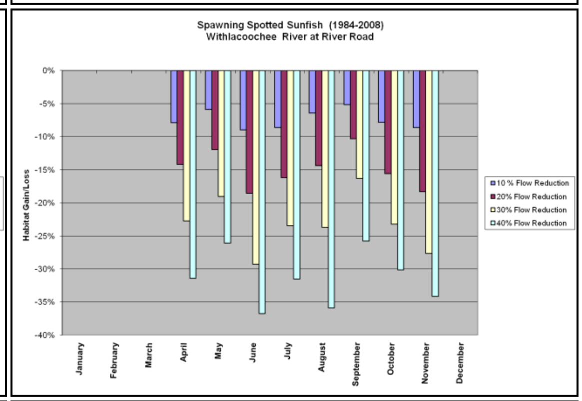
Spawning Spotted Sunfish (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
10 % Flow Reduction
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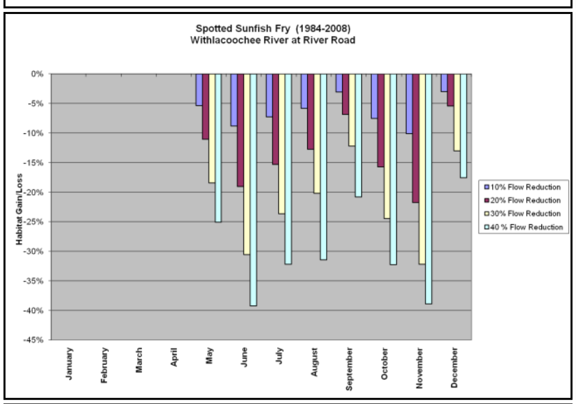
Spotted Sunfish Fry (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
10% Flow Reduction
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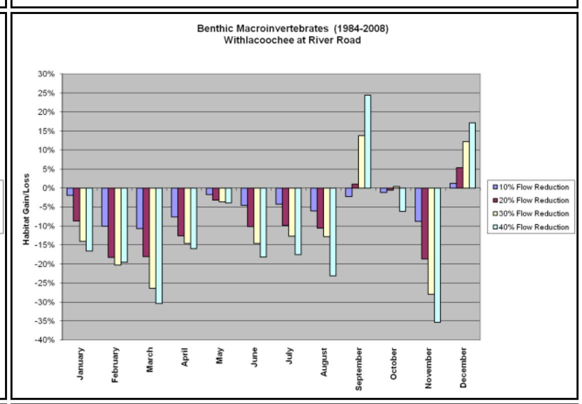
Benthic Macroinvertebrates (1984-2008)
Withlacoochee at River Road
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
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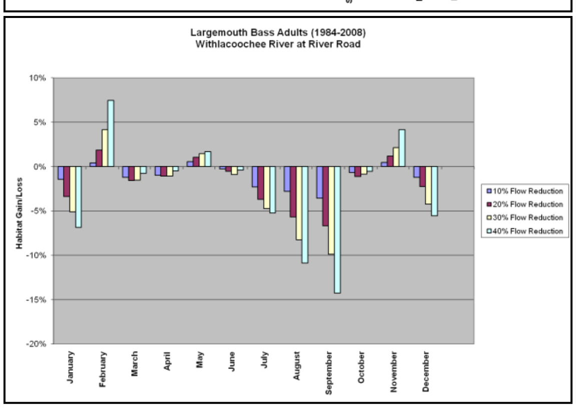
Largemouth Bass Adults (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
10% Flow Reduction
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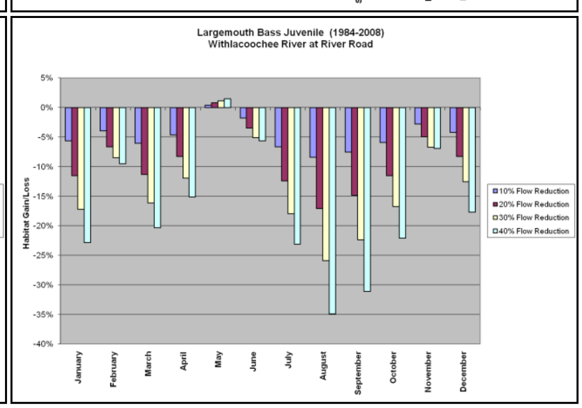
Largemouth Bass Juvenile (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
10% Flow Reduction
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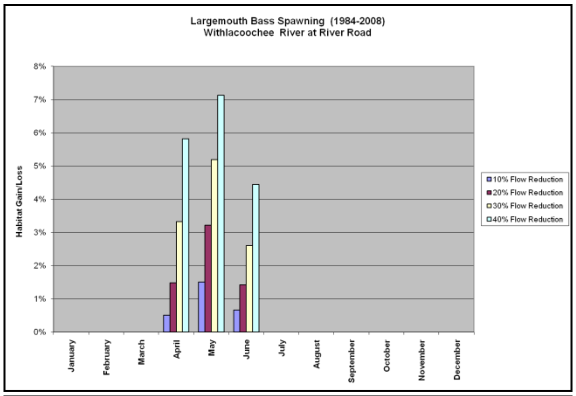
Largemouth Bass Spawning (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
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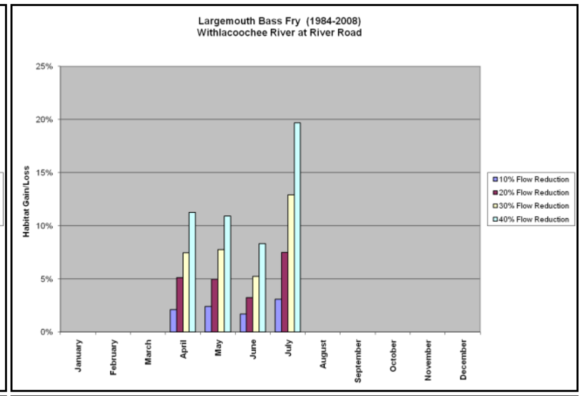
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Fry (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
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10% Flow Reduction
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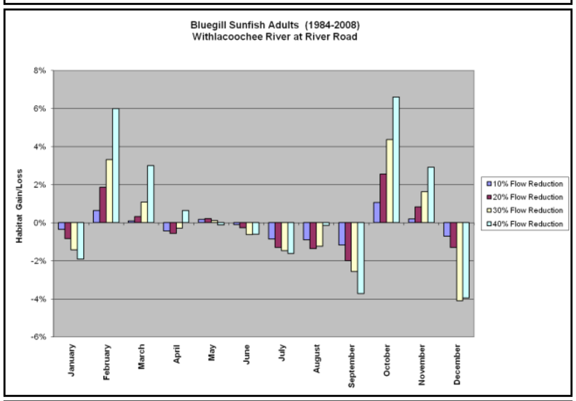
Bluegill Sunfish Adults (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
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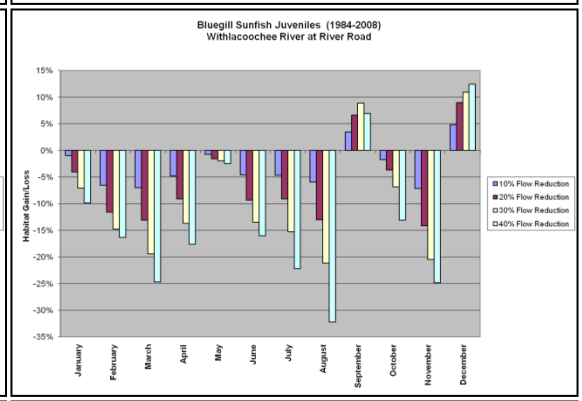
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Juveniles (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
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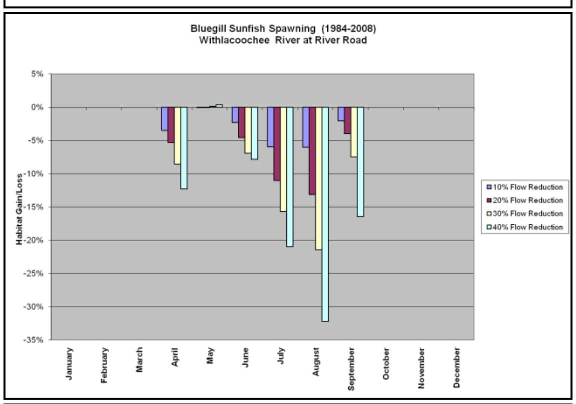
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Spawning (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
January
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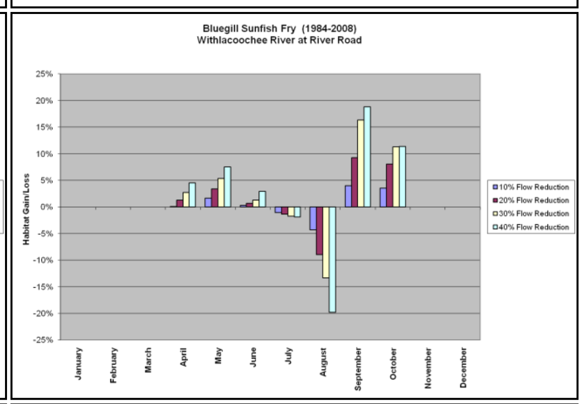
October
November
December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Fry (1984-2008)
Withlacoochee River at River Road
Habitat Gain/Loss
January
February
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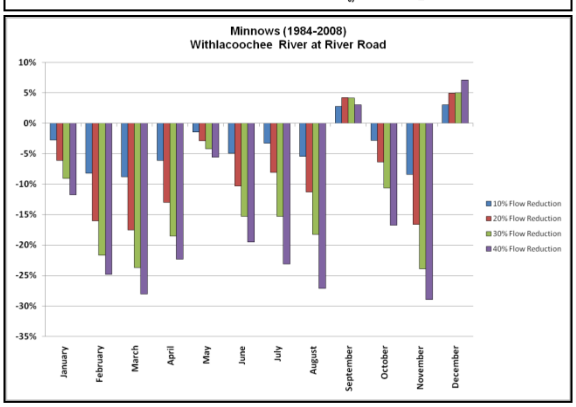
September
October
November
December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Minnows (1984-2008)
Withlacoochee River at River Road
January
February
March
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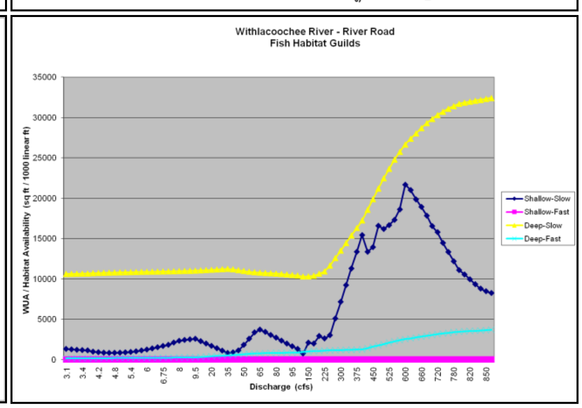
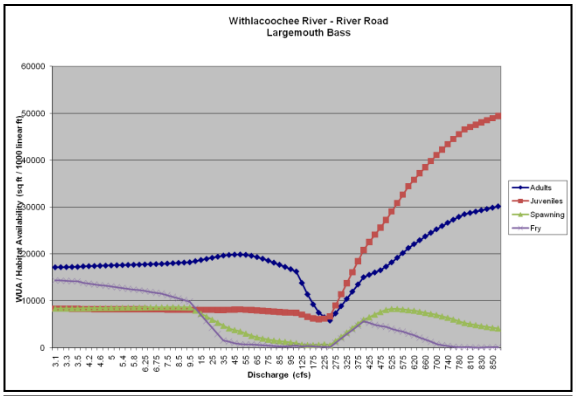
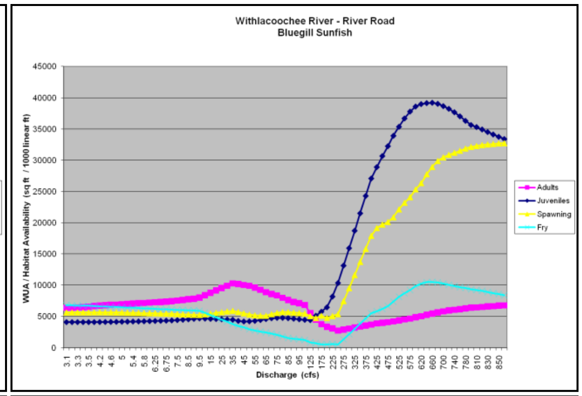
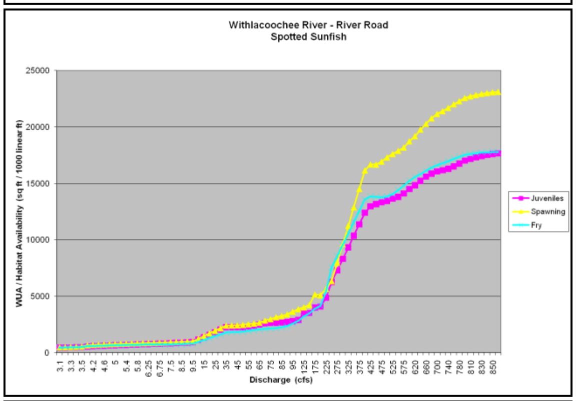
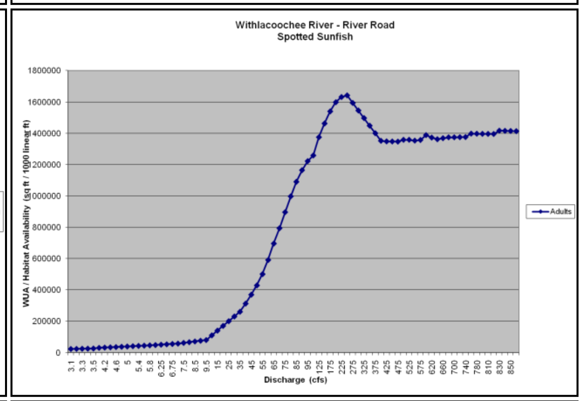
September
October
November
December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

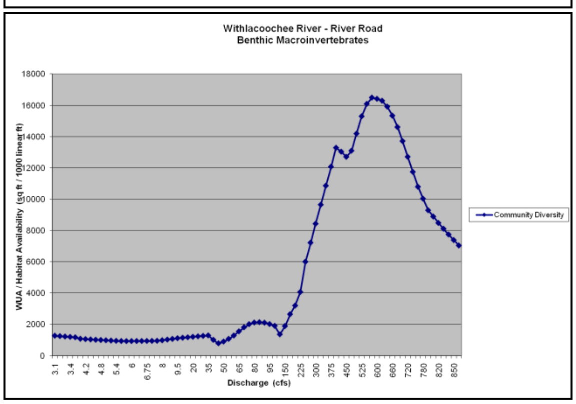

Withlacoochee River - River Road
Fish Habitat Guilds
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast

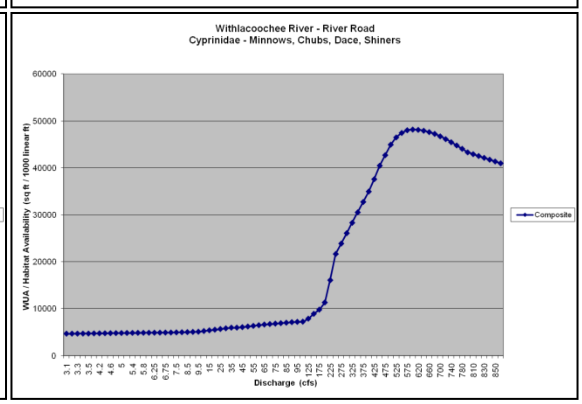




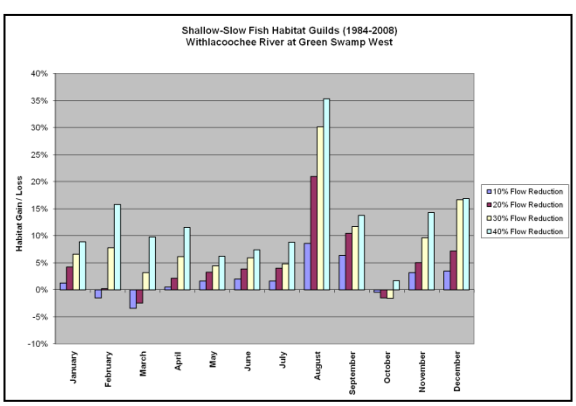


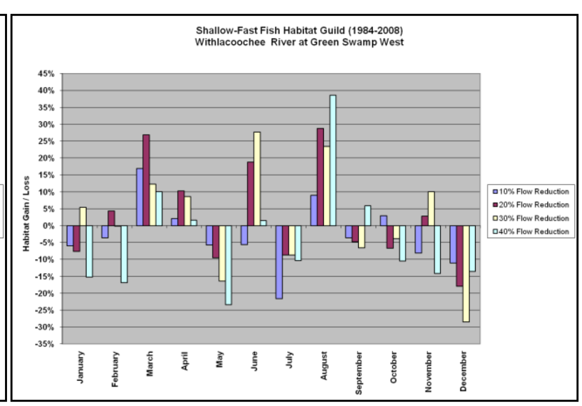


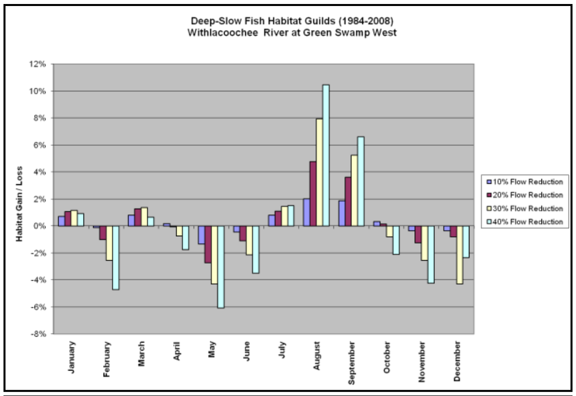


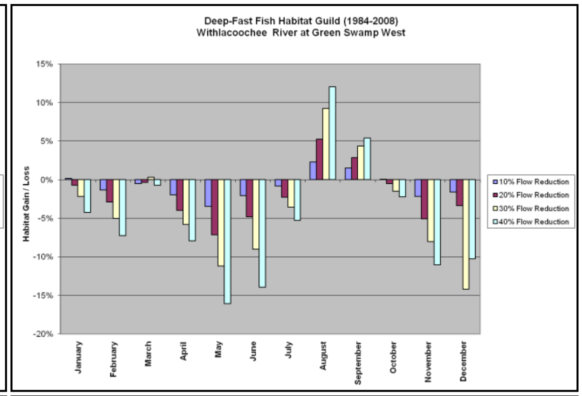


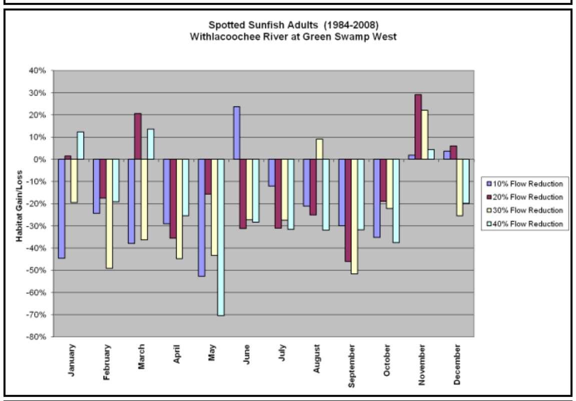
Withlacoochee River at Green Swamp West

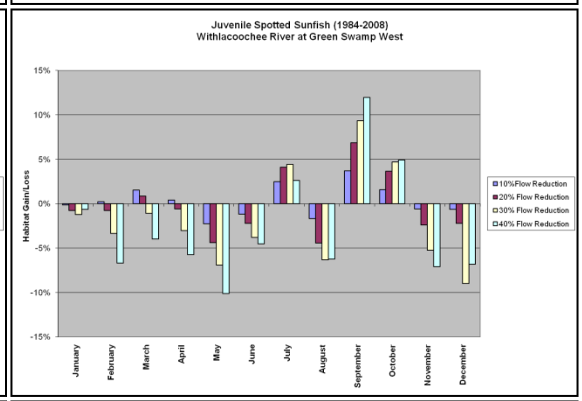


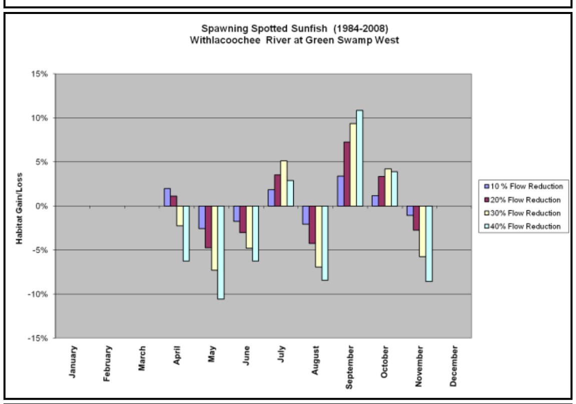


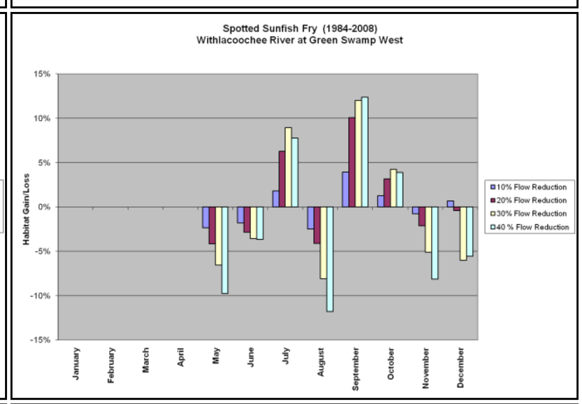

Deep-Slow Fish Habitat Guilds (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

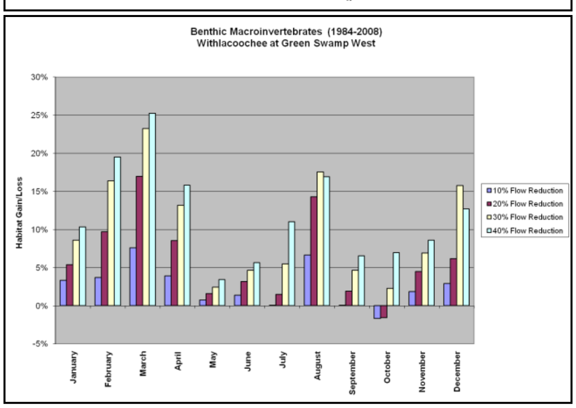

Deep-Fast Fish Habitat Guild (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

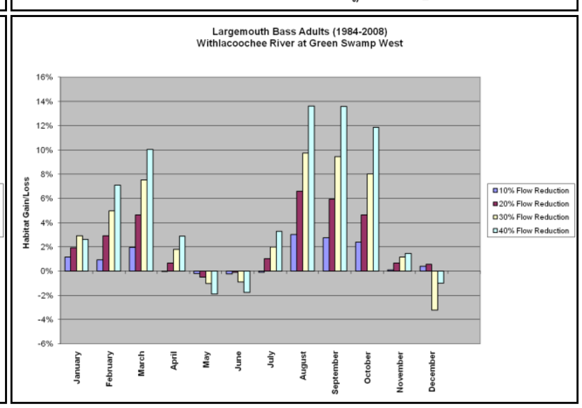

Spotted Sunfish Adults (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

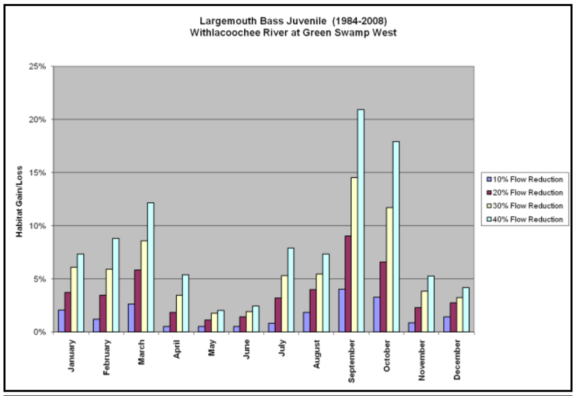

Juvenile Spotted Sunfish (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spawning Spotted Sunfish (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spotted Sunfish Fry (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40 % Flow Reduction


Benthic Macroinvertebrates (1984-2008)
Withlacoochee at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Adults (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Juvenile (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
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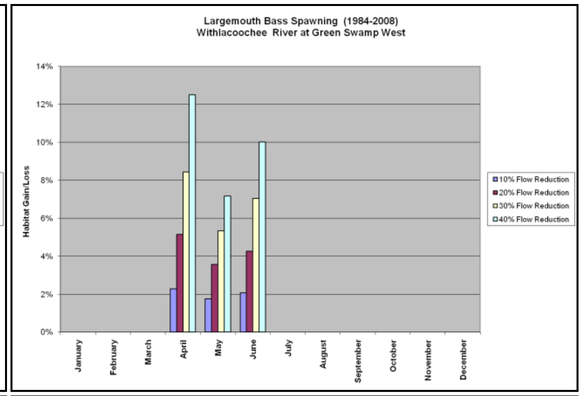
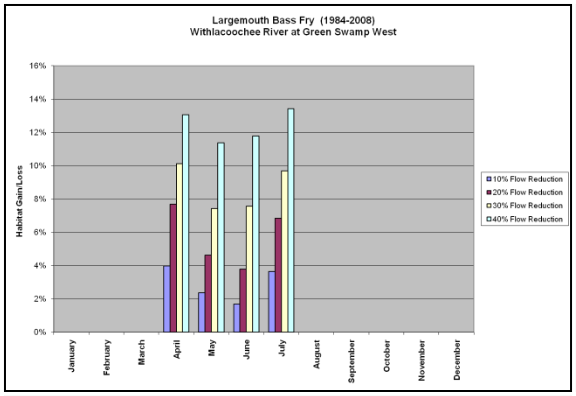
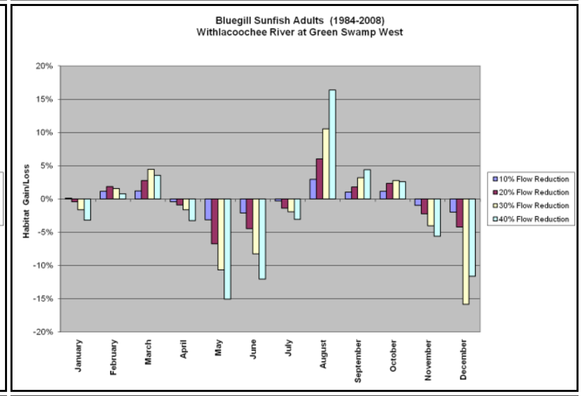
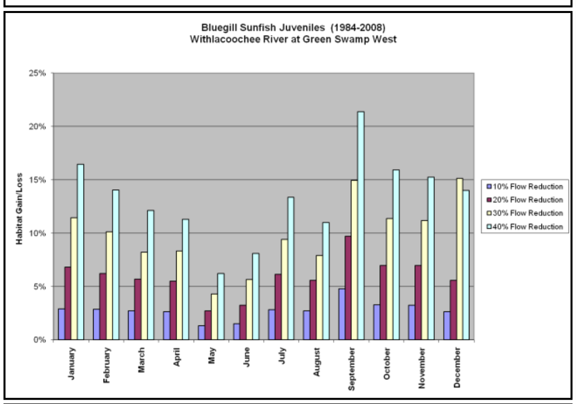
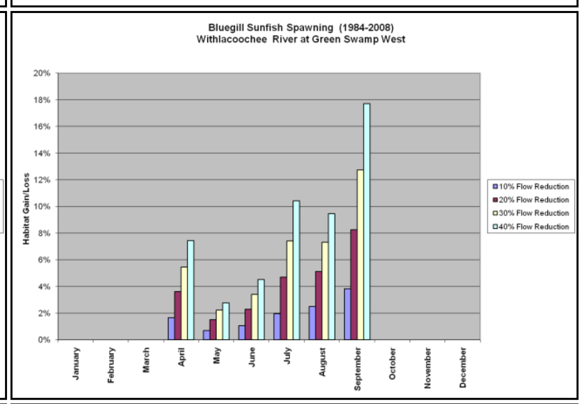
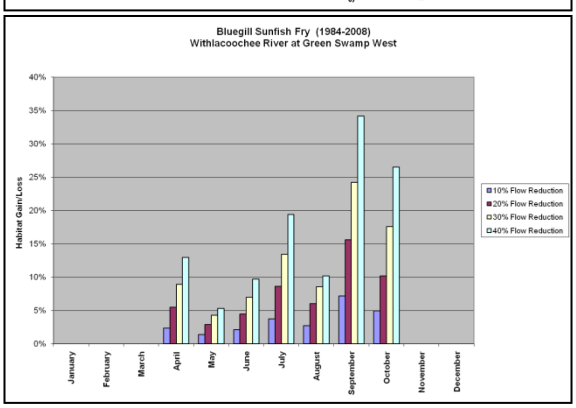

Largemouth Bass Spawning (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Fry (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Adults (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Juveniles (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Spawning (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Fry (1984-2008)
Withlacoochee River at Green Swamp West
Habitat Gain/Loss
10% Flow Reduction
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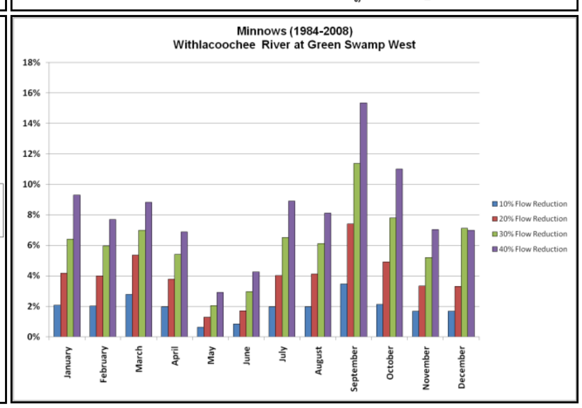
40% Flow Reduction


Minnows (1984-2008)
Withlacoochee River at Green Swamp West
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
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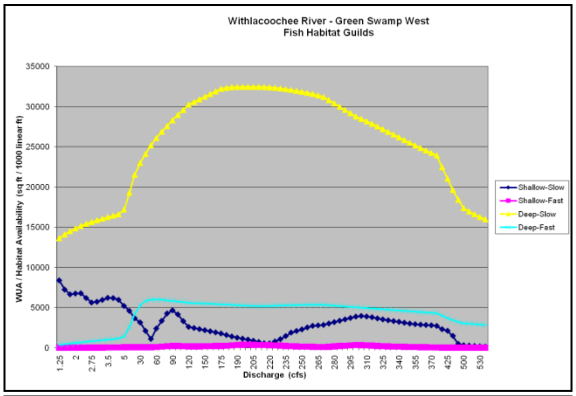
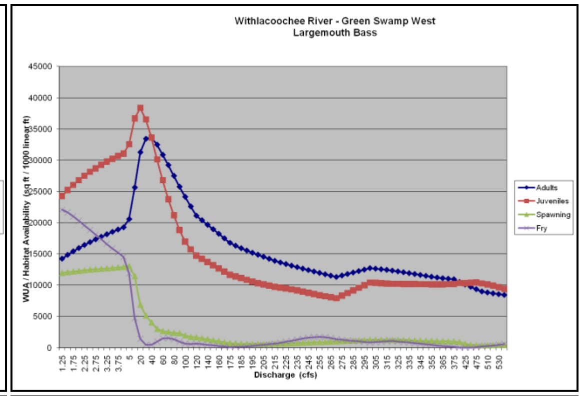
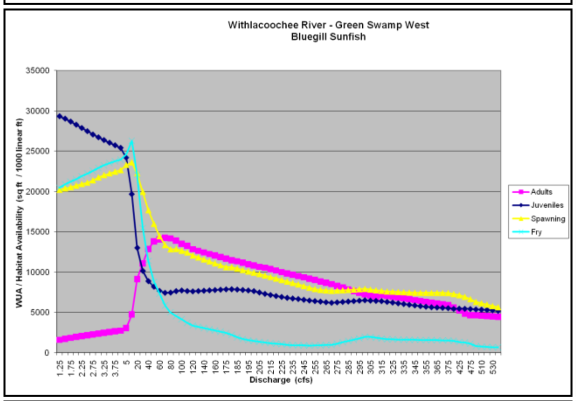
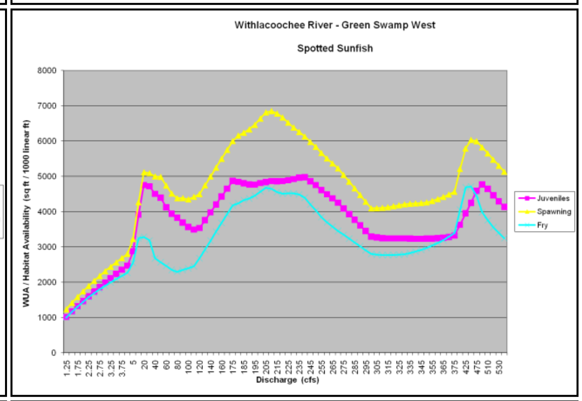
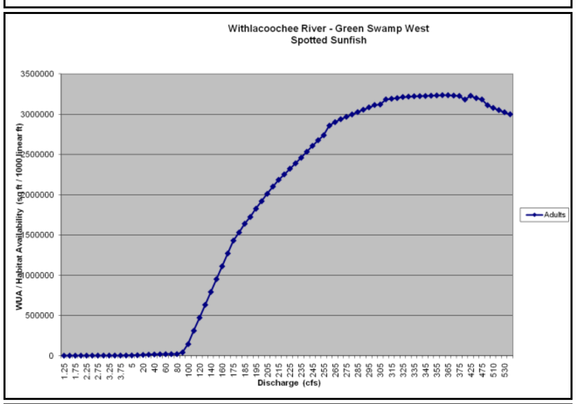
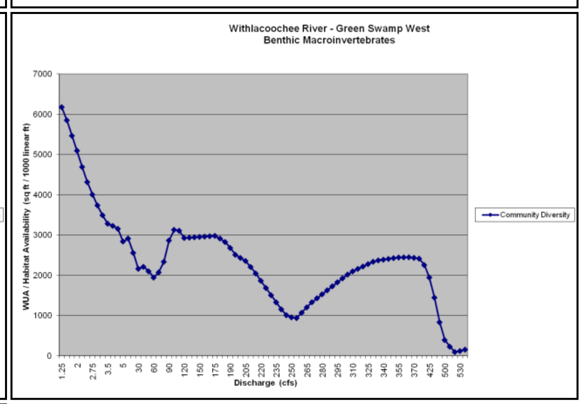


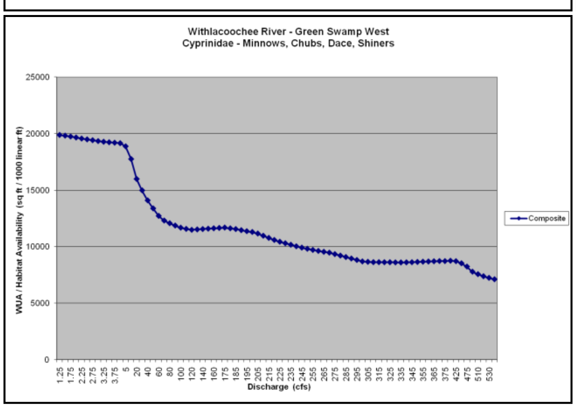




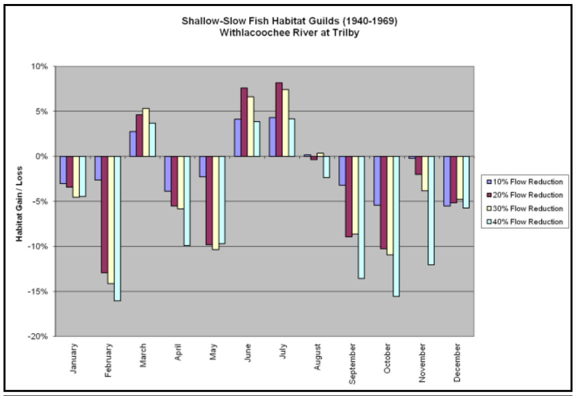








Withlacoochee River near Trilby


Shallow-Slow Fish Habitat Guilds (1940-1969)
Withlacoochee River at Trilby
Habitat Gain / Loss
January
February
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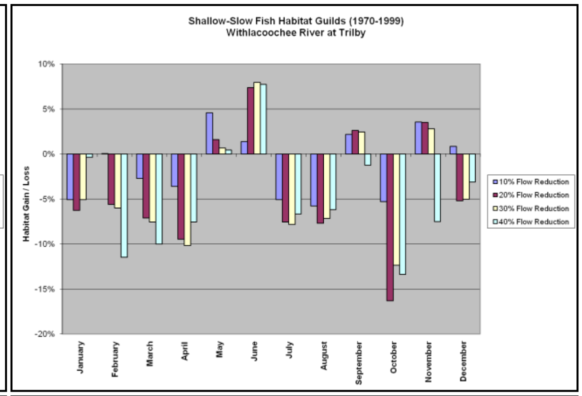
October
November
December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Shallow-Slow Fish Habitat Guilds (1970-1999)
Withlacoochee River at Trilby
Habitat Gain / Loss
January
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10% Flow Reduction
20% Flow Reduction
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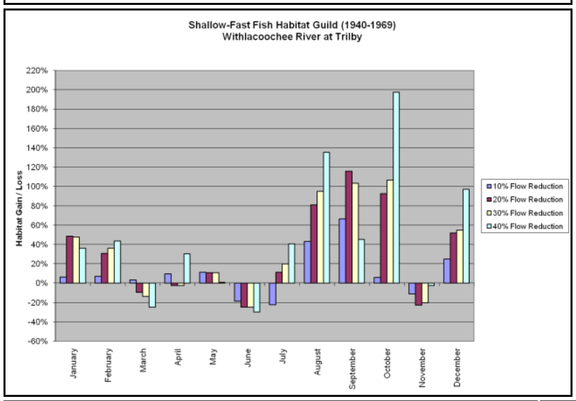
40% Flow Reduction


Shallow-Fast Fish Habitat Guild (1940-1969)
Withlacoochee River at Trilby
Habitat Gain / Loss
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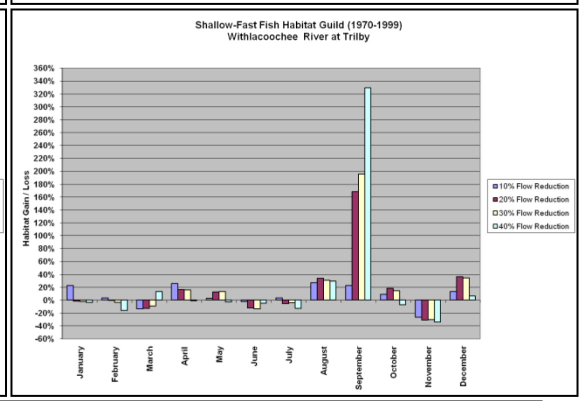
Shallow-Fast Fish Habitat Guild (1970-1999)
Withlacoochee River at Trilby
Habitat Gain / Loss
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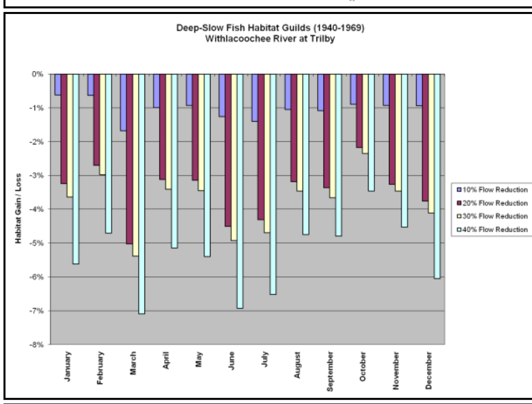
Deep-Slow Fish Habitat Guilds (1940-1969)
Withlacoochee River at Trilby
Habitat Gain / Loss
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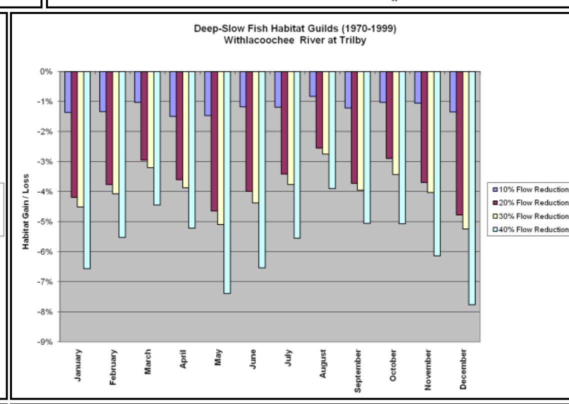
Deep-Slow Fish Habitat Guilds (1970-1999)
Withlacoochee River at Trilby
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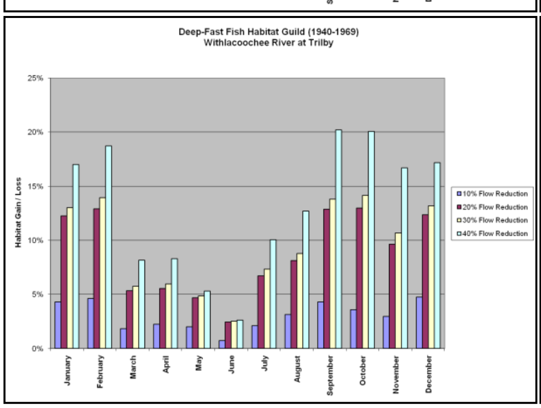
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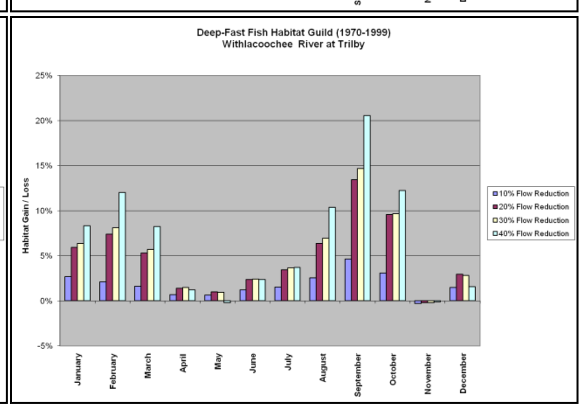
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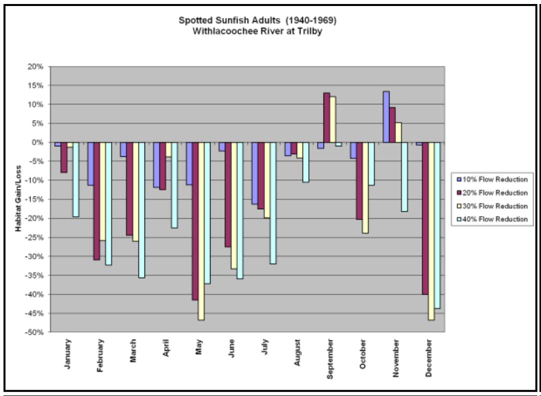
Spotted Sunfish Adults (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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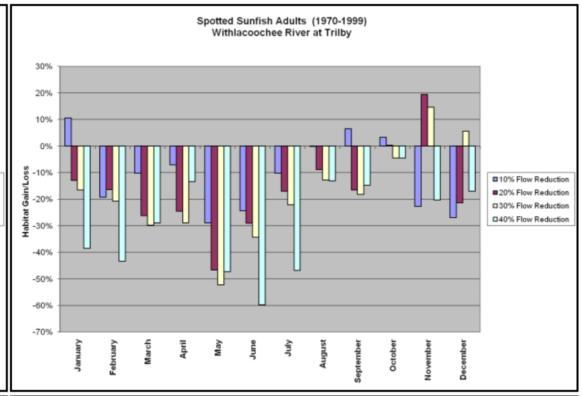
Spotted Sunfish Adults (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
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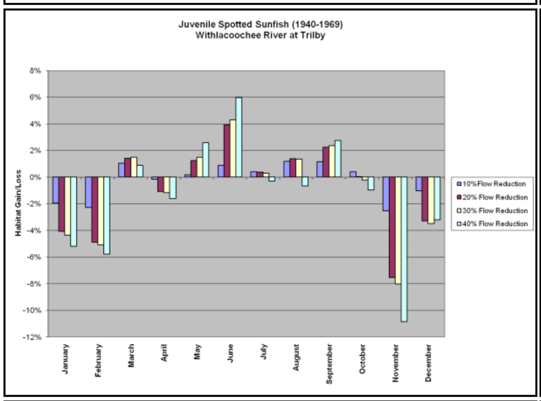
Juvenile Spotted Sunfish (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10%Flow Reduction
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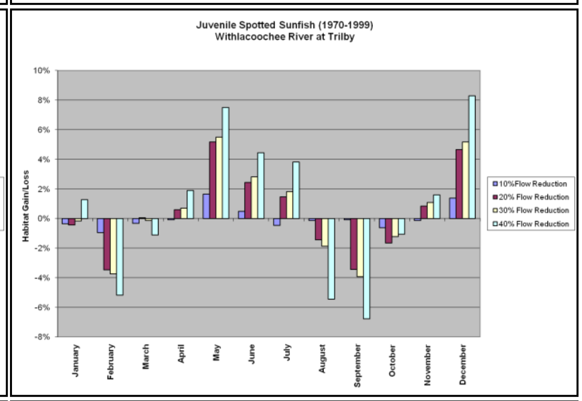
40% Flow Reduction


Juvenile Spotted Sunfish (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10%Flow Reduction
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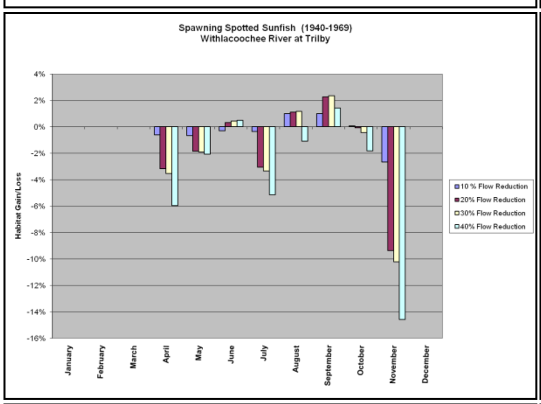
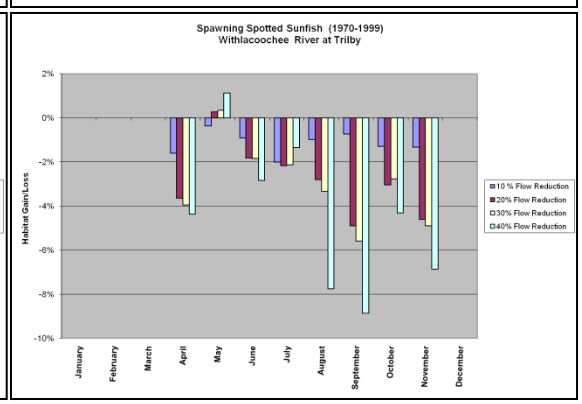

Spawning Spotted Sunfish (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spawning Spotted Sunfish (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
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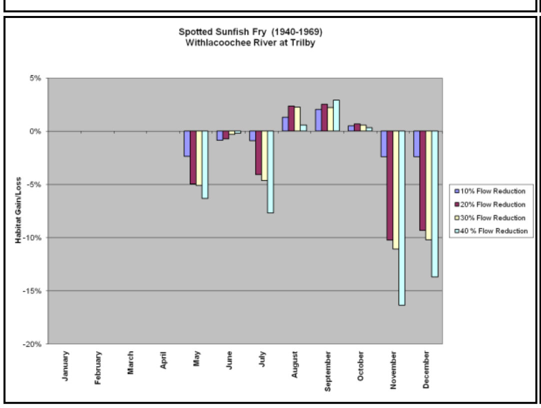
Spotted Sunfish Fry (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
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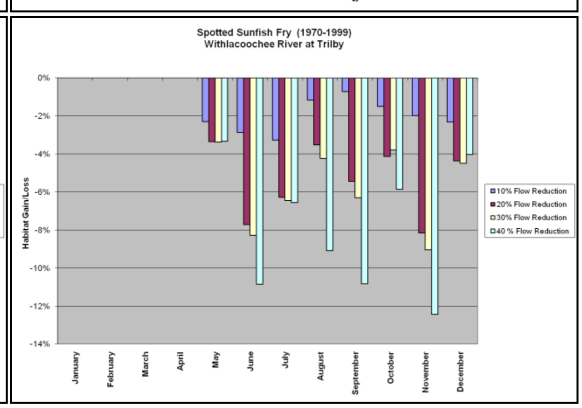
Spotted Sunfish Fry (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
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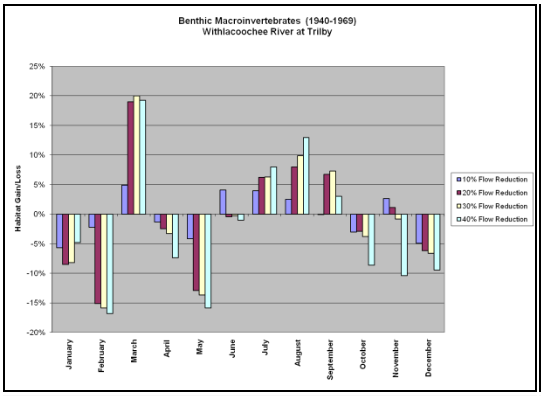
Benthic Macroinvertebrates (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
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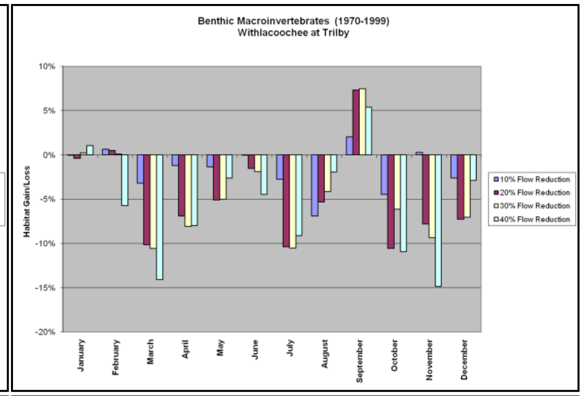
Benthic Macroinvertebrates (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
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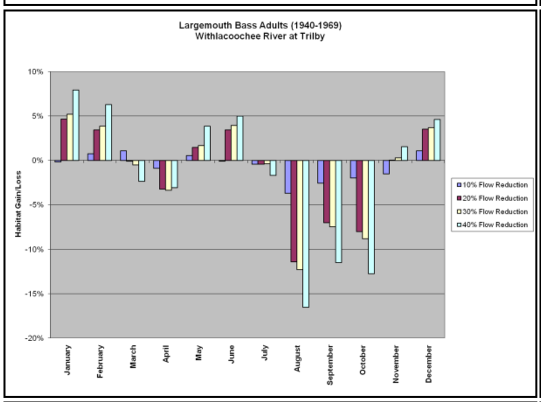
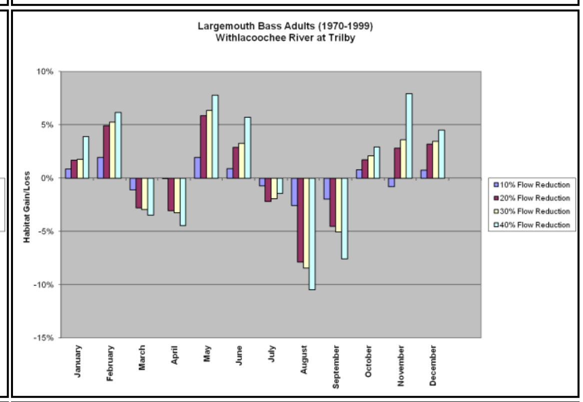
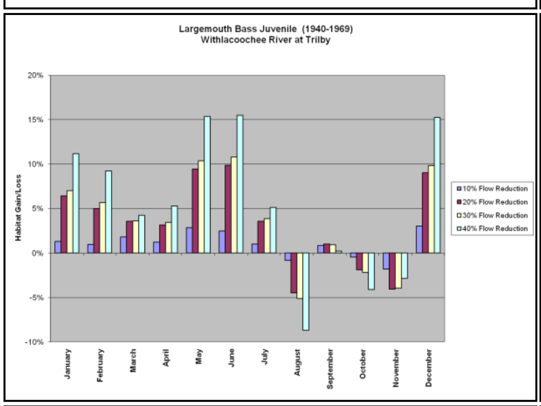
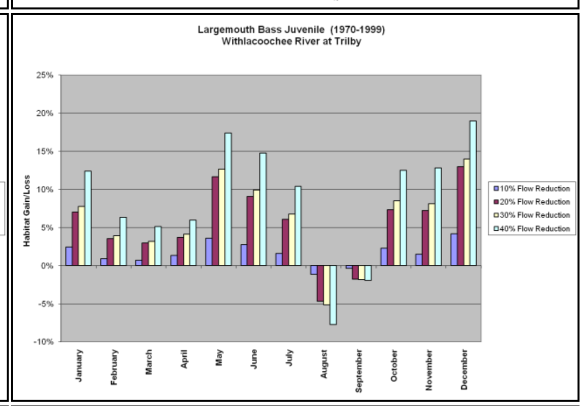
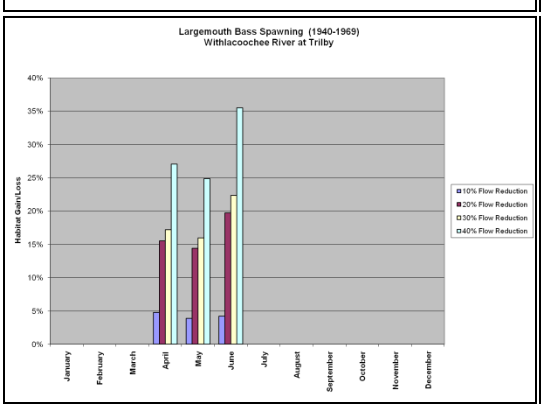
30% Flow Reduction
40% Flow Reduction

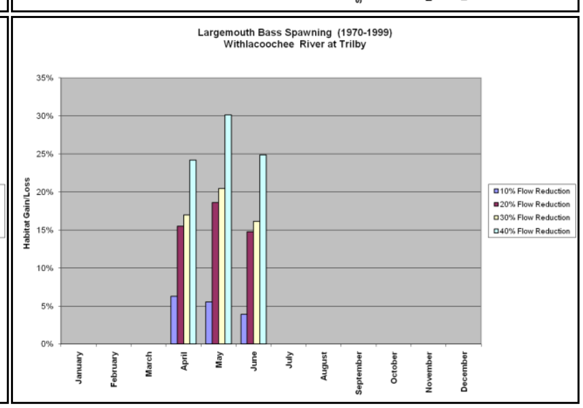

Largemouth Bass Adults (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

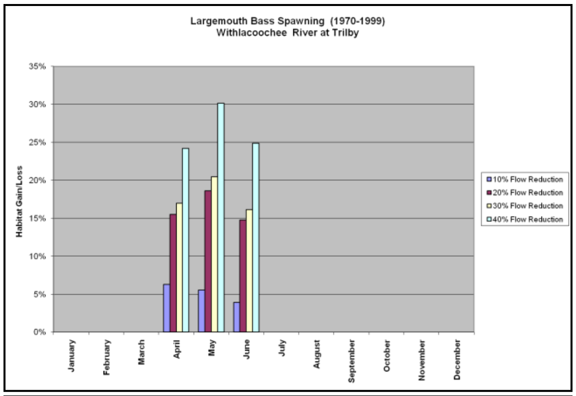

Largemouth Bass Adults (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Juvenile (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Juvenile (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Spawning (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Spawning (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Spawning (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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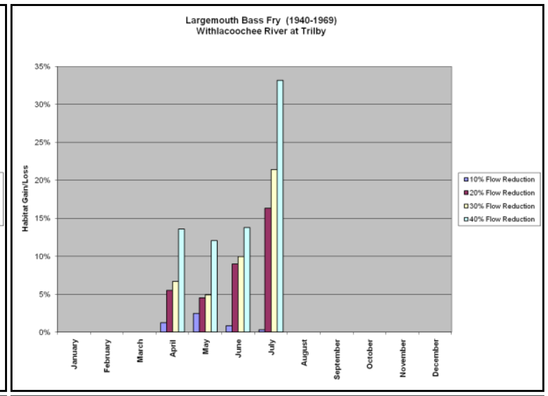
Largemouth Bass Fry (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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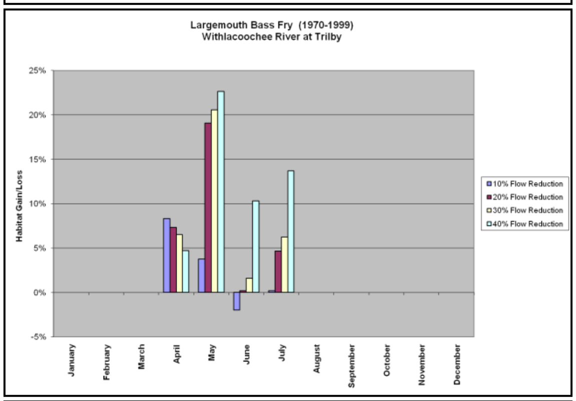
Largemouth Bass Fry (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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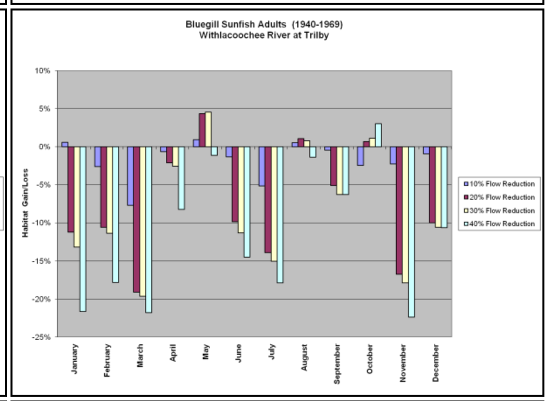
Bluegill Sunfish Adults (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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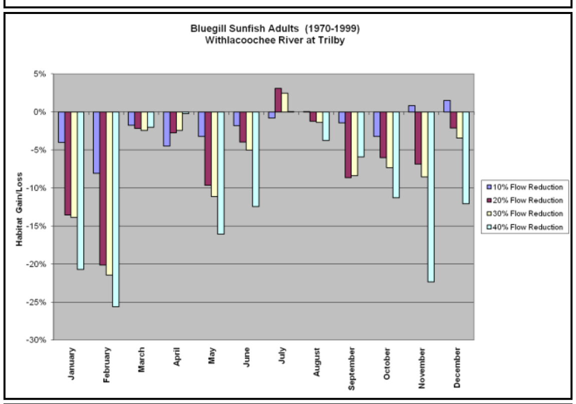
Bluegill Sunfish Adults (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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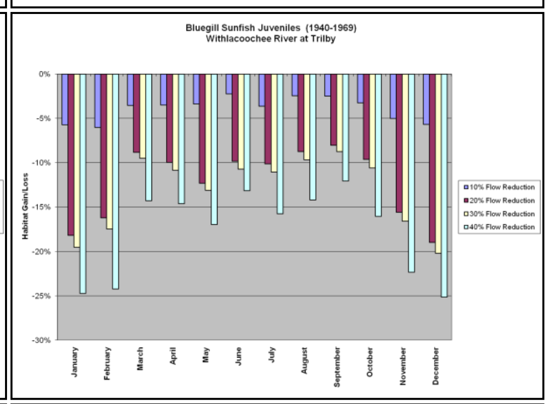
Bluegill Sunfish Juveniles (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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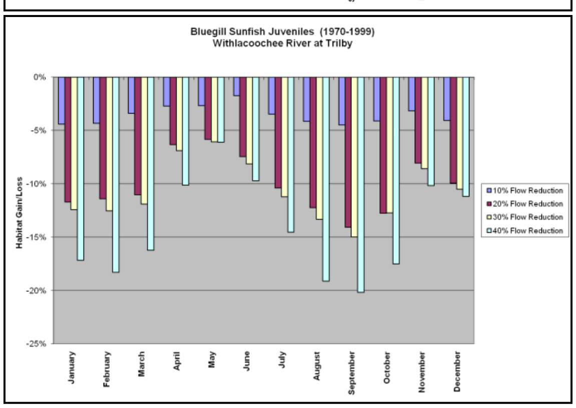
Bluegill Sunfish Juveniles (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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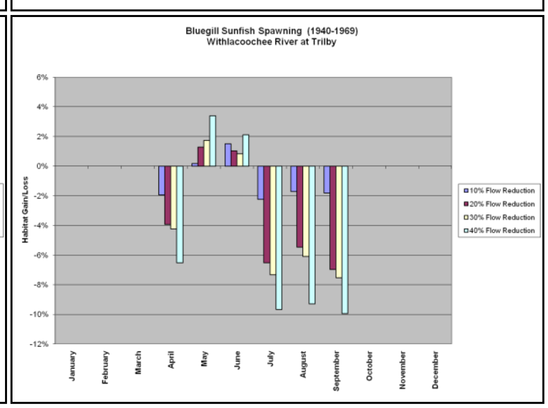
Bluegill Sunfish Spawning (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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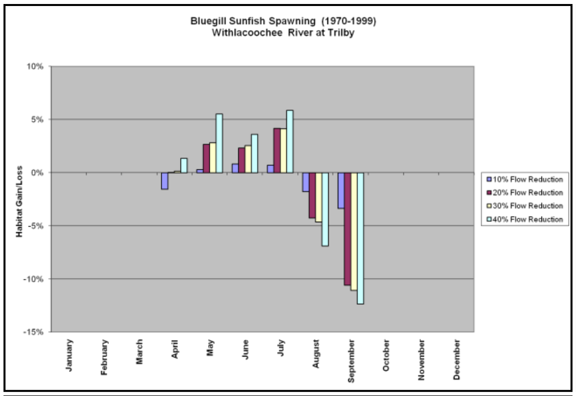
Bluegill Sunfish Spawning (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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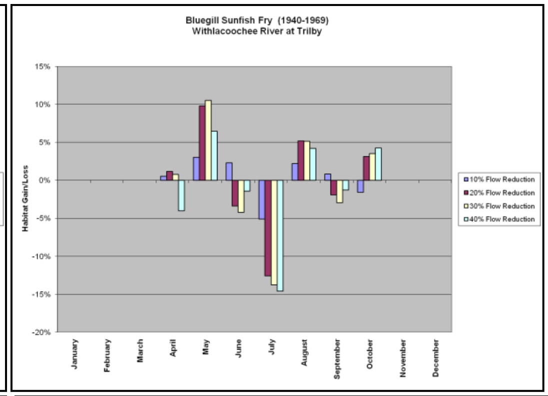
Bluegill Sunfish Fry (1940-1969)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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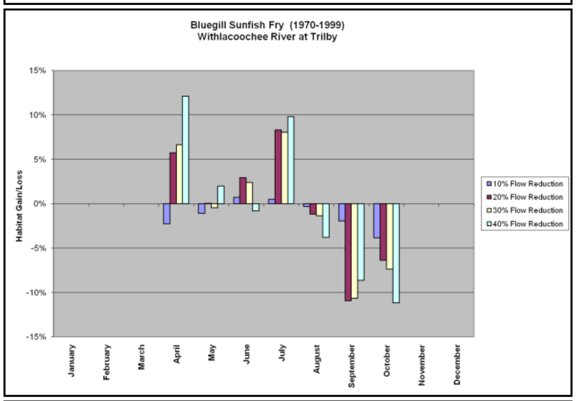
Bluegill Sunfish Fry (1970-1999)
Withlacoochee River at Trilby
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
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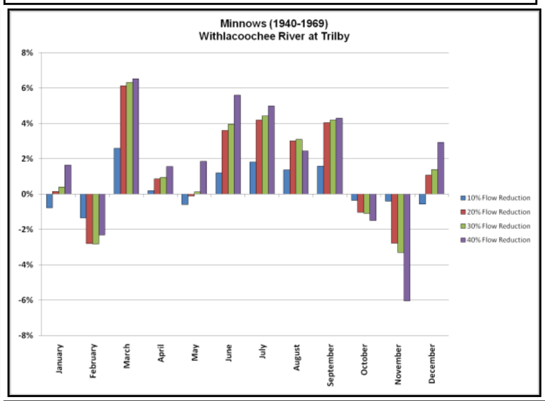
Minnows (1940-1969)
Withlacoochee River at Trilby
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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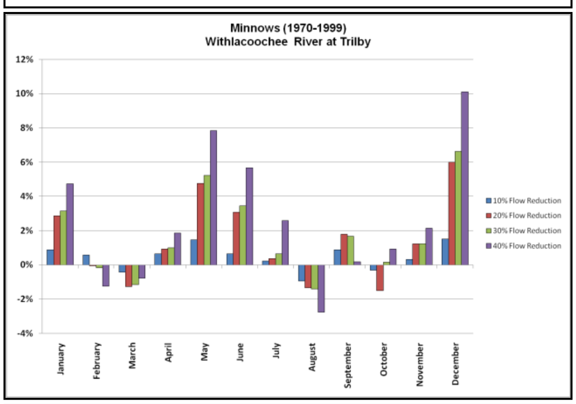
Minnows (1970-1999)
Withlacoochee River at Trilby
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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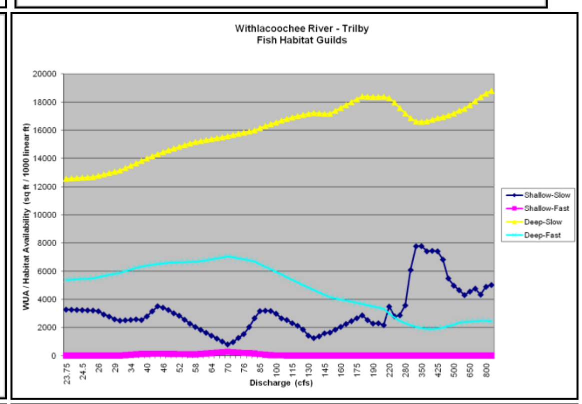
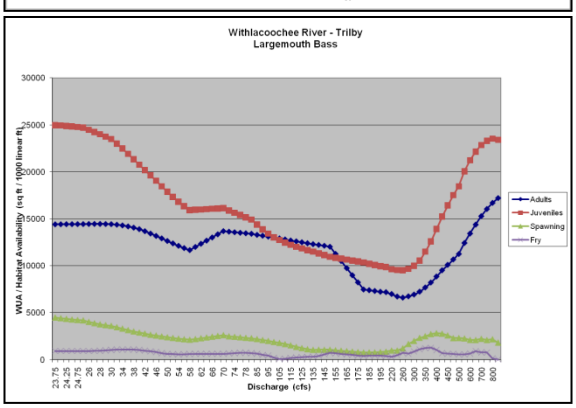
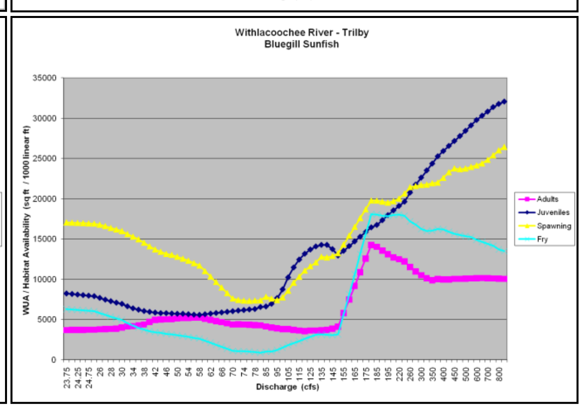
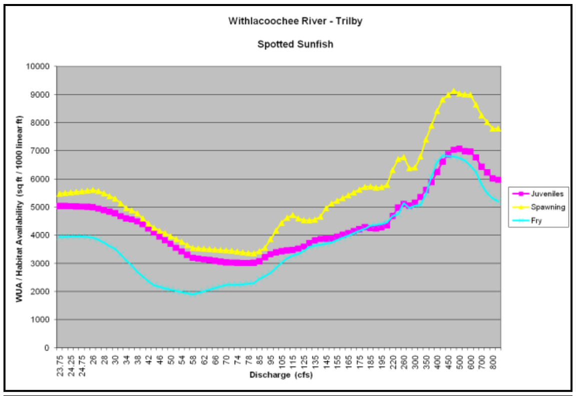
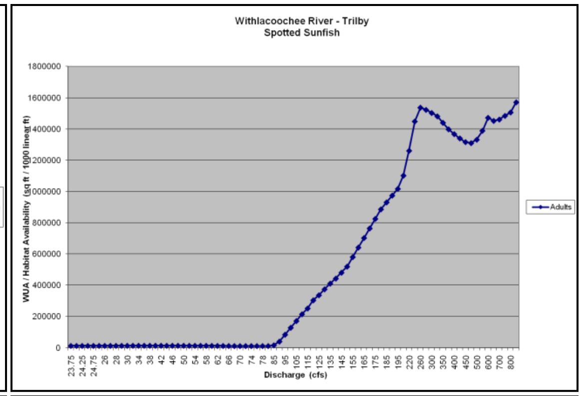
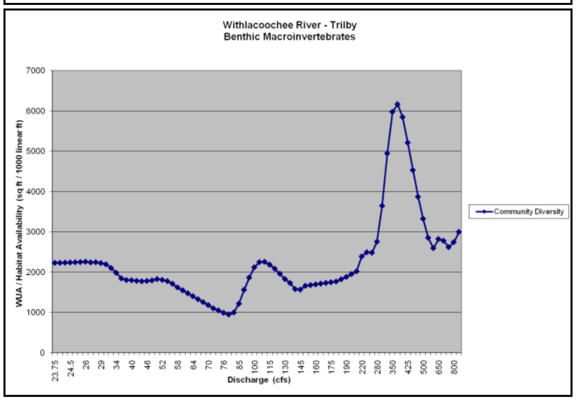

Withlacoochee River - Trilby
Fish Habitat Guilds
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast

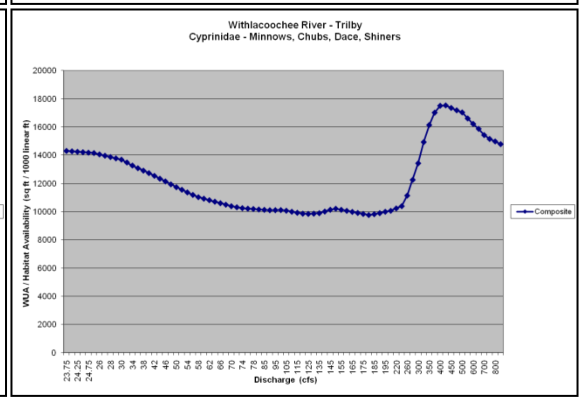

Withlacoochee River - Trilby
Largemouth Bass
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults
Juveniles
Spawning
Fry


Withlacoochee River - Trilby
Bluegill Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults
Juveniles
Spawning
Fry

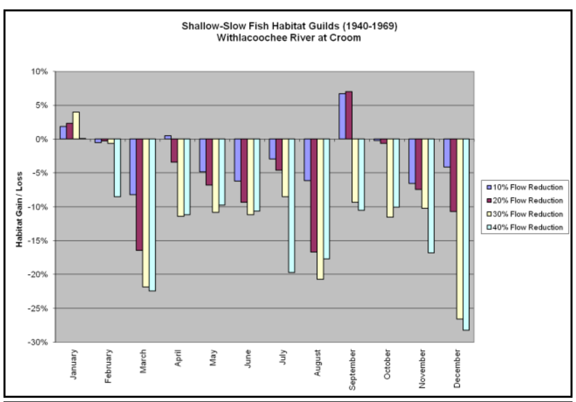


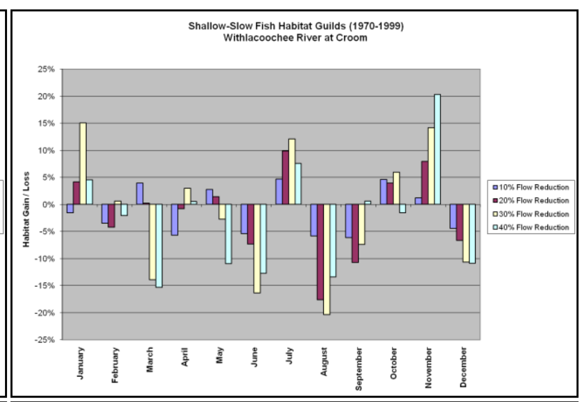


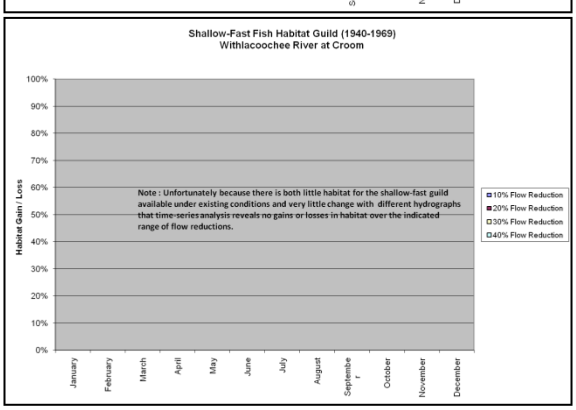


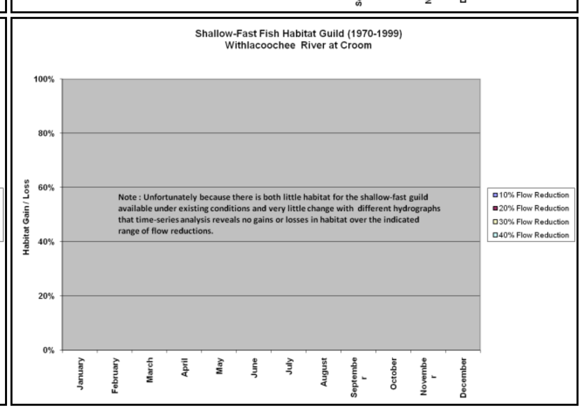


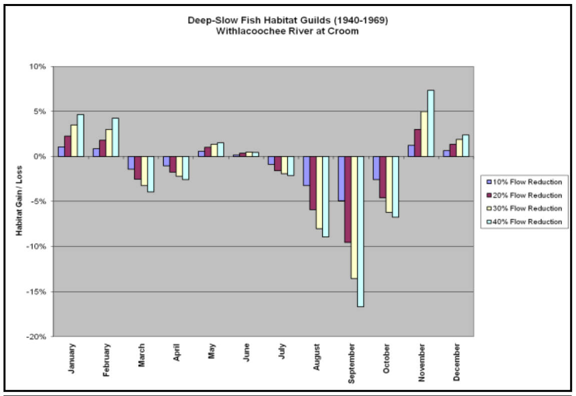
Withlacoochee River near Croom










Deep-Slow Fish Habitat Guilds (1940-1969)
Withlacoochee River at Croom
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
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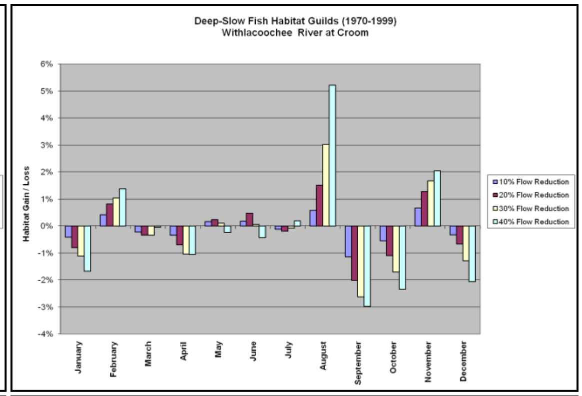
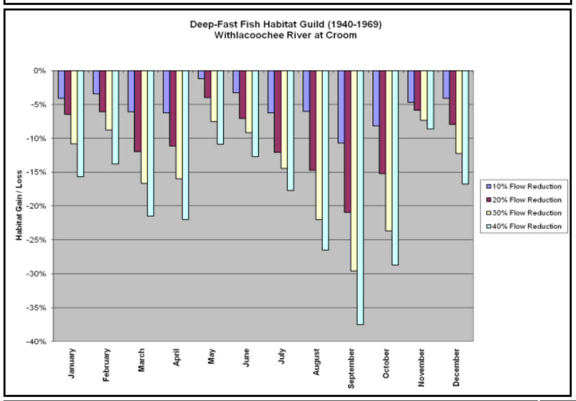
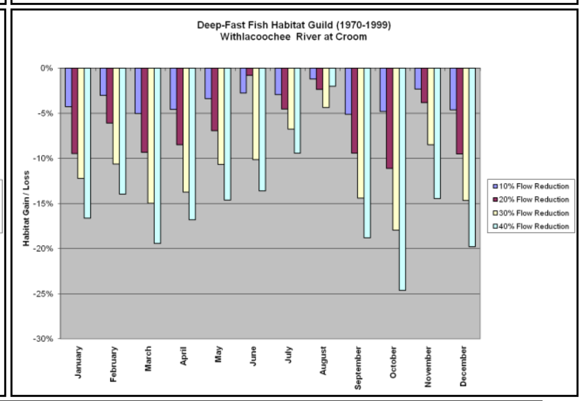
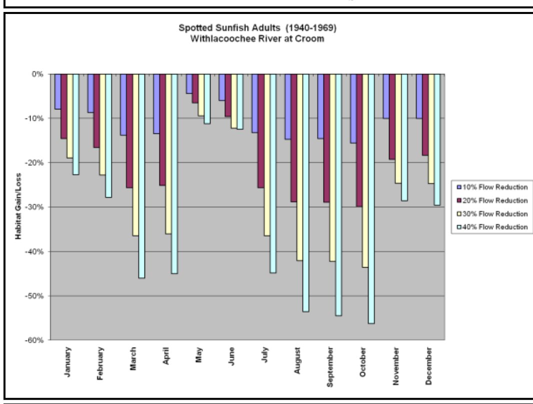
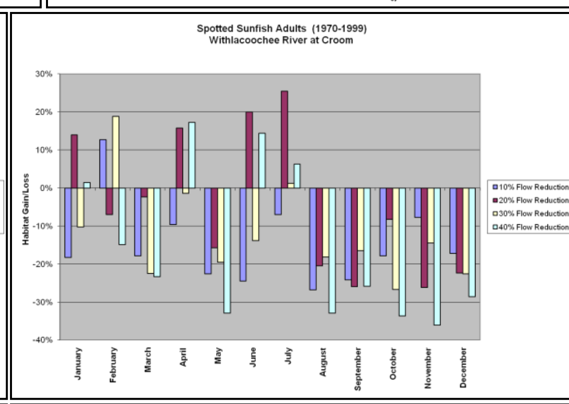
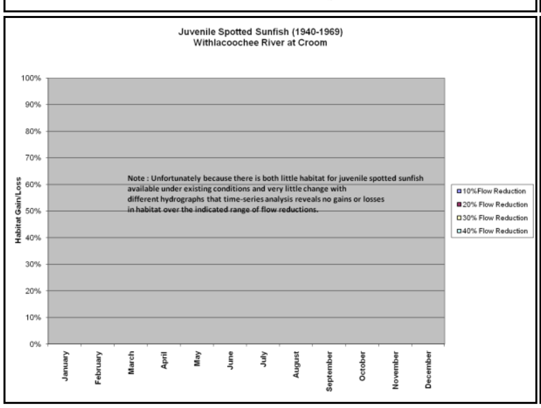

Deep-Slow Fish Habitat Guilds (1970-1999)
Withlacoochee River at Croom
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

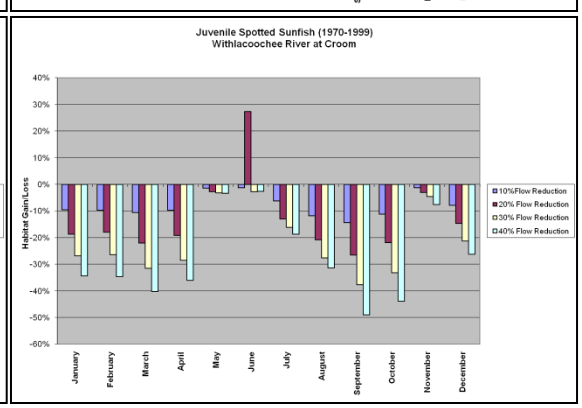

Deep-Fast Fish Habitat Guild (1940-1969)
Withlacoochee River at Croom
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

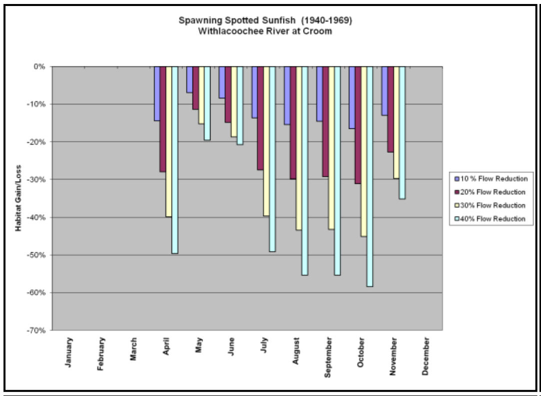

Deep-Fast Fish Habitat Guild (1970-1999)
Withlacoochee River at Croom
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spotted Sunfish Adults (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spotted Sunfish Adults (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Juvenile Spotted Sunfish (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
Note : Unfortunately because there is both little habitat for juvenile spotted sunfish available under existing conditions and very little change with different hydrographs that time-series analysis reveals no gains or losses in habitat over the indicated range of flow reductions.
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Juvenile Spotted Sunfish (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spawning Spotted Sunfish (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
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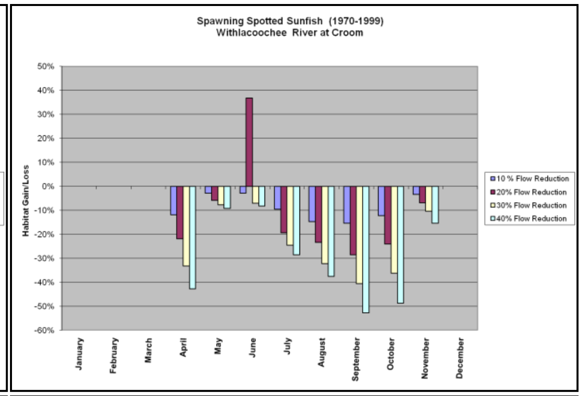
Spawning Spotted Sunfish (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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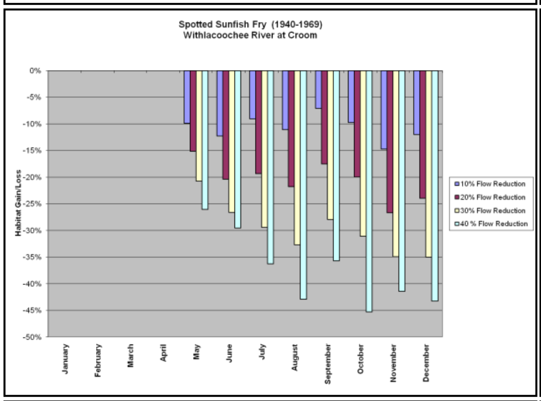
Spotted Sunfish Fry (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40 % Flow Reduction
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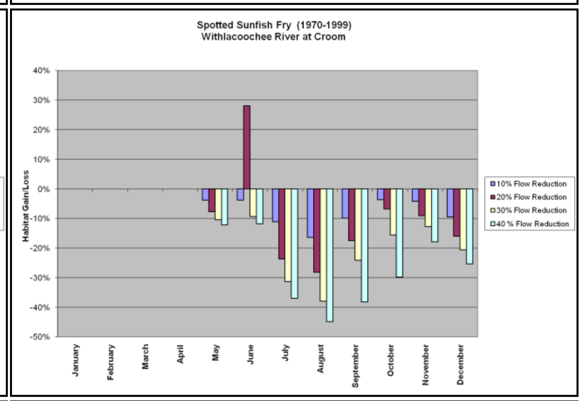
Spotted Sunfish Fry (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40 % Flow Reduction
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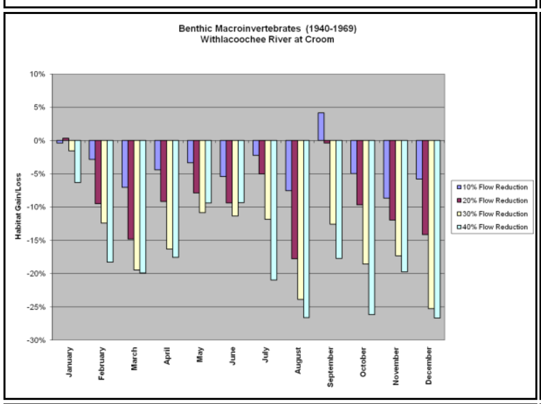
Benthic Macroinvertebrates (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
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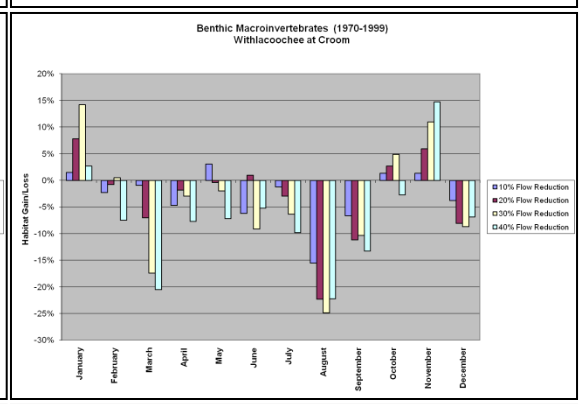
Benthic Macroinvertebrates (1970-1999)
Withlacoochee at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
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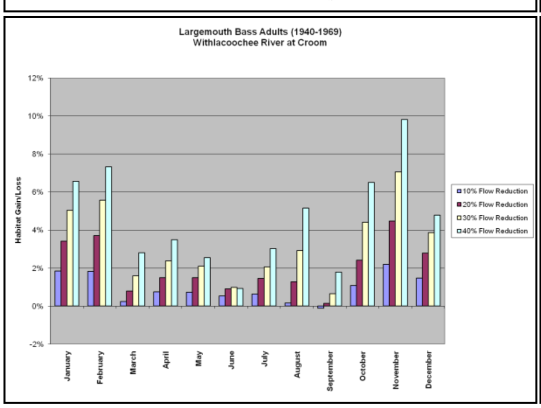
Largemouth Bass Adults (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
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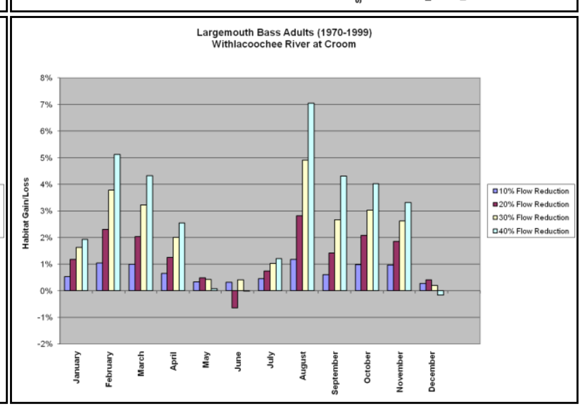
Largemouth Bass Adults (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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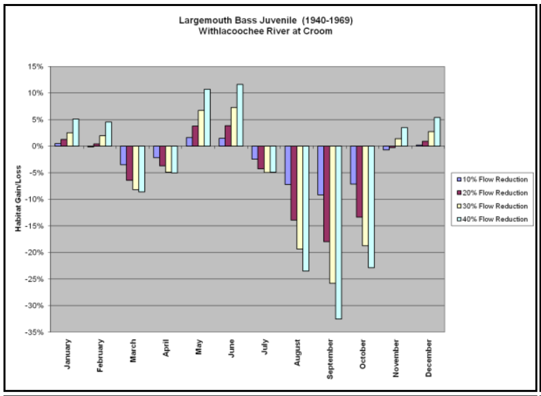
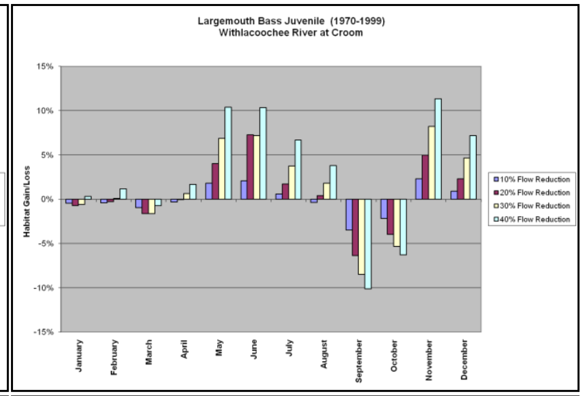
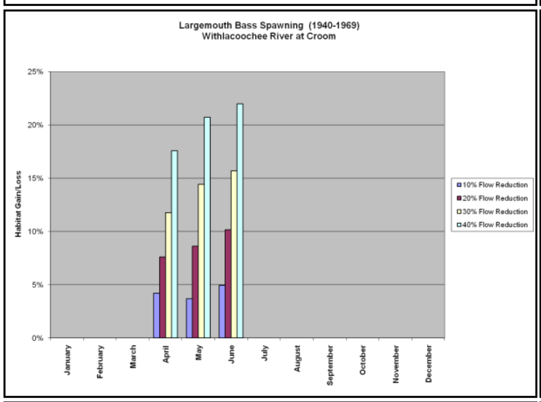
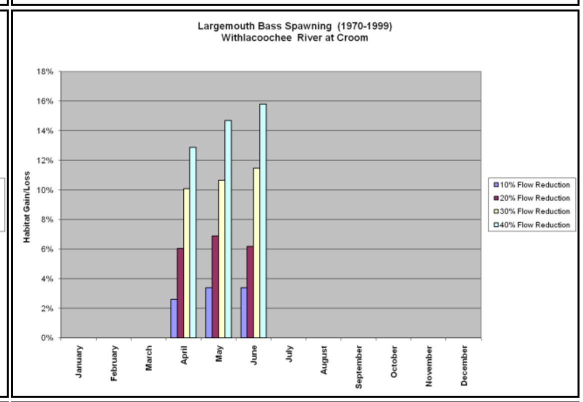

Largemouth Bass Juvenile (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Juvenile (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Spawning (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Spawning (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
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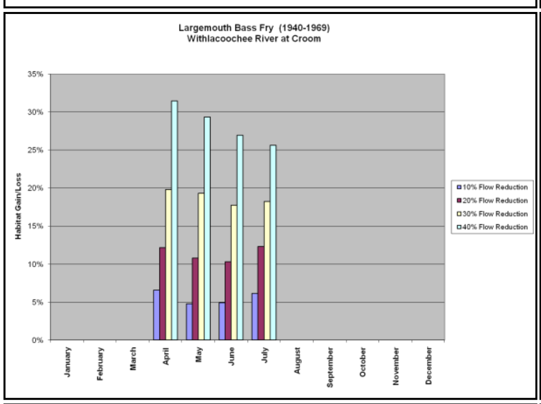
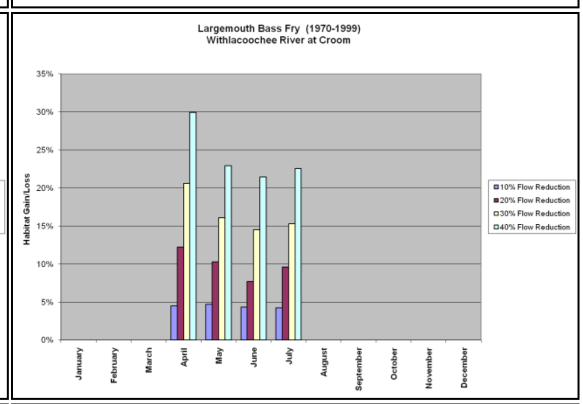
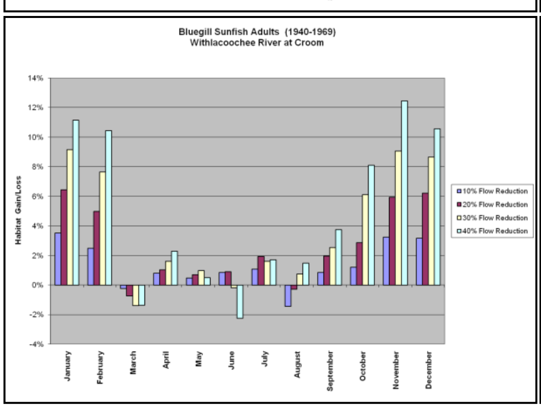
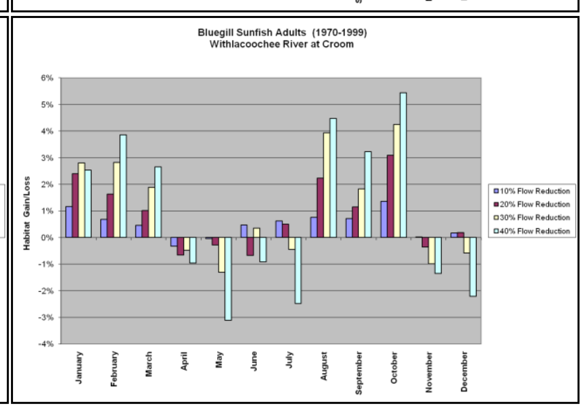
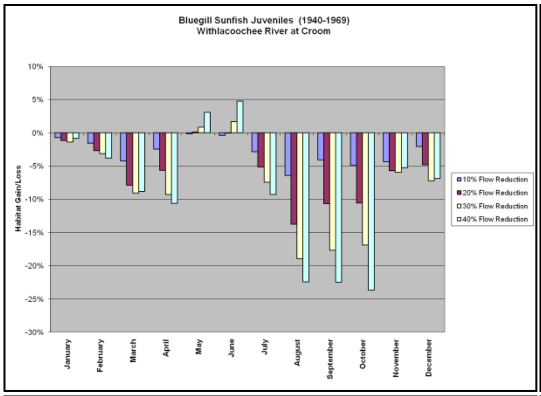

Largemouth Bass Fry (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Fry (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Adults (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Adults (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Juveniles (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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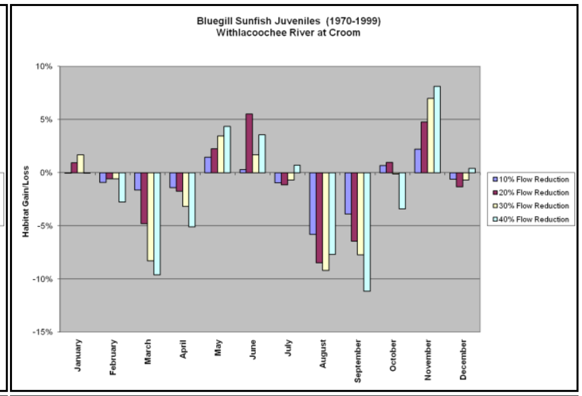
Bluegill Sunfish Juveniles (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
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40% Flow Reduction
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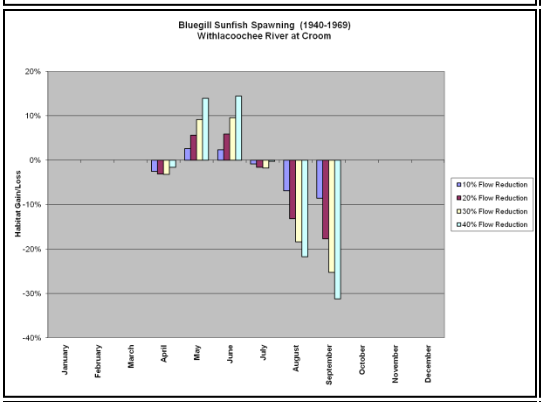
Bluegill Sunfish Spawning (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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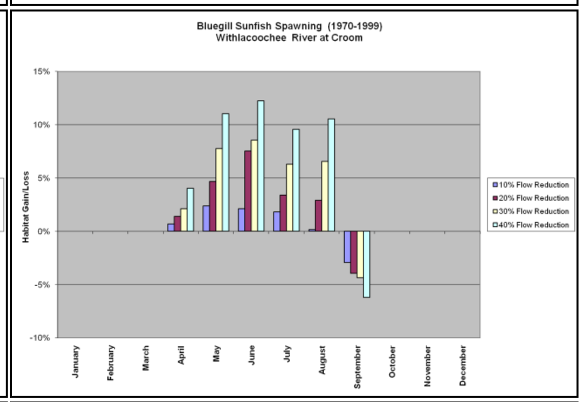
Bluegill Sunfish Spawning (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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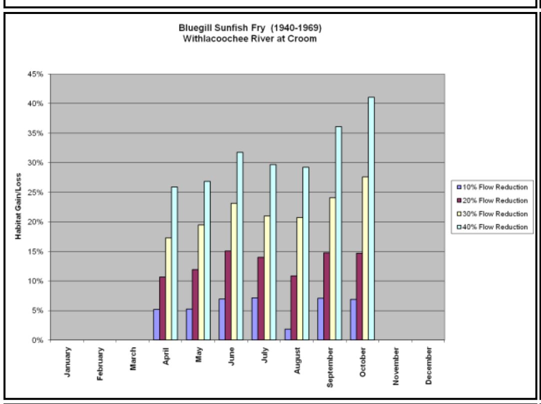
Bluegill Sunfish Fry (1940-1969)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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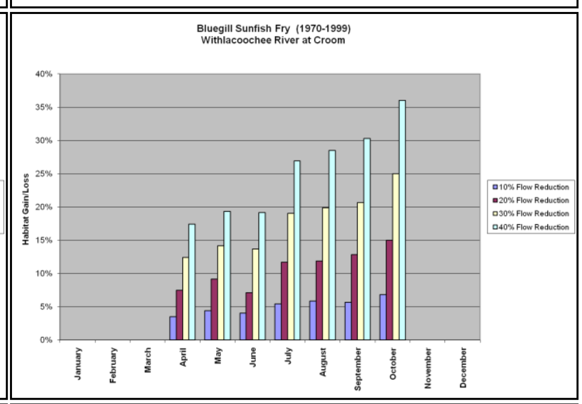
Bluegill Sunfish Fry (1970-1999)
Withlacoochee River at Croom
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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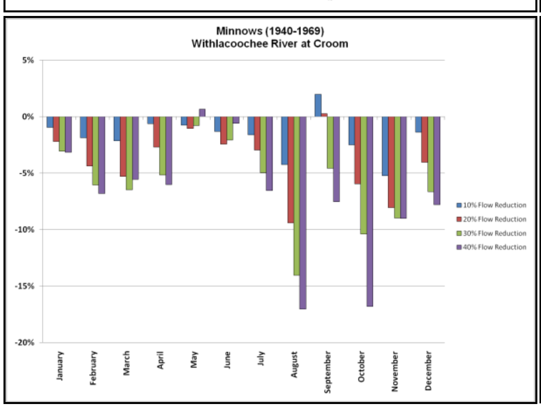
Minnows (1940-1969)
Withlacoochee River at Croom
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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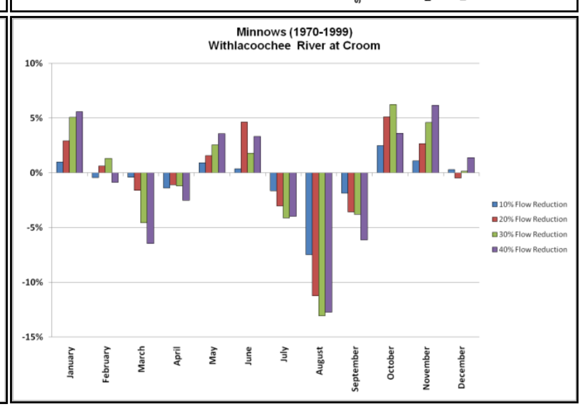
Minnows (1970-1999)
Withlacoochee River at Croom
10% Flow Reduction
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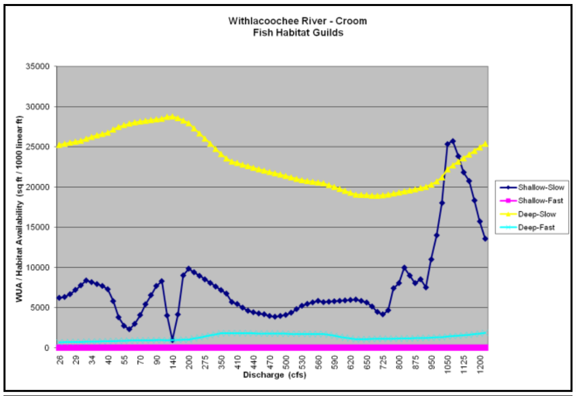
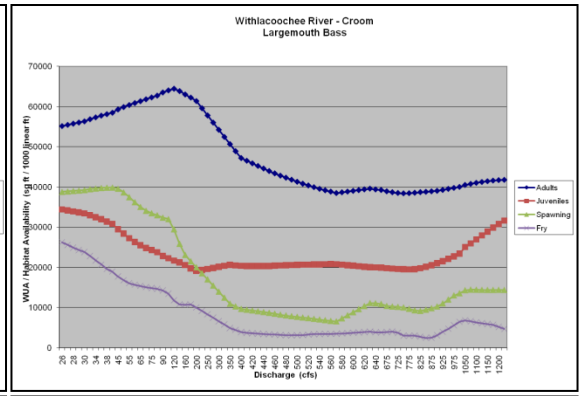
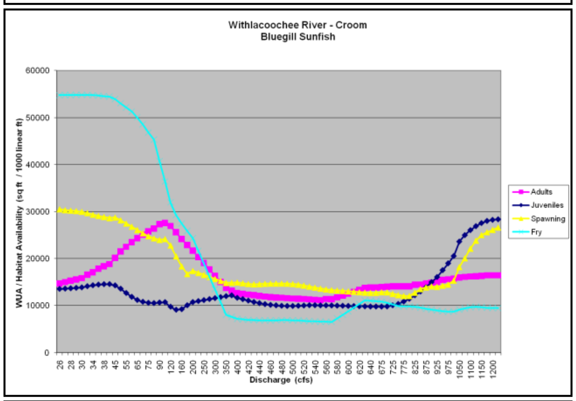
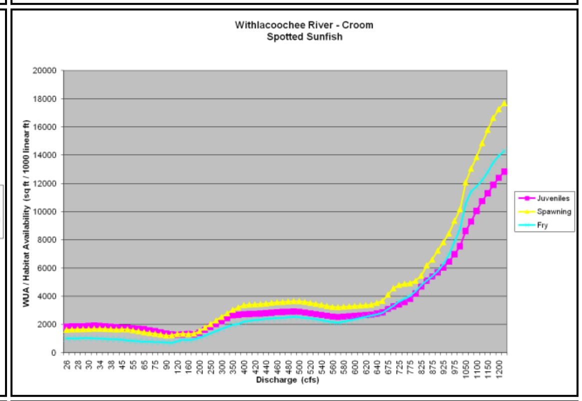
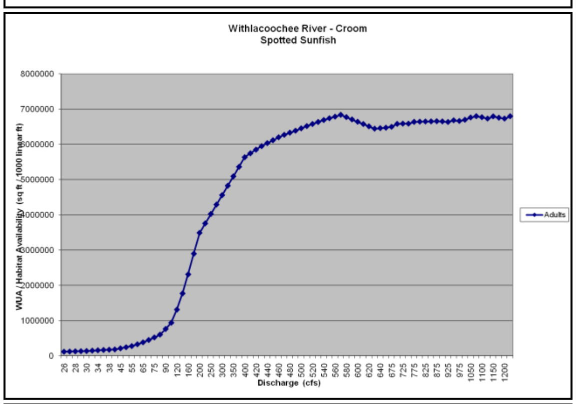
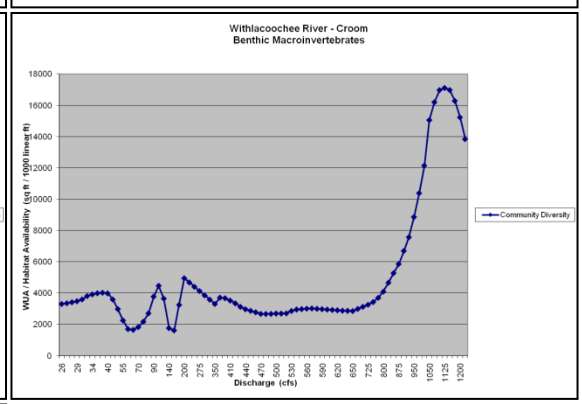


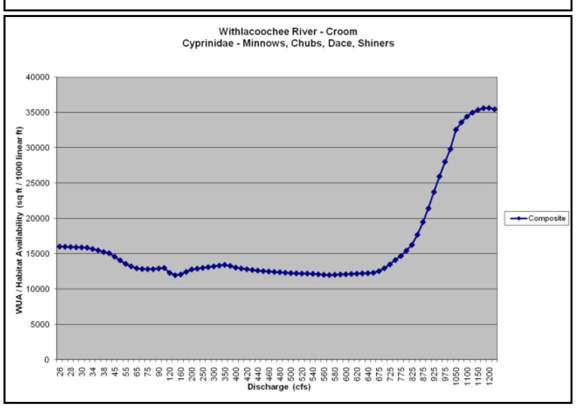




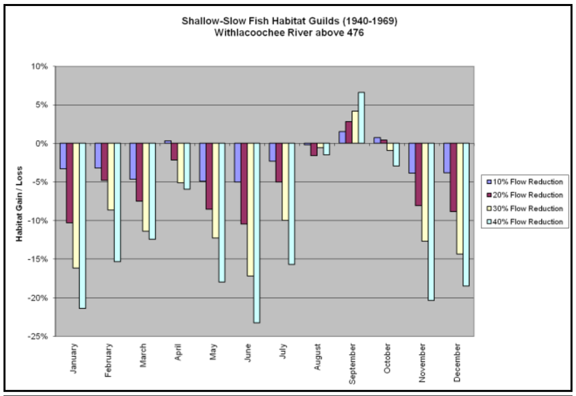








Withlacoochee River above 476


Shallow-Slow Fish Habitat Guilds (1940-1969)
Withlacoochee River above 476
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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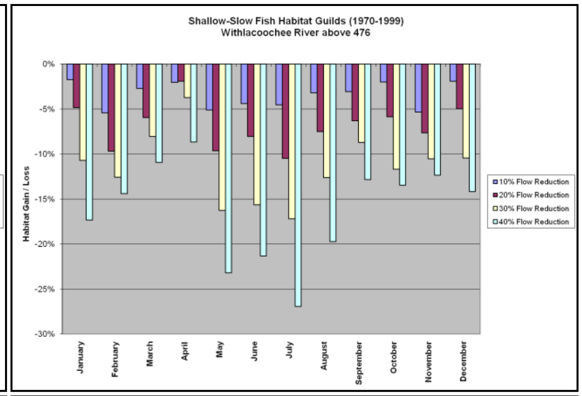
Shallow-Slow Fish Habitat Guilds (1970-1999)
Withlacoochee River above 476
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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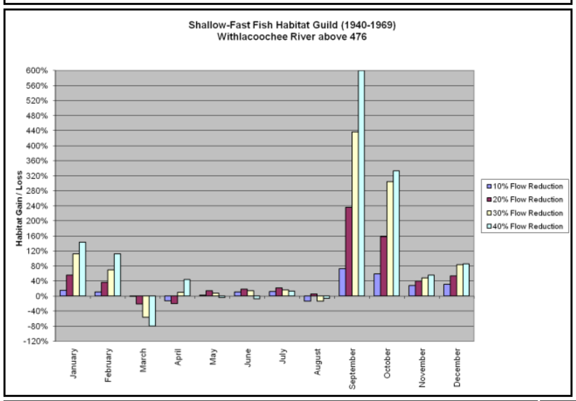
Shallow-Fast Fish Habitat Guild (1940-1969)
Withlacoochee River above 476
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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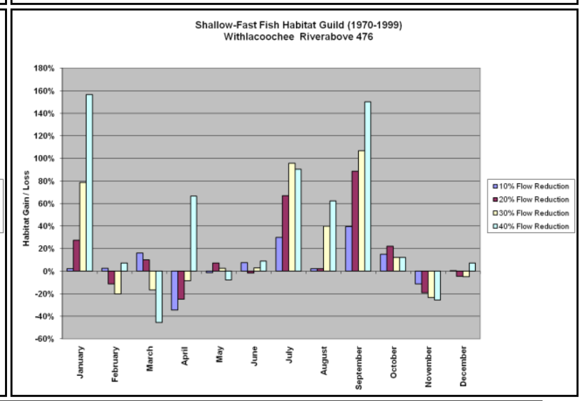
Shallow-Fast Fish Habitat Guild (1970-1999)
Withlacoochee Riverabove 476
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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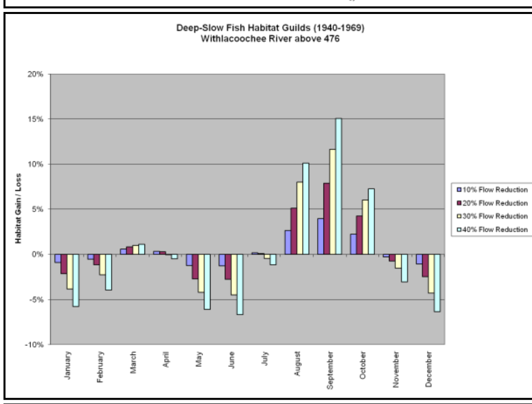
Deep-Slow Fish Habitat Guilds (1940-1969)
Withlacoochee River above 476
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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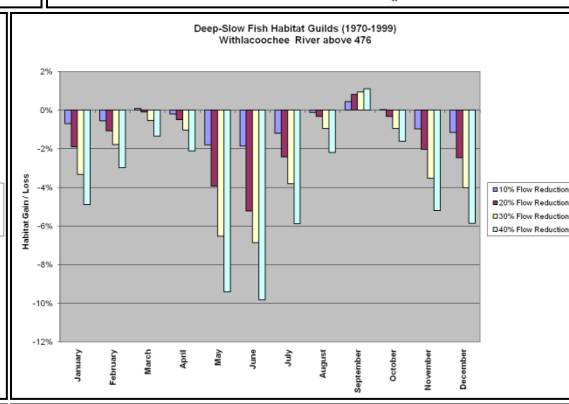
Deep-Slow Fish Habitat Guilds (1970-1999)
Withlacoochee River above 476
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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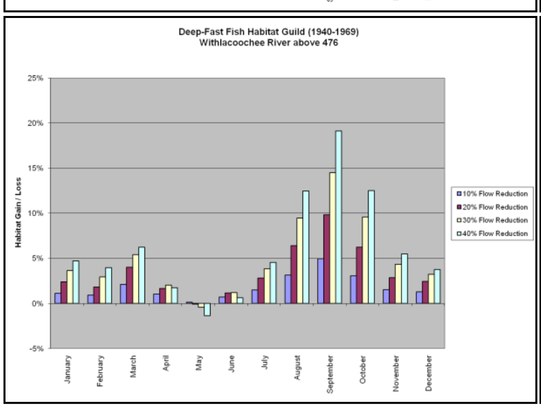
Deep-Fast Fish Habitat Guild (1940-1969)
Withlacoochee River above 476
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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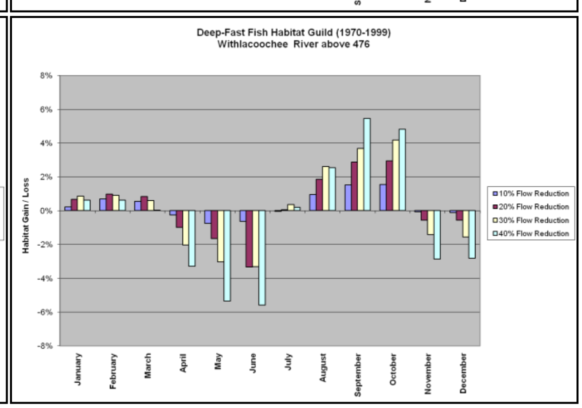
Deep-Fast Fish Habitat Guild (1970-1999)
Withlacoochee River above 476
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
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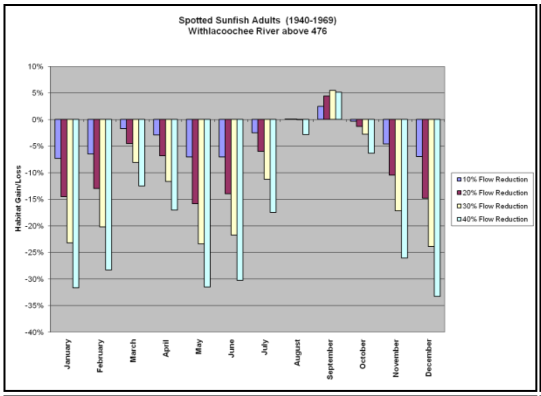
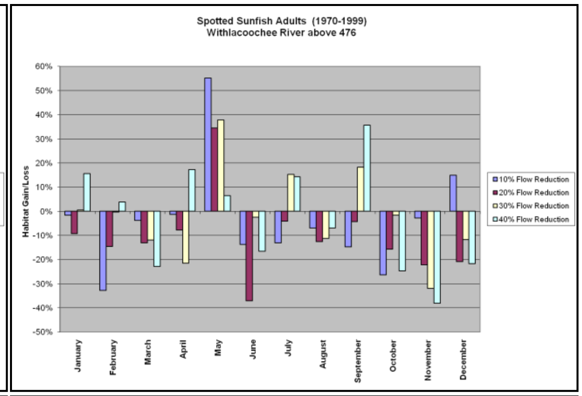
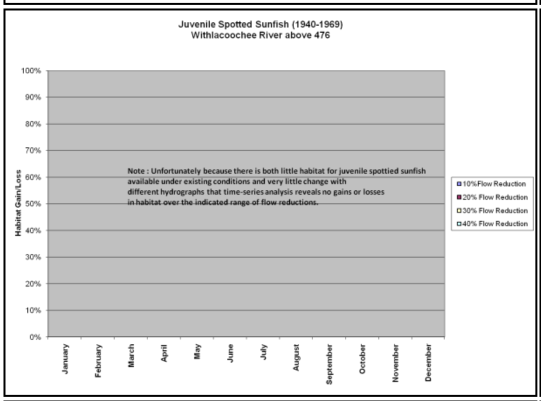
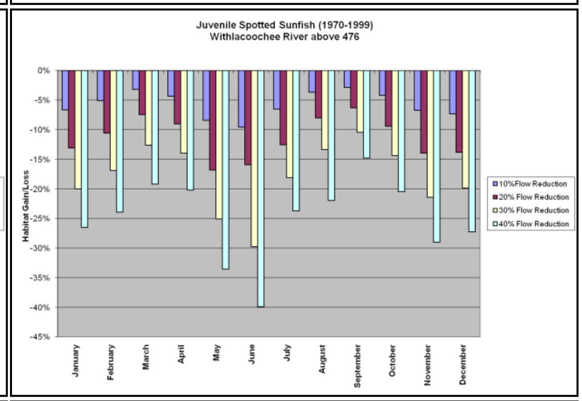
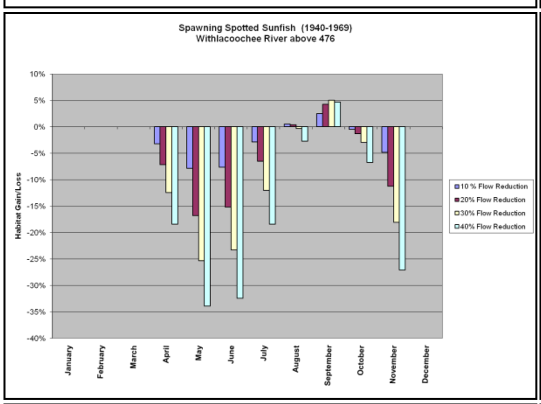
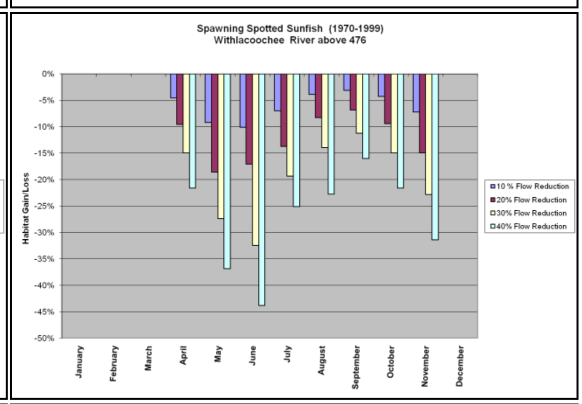

Spotted Sunfish Adults (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spotted Sunfish Adults (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Juvenile Spotted Sunfish (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
Note : Unfortunately because there is both little habitat for juvenile spotted sunfish available under existing conditions and very little change with different hydrographs that time-series analysis reveals no gains or losses in habitat over the indicated range of flow reductions.
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Juvenile Spotted Sunfish (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spawning Spotted Sunfish (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Spawning Spotted Sunfish (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
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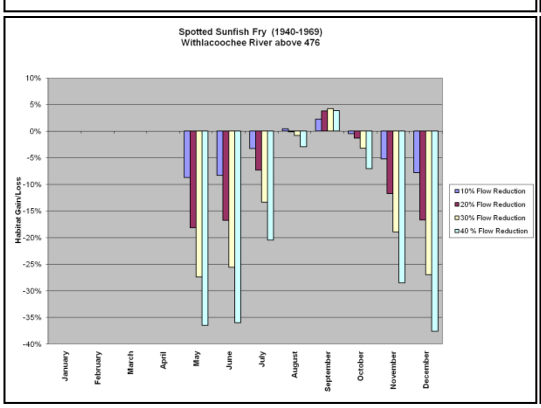
Spotted Sunfish Fry (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
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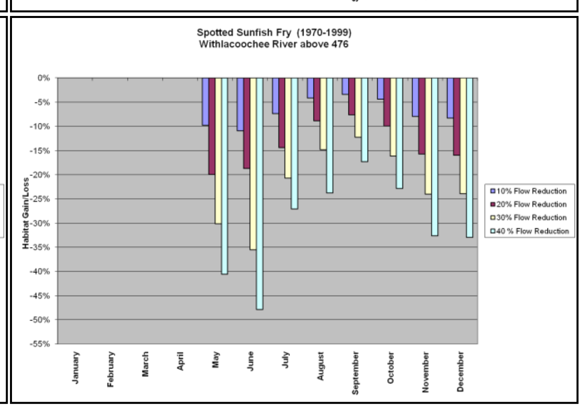
40 % Flow Reduction


Spotted Sunfish Fry (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
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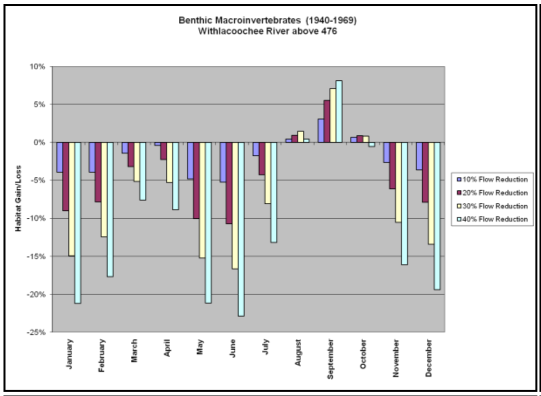
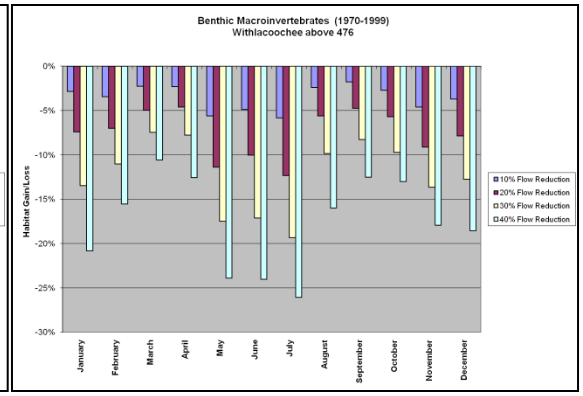
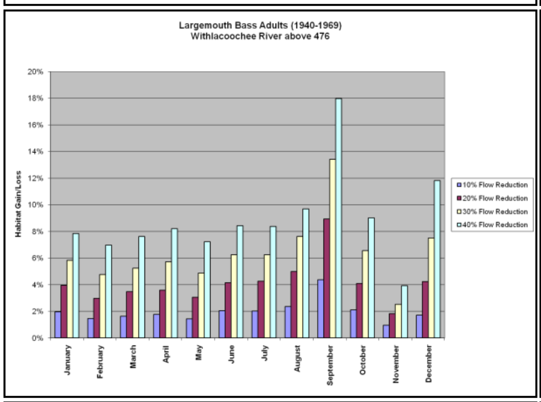
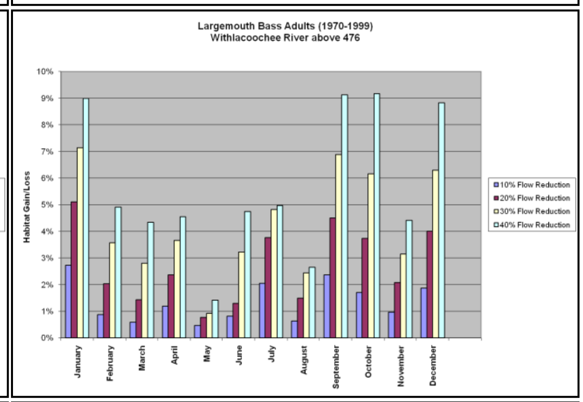
40 % Flow Reduction


Benthic Macroinvertebrates (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January February March April May June July August September October November December


Benthic Macroinvertebrates (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January February March April May June July August September October November December


Largemouth Bass Adults (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January February March April May June July August September October November December


Largemouth Bass Adults (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
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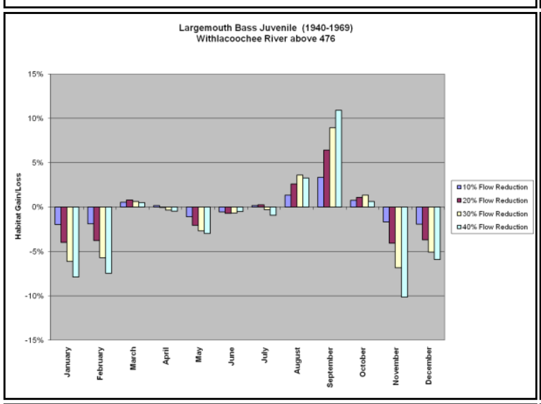
Largemouth Bass Juvenile (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
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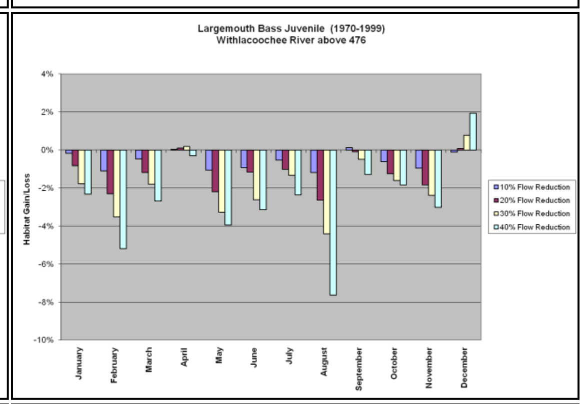
Largemouth Bass Juvenile (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
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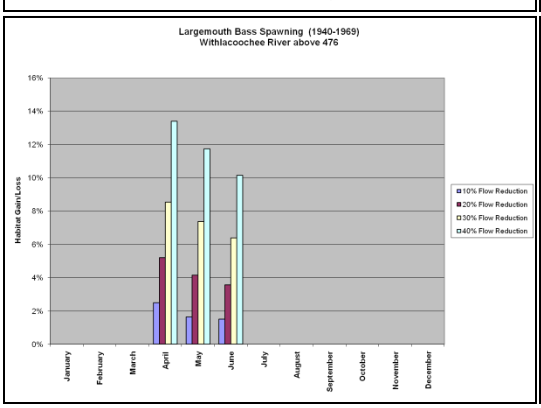
Largemouth Bass Spawning (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
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40% Flow Reduction
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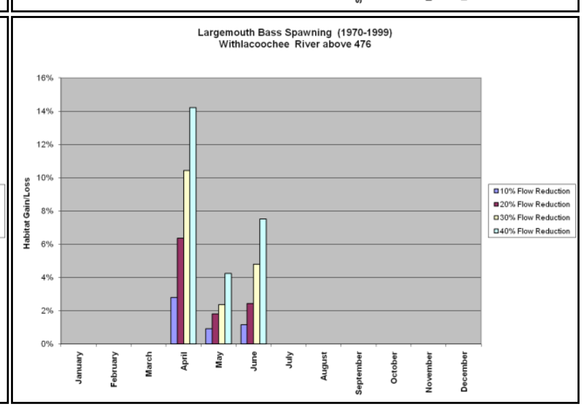
Largemouth Bass Spawning (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
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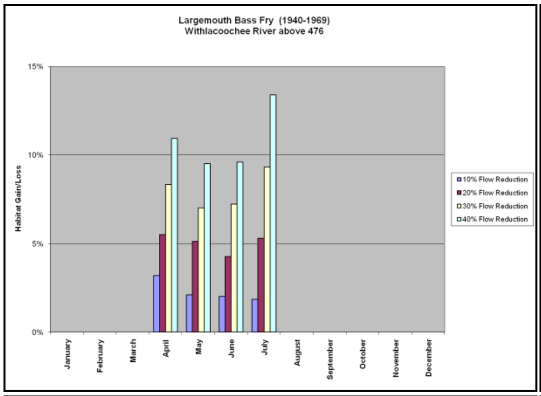
Largemouth Bass Fry (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
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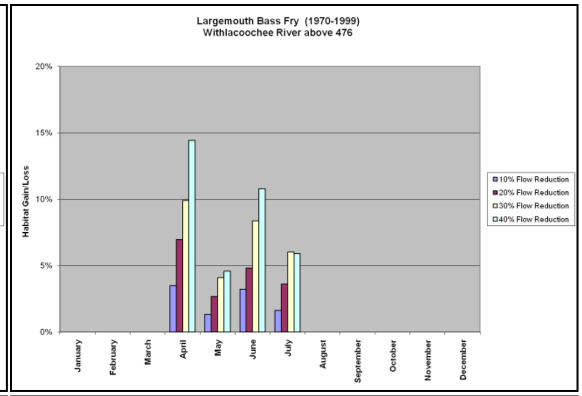
Largemouth Bass Fry (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
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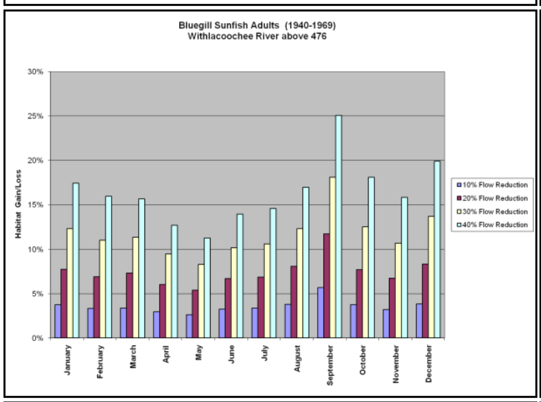
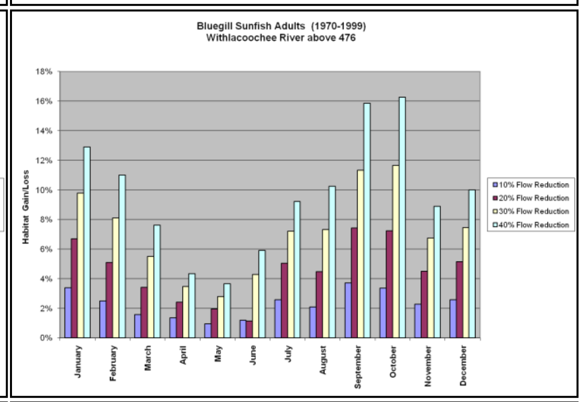
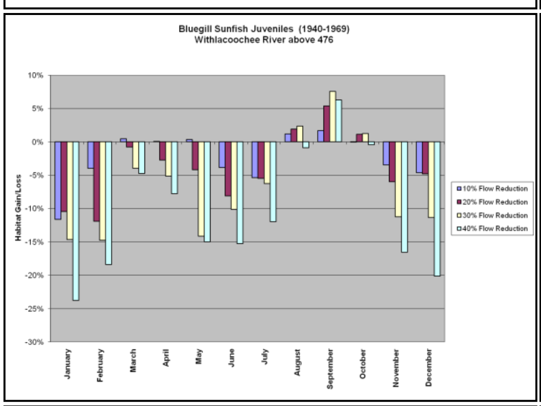
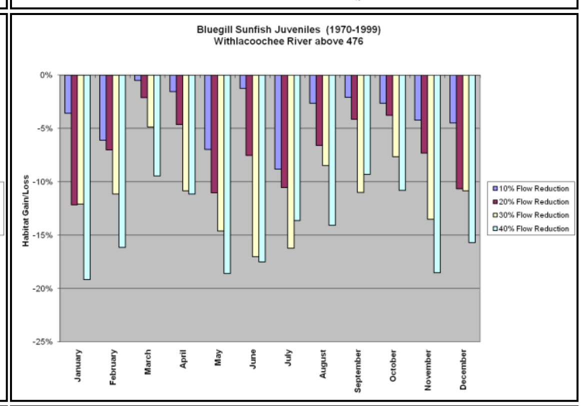
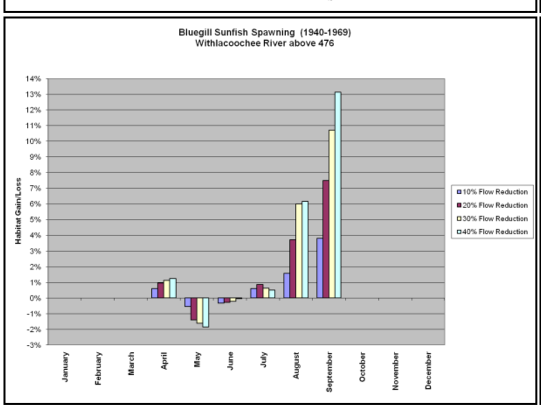
30% Flow Reduction
40% Flow Reduction

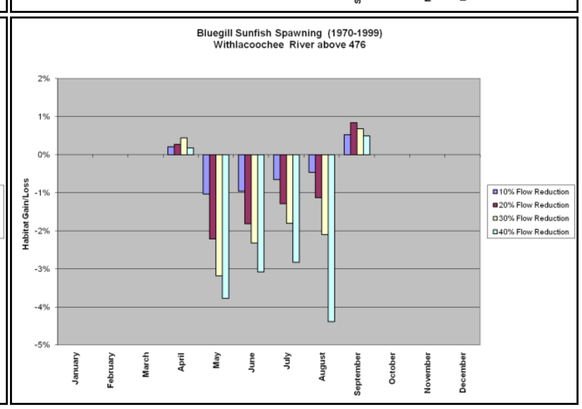

Bluegill Sunfish Adults (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

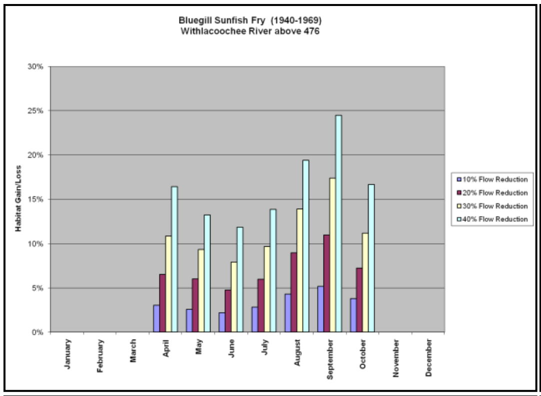

Bluegill Sunfish Adults (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

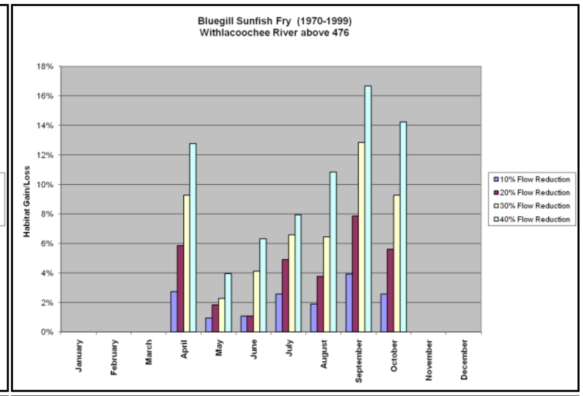

Bluegill Sunfish Juveniles (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

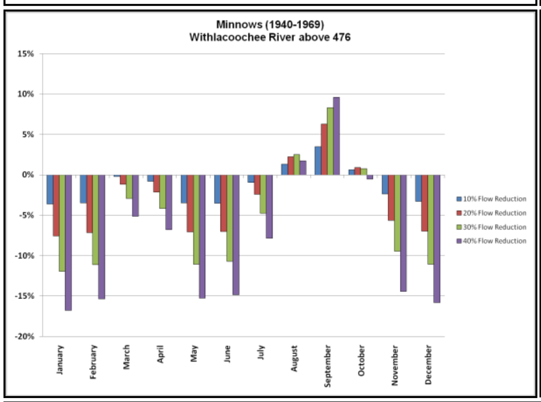

Bluegill Sunfish Juveniles (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

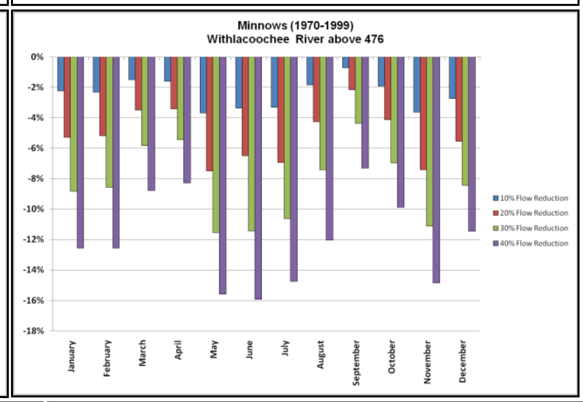

Bluegill Sunfish Spawning (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

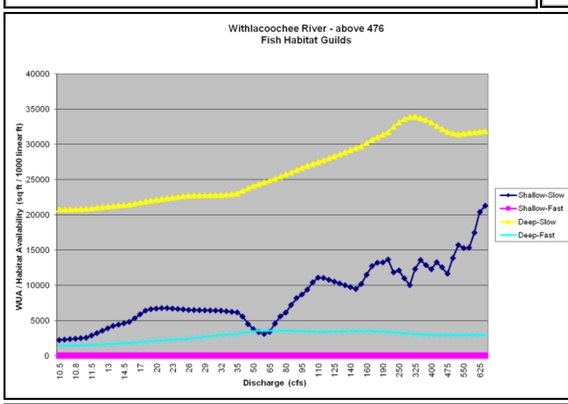

Bluegill Sunfish Spawning (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

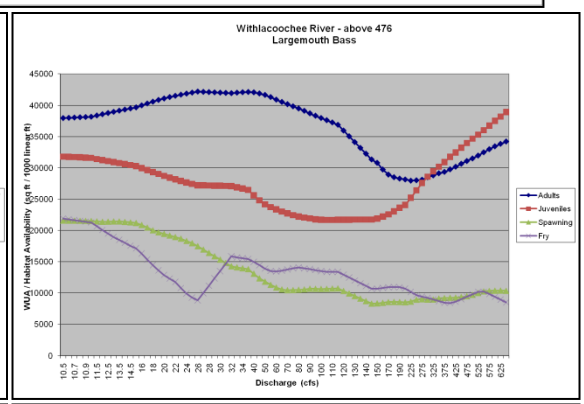

Bluegill Sunfish Fry (1940-1969)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
February
March
April
May
June
July
August
September
October
November
December

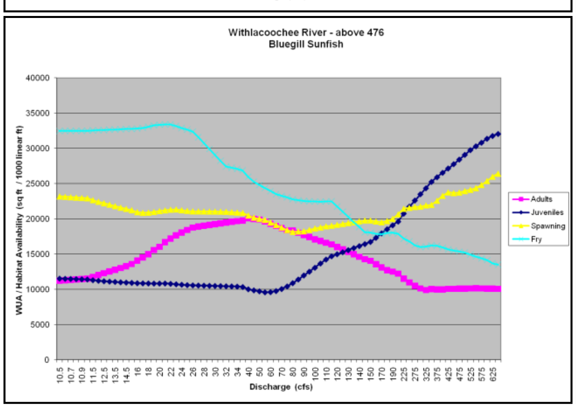

Bluegill Sunfish Fry (1970-1999)
Withlacoochee River above 476
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
February
March
April
May
June
July
August
September
October
November
December

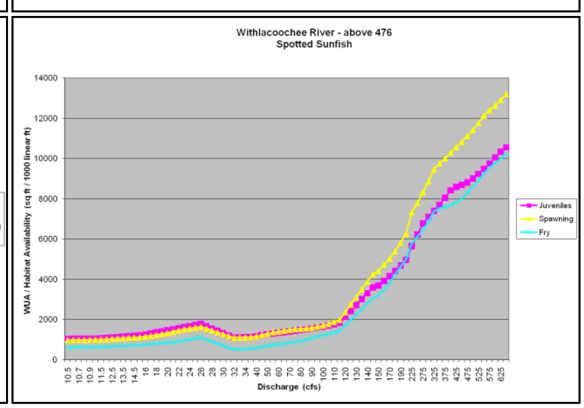

Minnows (1940-1969)
Withlacoochee River above 476
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
February
March
April
May
June
July
August
September
October
November
December

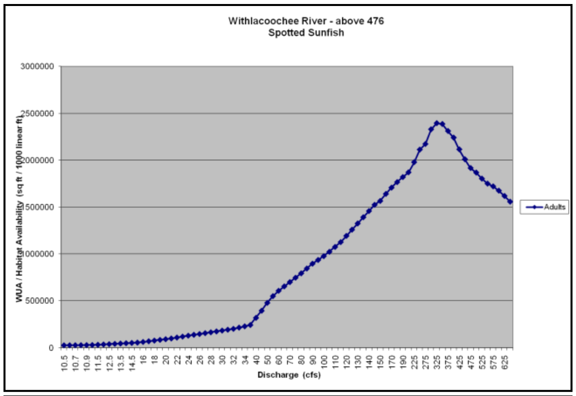

Minnows (1970-1999)
Withlacoochee River above 476
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction
January
February
March
April
May
June
July
August
September
October
November
December

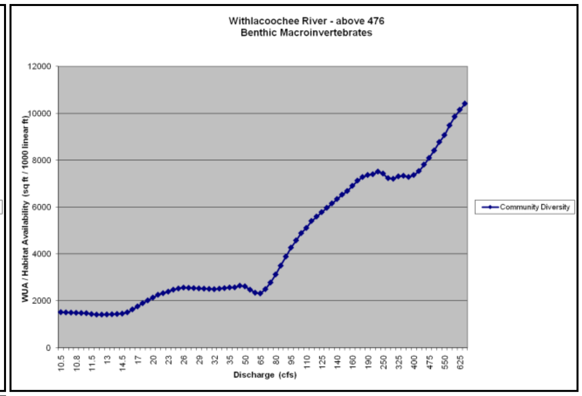

Withlacoochee River - above 476
Fish Habitat Guilds
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast

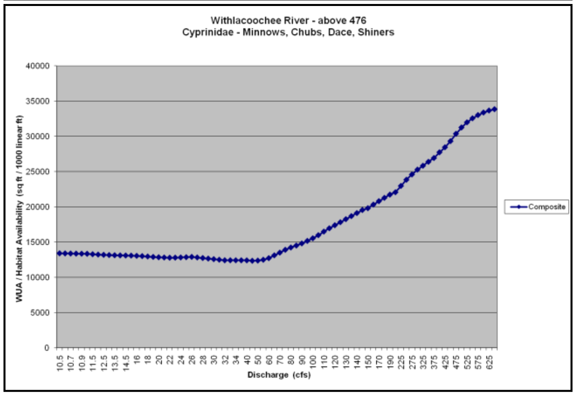

Withlacoochee River - above 476
Largemouth Bass
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults
Juveniles
Spawning
Fry


Withlacoochee River - above 476
Bluegill Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults
Juveniles
Spawning
Fry

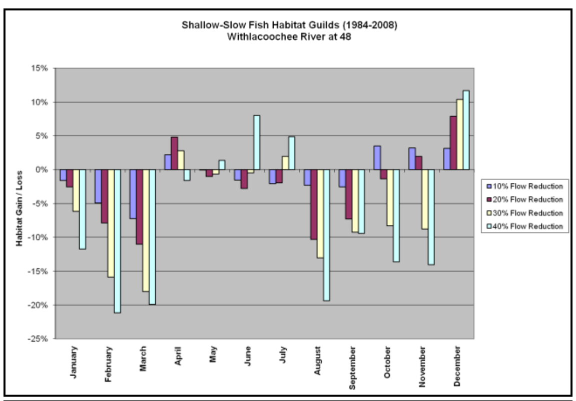

Withlacoochee River - above 476
Spotted Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Juveniles
Spawning
Fry

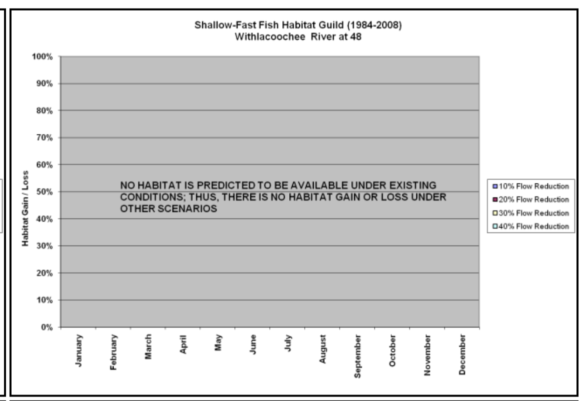


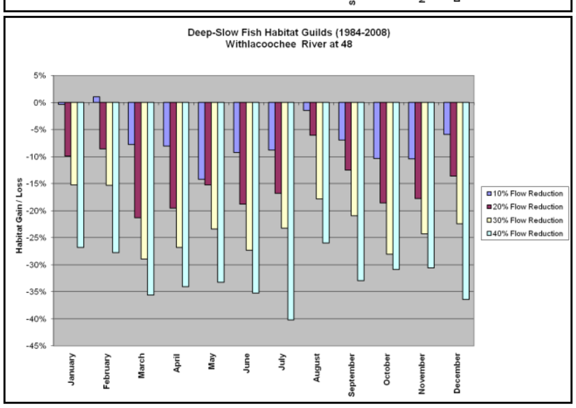


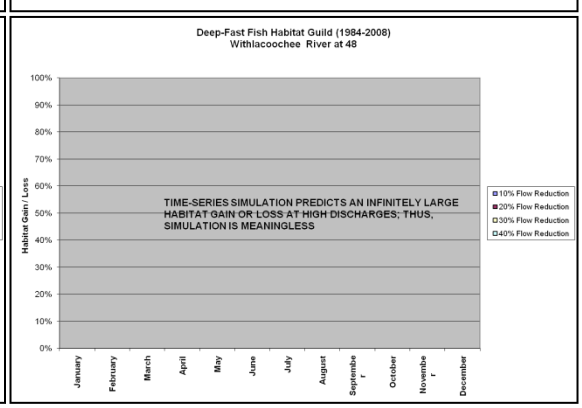


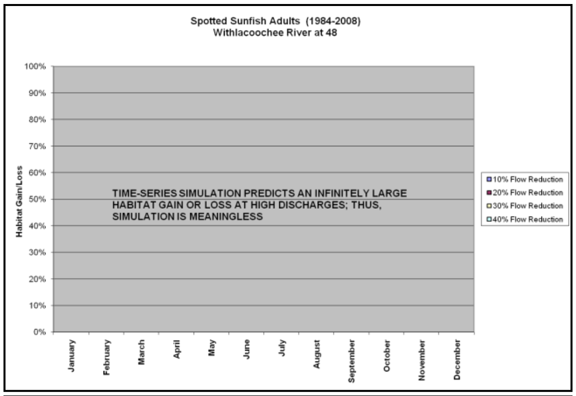
Withlacoochee River above 48

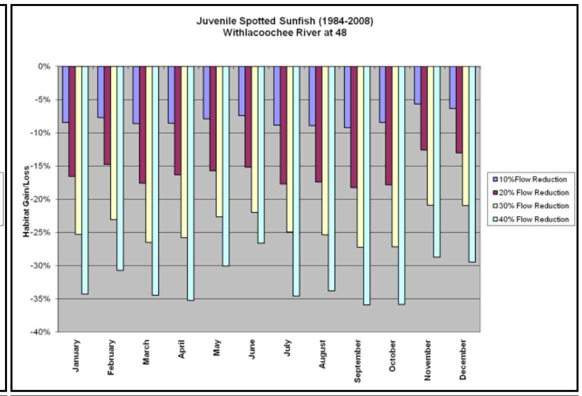


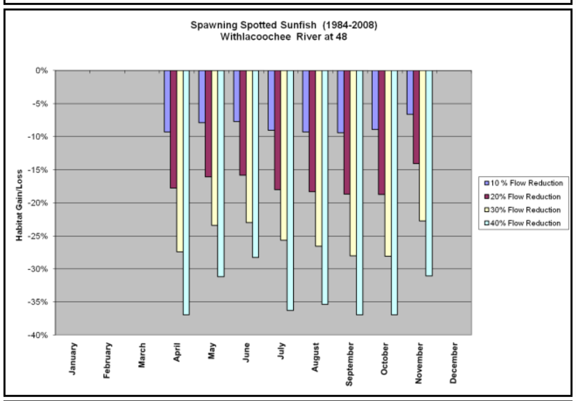


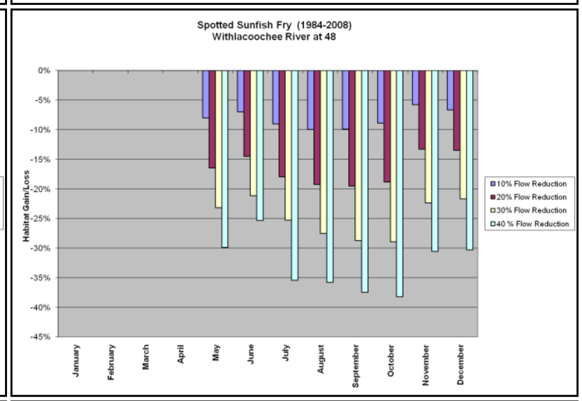


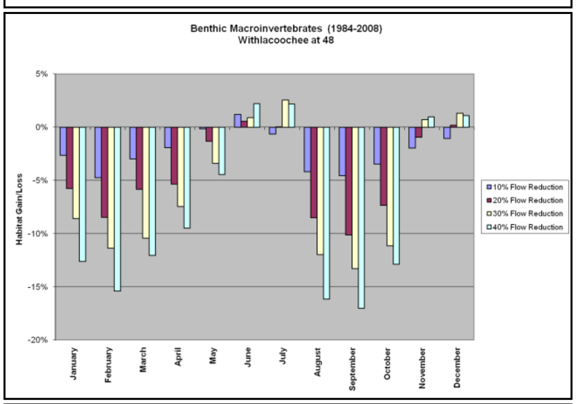


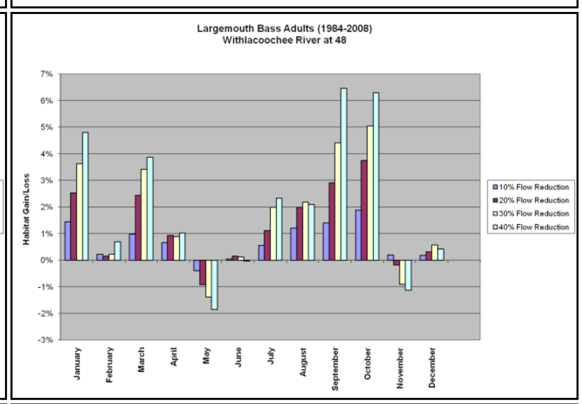

Spotted Sunfish Adults (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
TIME-SERIES SIMULATION PREDICTS AN INFINITELY LARGE HABITAT GAIN OR LOSS AT HIGH DISCHARGES; THUS, SIMULATION IS MEANINGLESS
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

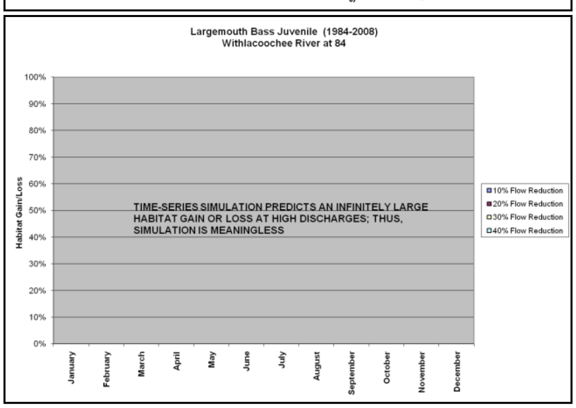

Juvenile Spotted Sunfish (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

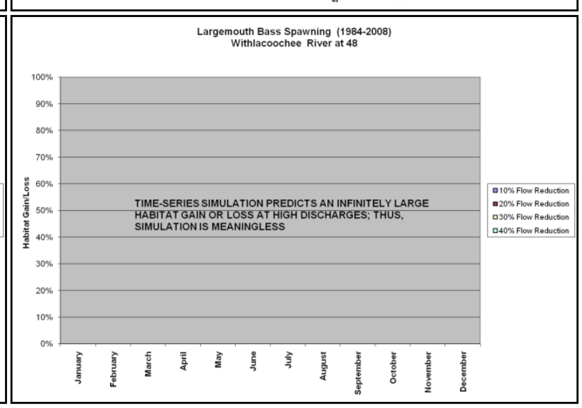

Spawning Spotted Sunfish (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

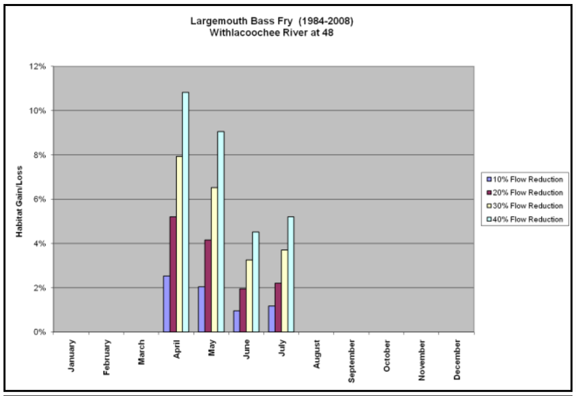

Spotted Sunfish Fry (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40 % Flow Reduction

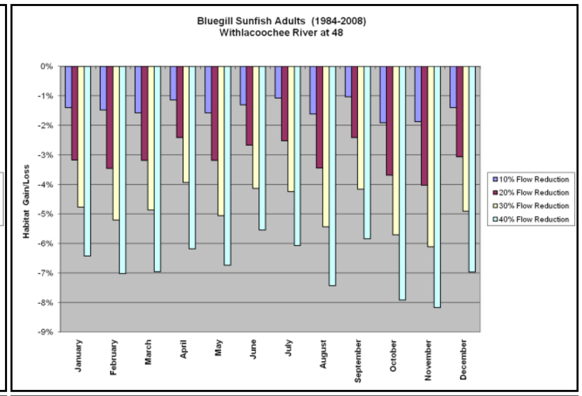

Benthic Macroinvertebrates (1984-2008)
Withlacoochee at 48
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

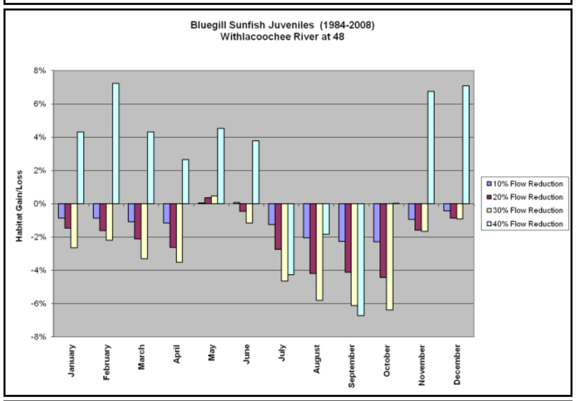

Largemouth Bass Adults (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

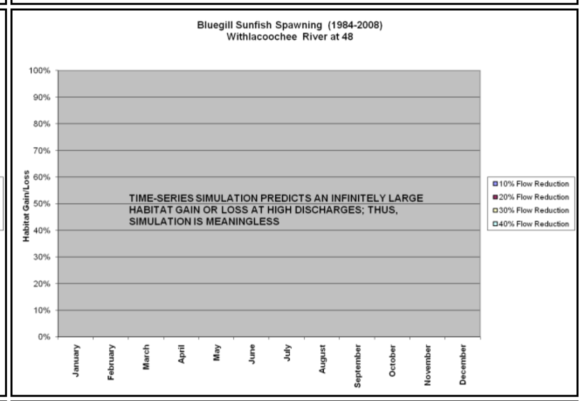

Largemouth Bass Juvenile (1984-2008)
Withlacoochee River at 84
Habitat Gain/Loss
TIME-SERIES SIMULATION PREDICTS AN INFINITELY LARGE HABITAT GAIN OR LOSS AT HIGH DISCHARGES; THUS, SIMULATION IS MEANINGLESS
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

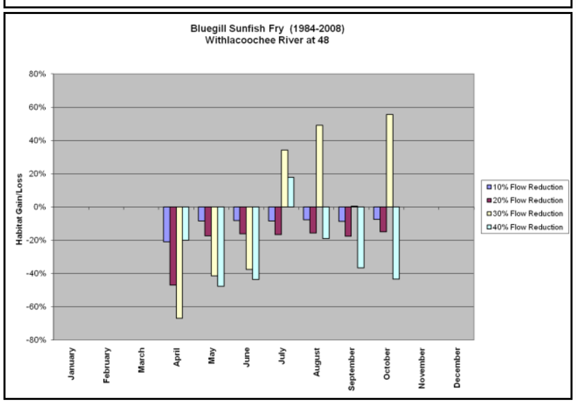

Largemouth Bass Spawning (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
TIME-SERIES SIMULATION PREDICTS AN INFINITELY LARGE HABITAT GAIN OR LOSS AT HIGH DISCHARGES; THUS, SIMULATION IS MEANINGLESS
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

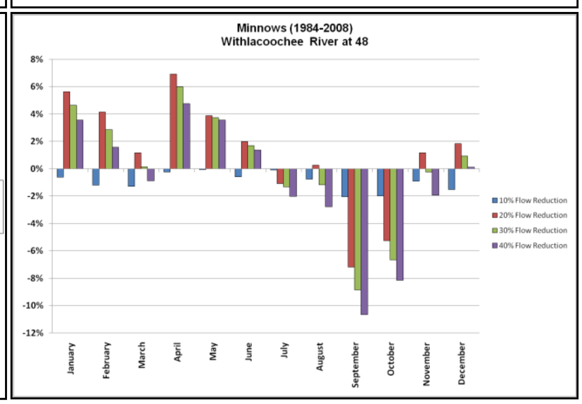

Largemouth Bass Fry (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

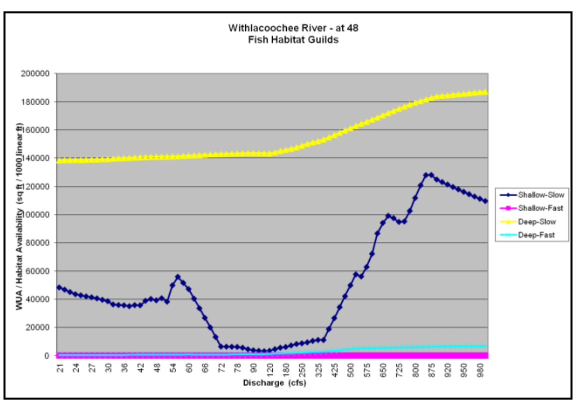

Bluegill Sunfish Adults (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

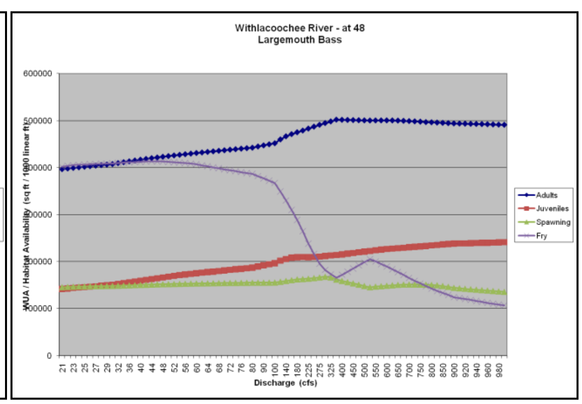

Bluegill Sunfish Juveniles (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

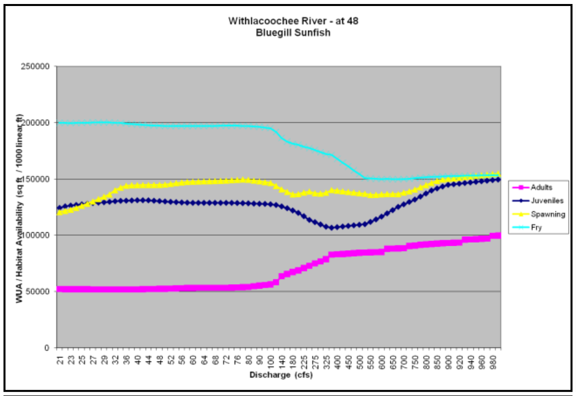

Bluegill Sunfish Spawning (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
TIME-SERIES SIMULATION PREDICTS AN INFINITELY LARGE HABITAT GAIN OR LOSS AT HIGH DISCHARGES; THUS, SIMULATION IS MEANINGLESS
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

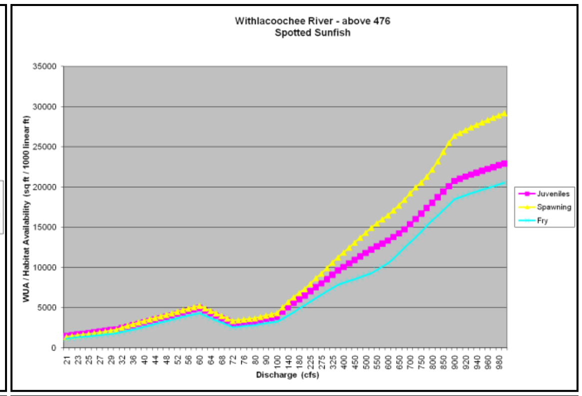

Bluegill Sunfish Fry (1984-2008)
Withlacoochee River at 48
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

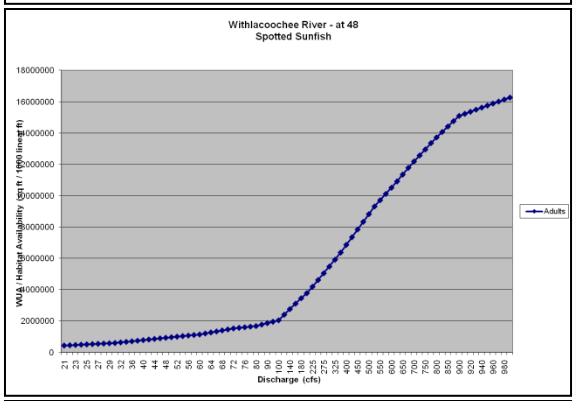

Minnows (1984-2008)
Withlacoochee River at 48
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

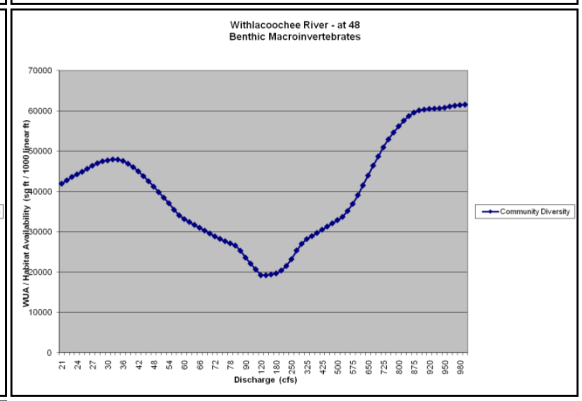

Withlacoochee River - at 48
Fish Habitat Guilds
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast

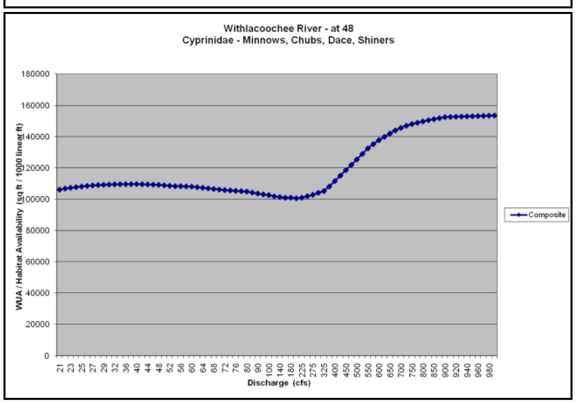

Withlacoochee River - at 48
Largemouth Bass
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults
Juveniles
Spawning
Fry



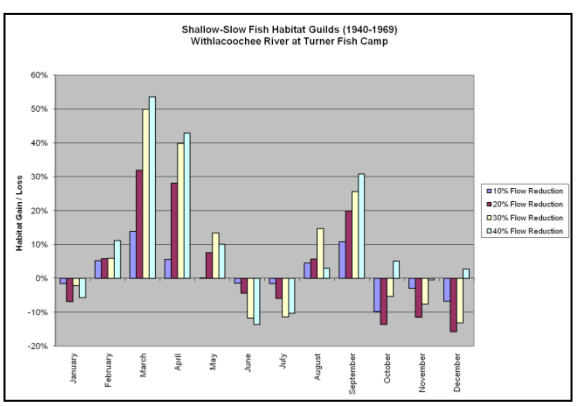


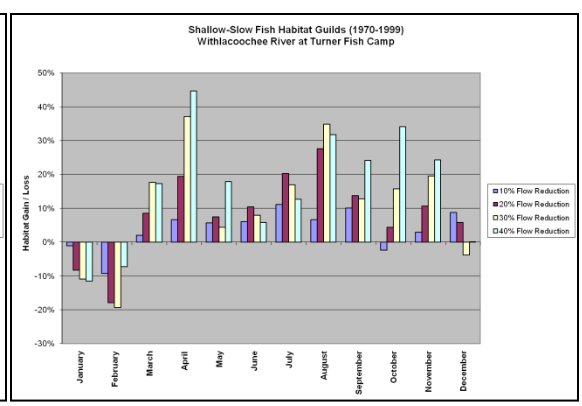


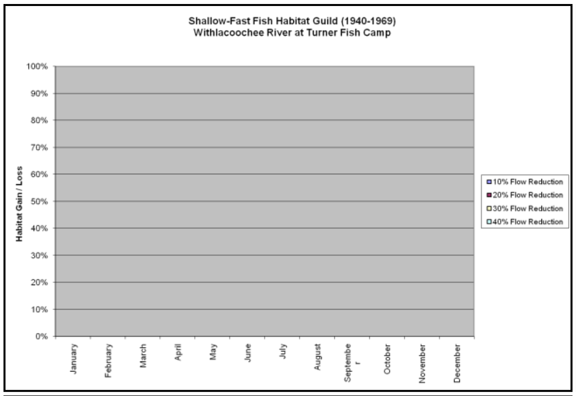


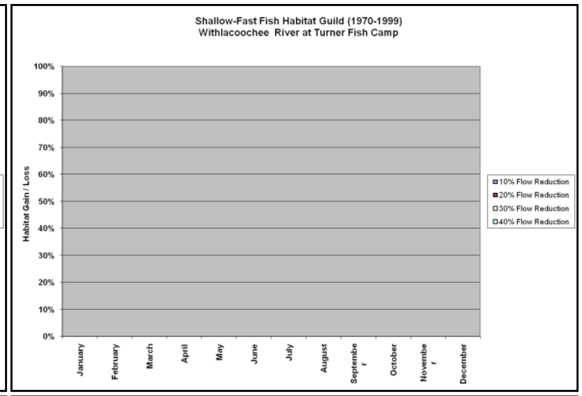


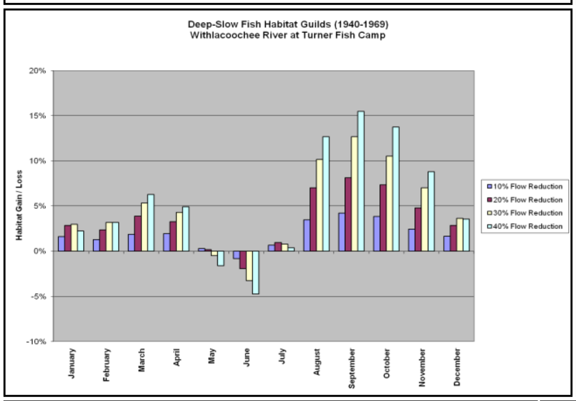
Withlacoochee River at Turner Camp

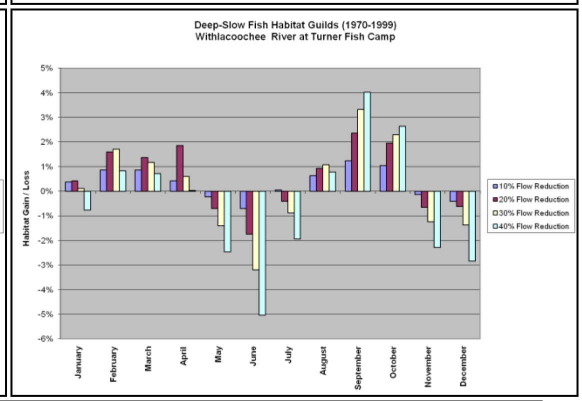


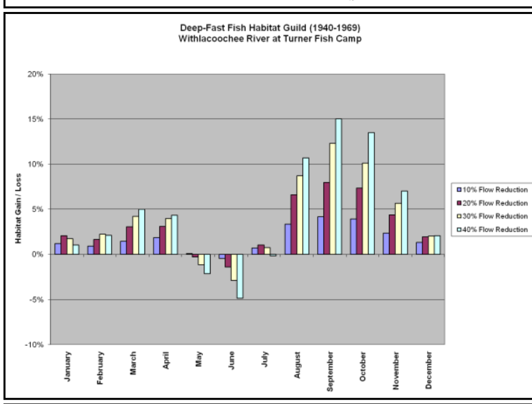


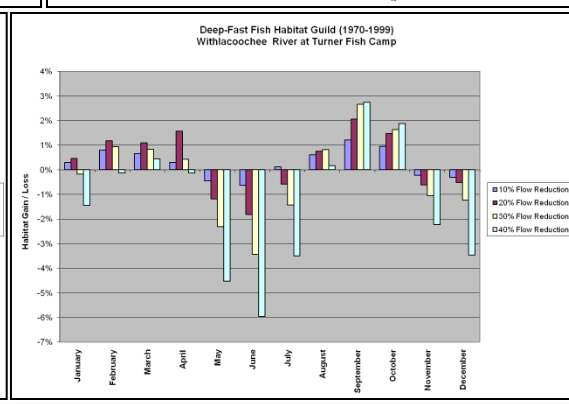

Shallow-Fast Fish Habitat Guild (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

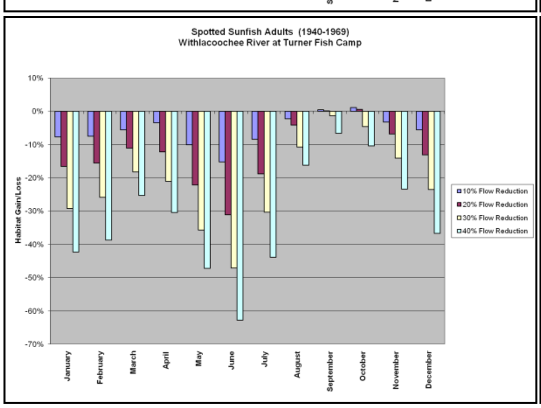

Shallow-Fast Fish Habitat Guild (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

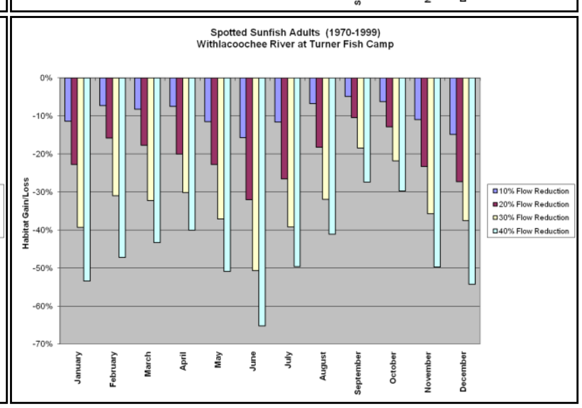

Deep-Slow Fish Habitat Guilds (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

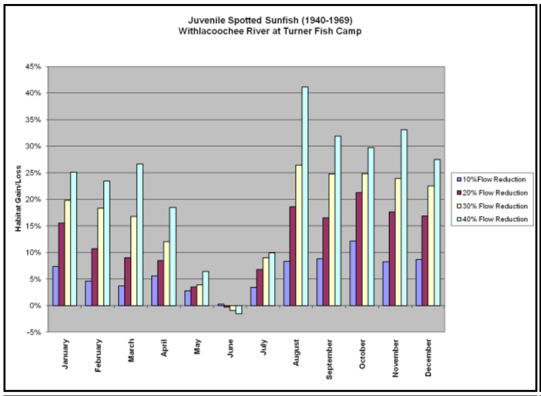

Deep-Slow Fish Habitat Guilds (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

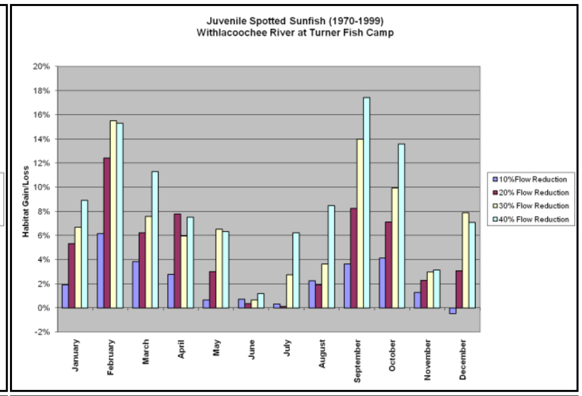

Deep-Fast Fish Habitat Guild (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

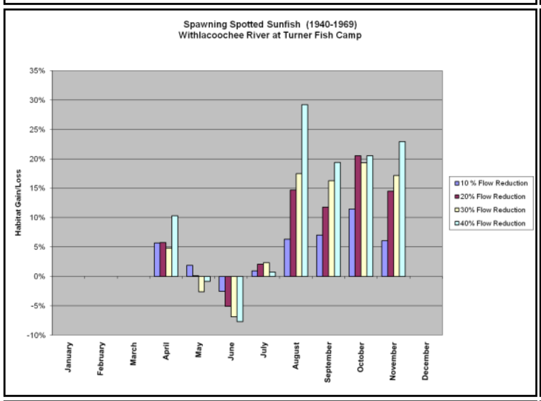

Deep-Fast Fish Habitat Guild (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

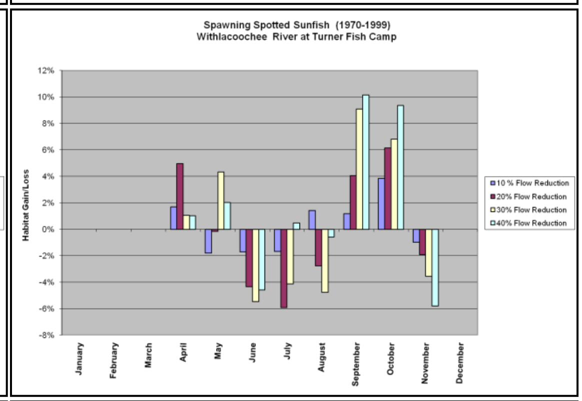

Spotted Sunfish Adults (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

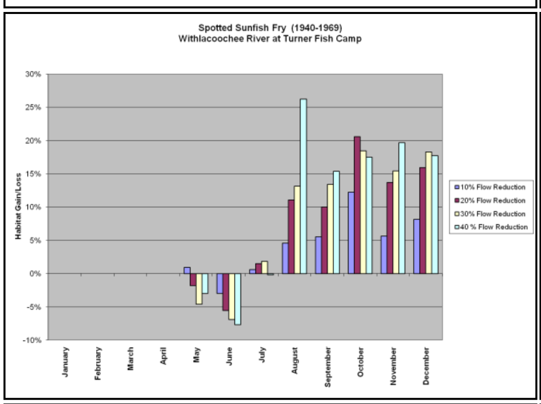

Spotted Sunfish Adults (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

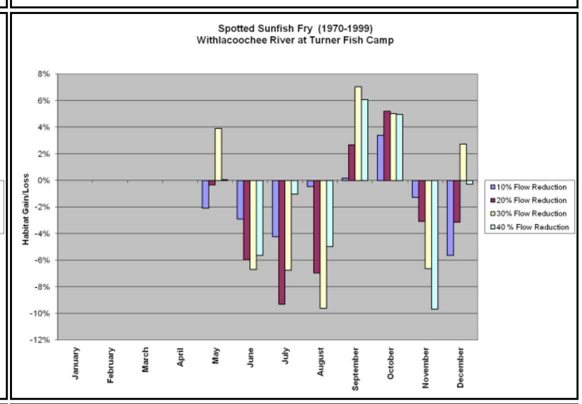

Juvenile Spotted Sunfish (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

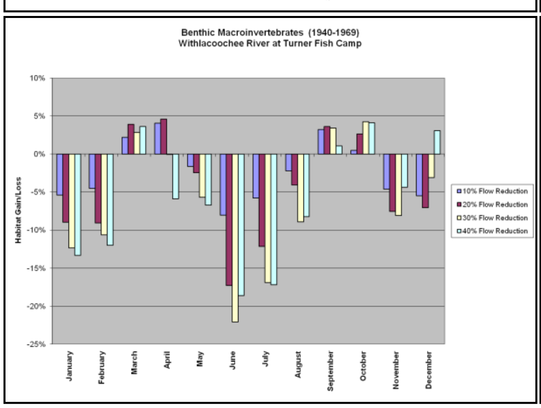

Juvenile Spotted Sunfish (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

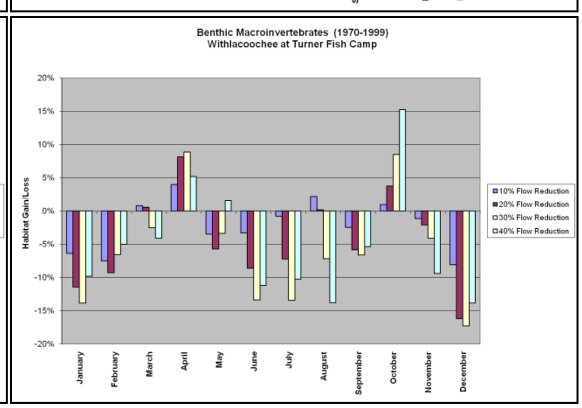

Spawning Spotted Sunfish (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

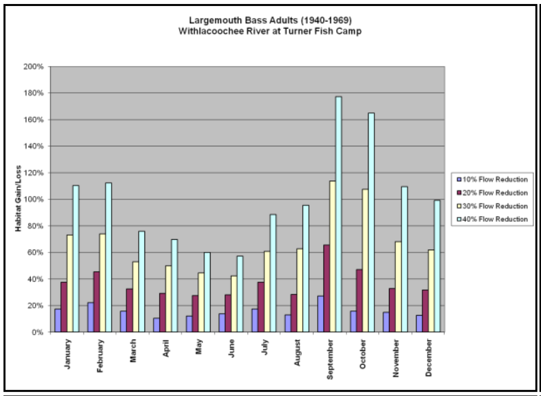

Spawning Spotted Sunfish (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

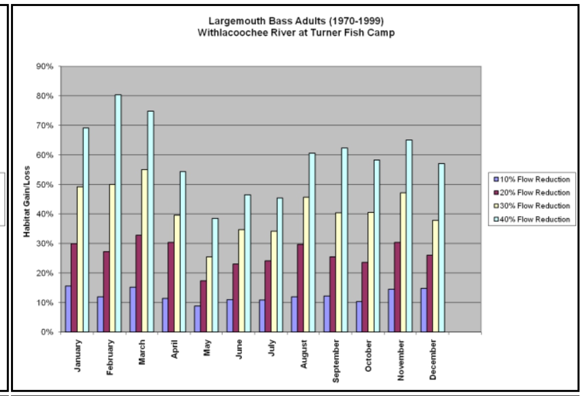

Spotted Sunfish Fry (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40 % Flow Reduction

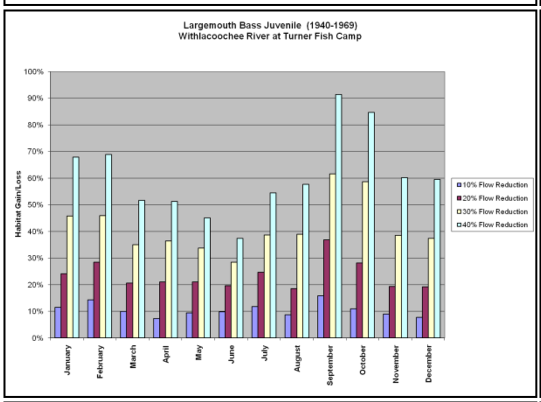

Spotted Sunfish Fry (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40 % Flow Reduction

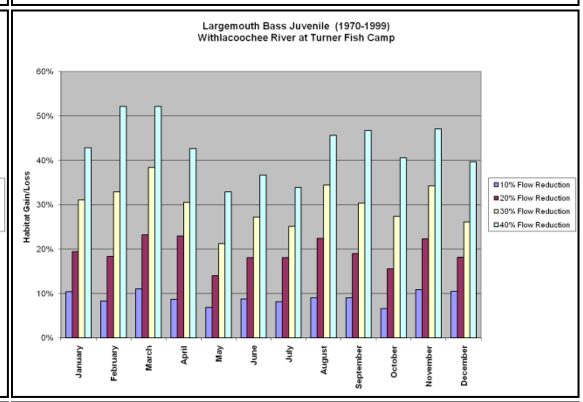

Benthic Macroinvertebrates (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

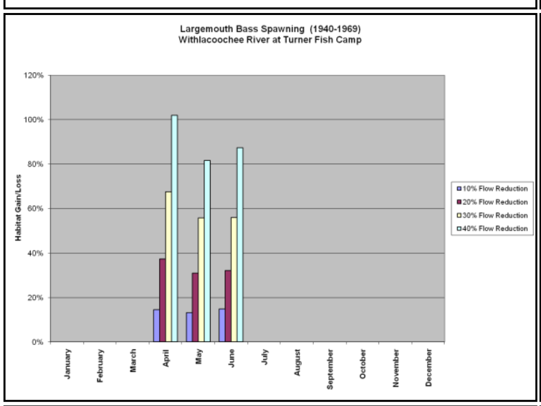

Benthic Macroinvertebrates (1970-1999)
Withlacoochee at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

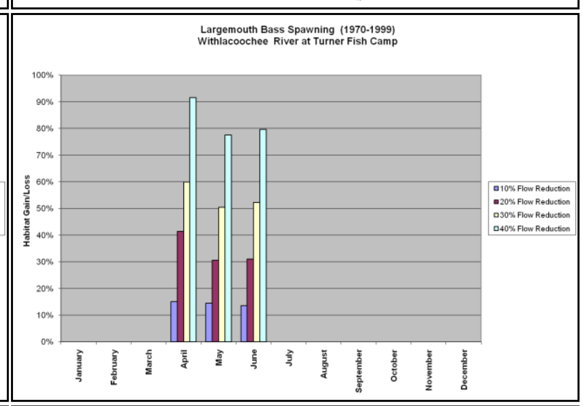

Largemouth Bass Adults (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
January February March April May June July August September October November December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

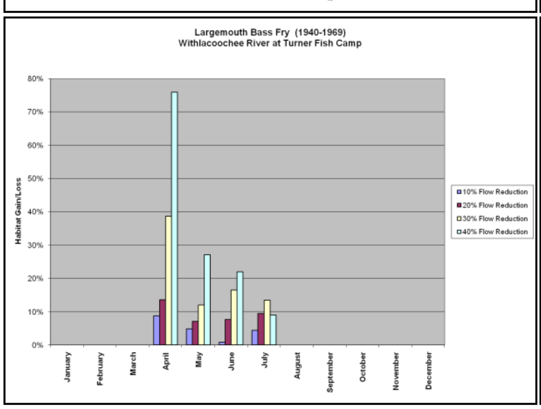

Largemouth Bass Adults (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
January February March April May June July August September October November December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

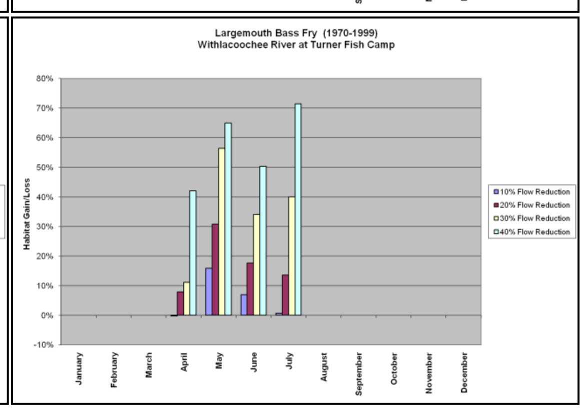

Largemouth Bass Juvenile (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
January February March April May June July August September October November December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

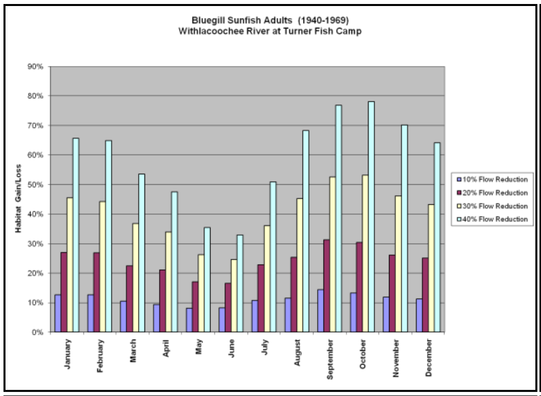

Largemouth Bass Juvenile (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
January February March April May June July August September October November December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

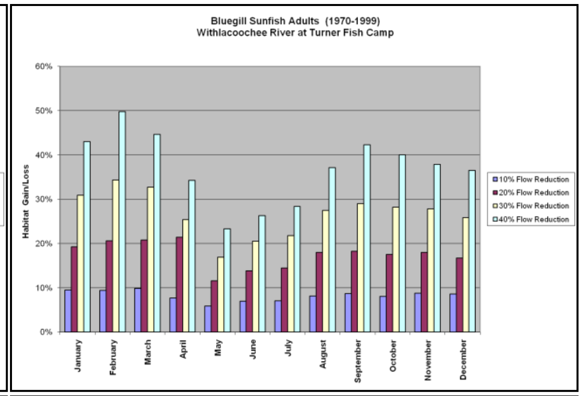

Largemouth Bass Spawning (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
January February March April May June July August September October November December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

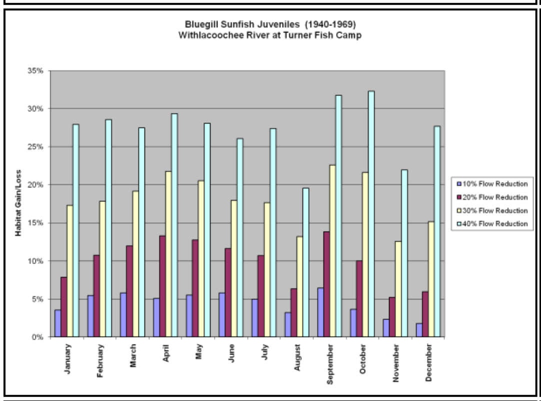

Largemouth Bass Spawning (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
January February March April May June July August September October November December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

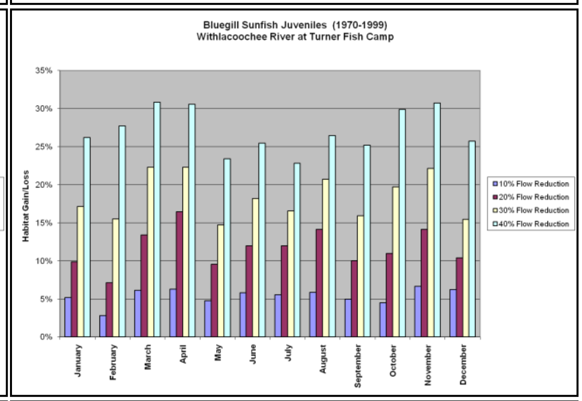

Largemouth Bass Fry (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
January February March April May June July August September October November December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

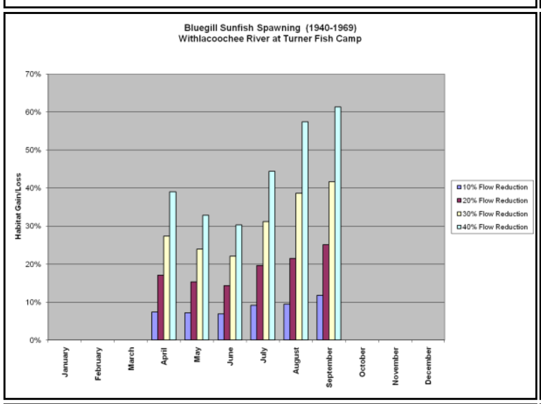

Largemouth Bass Fry (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
January February March April May June July August September October November December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

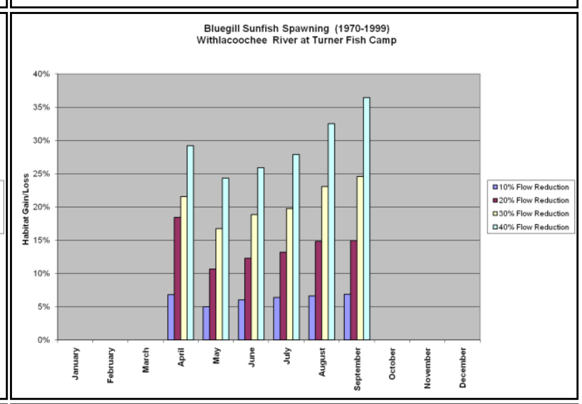

Bluegill Sunfish Adults (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

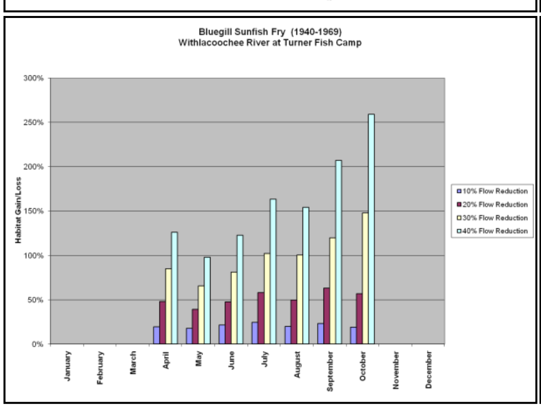

Bluegill Sunfish Adults (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

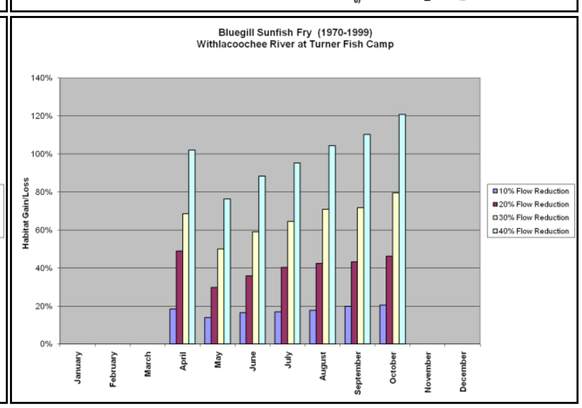

Bluegill Sunfish Juveniles (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

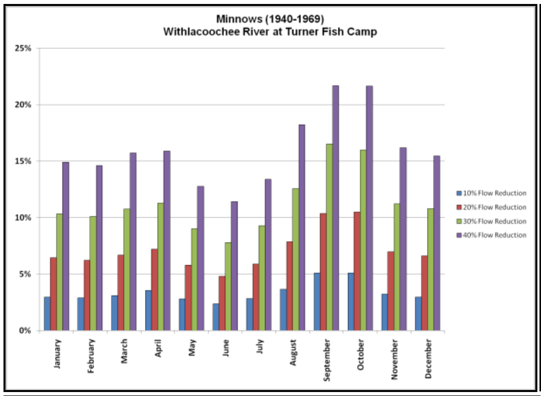

Bluegill Sunfish Juveniles (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

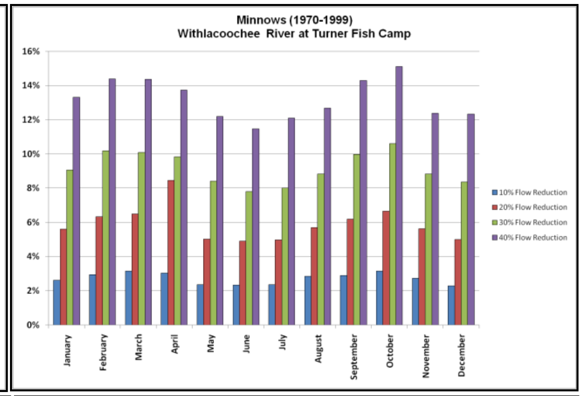

Bluegill Sunfish Spawning (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

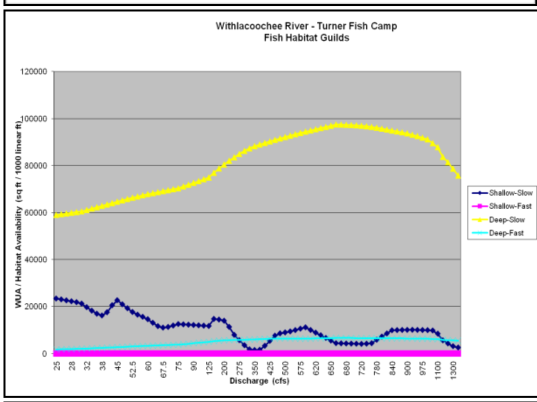

Bluegill Sunfish Spawning (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

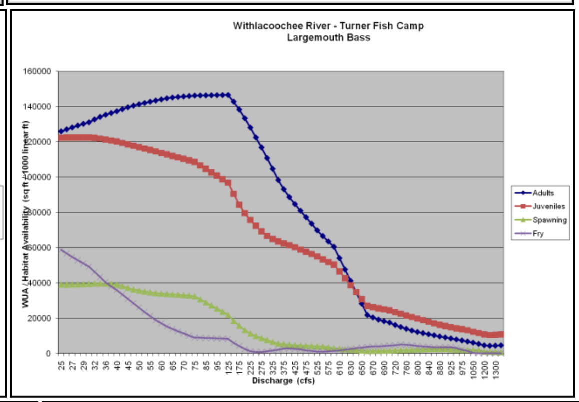

Bluegill Sunfish Fry (1940-1969)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

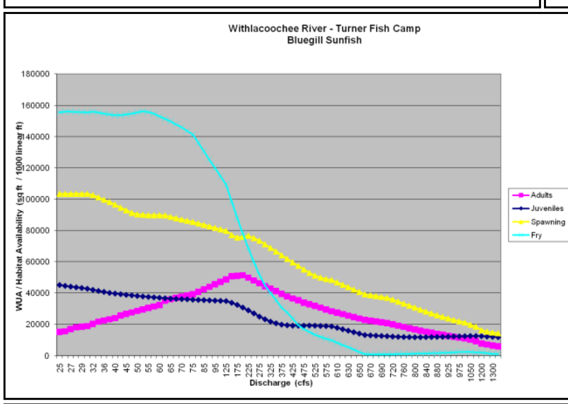

Bluegill Sunfish Fry (1970-1999)
Withlacoochee River at Turner Fish Camp
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

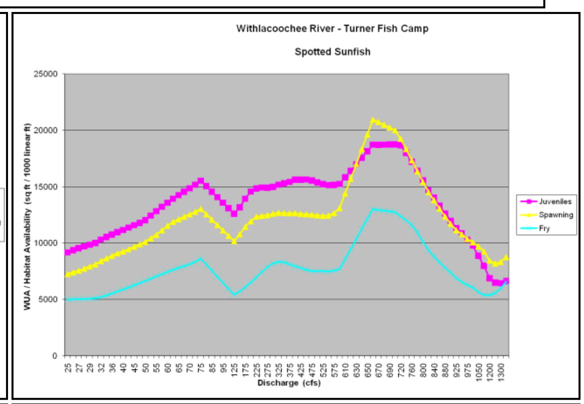

Minnows (1940-1969)
Withlacoochee River at Turner Fish Camp
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

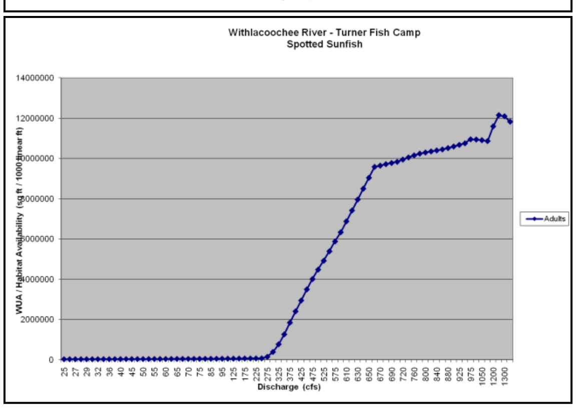

Minnows (1970-1999)
Withlacoochee River at Turner Fish Camp
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

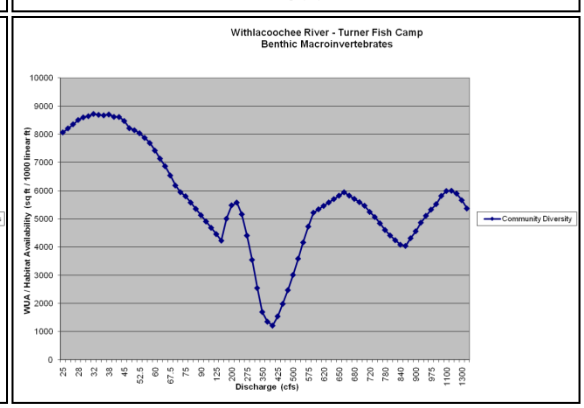

Withlacoochee River - Turner Fish Camp
Fish Habitat Guilds
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast

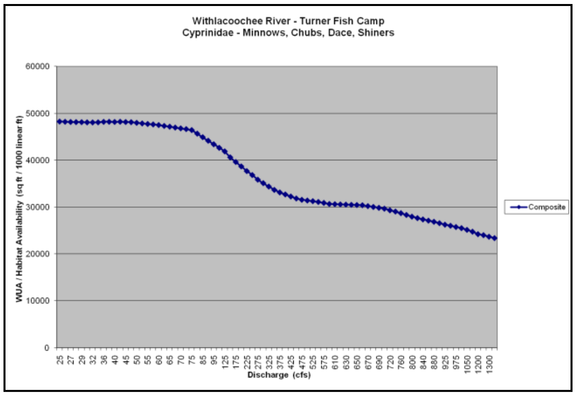

Withlacoochee River - Turner Fish Camp
Largemouth Bass
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults
Juveniles
Spawning
Fry


Withlacoochee River - Turner Fish Camp
Bluegill Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults
Juveniles
Spawning
Fry

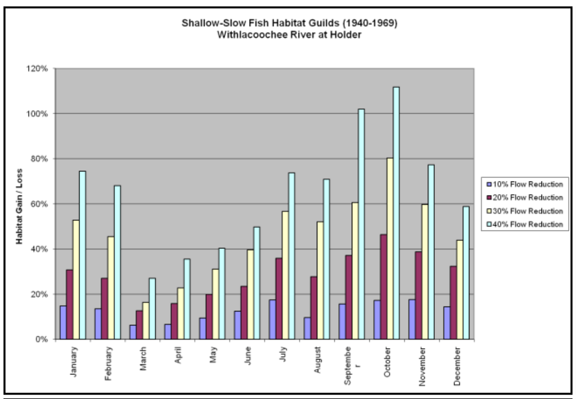

Withlacoochee River - Turner Fish Camp
Spotted Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Juveniles
Spawning
Fry

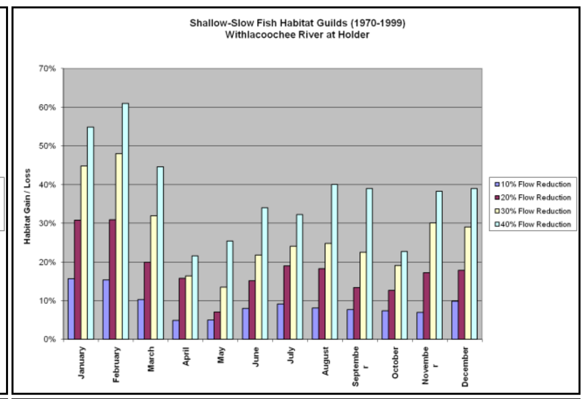

Withlacoochee River - Turner Fish Camp
Spotted Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults

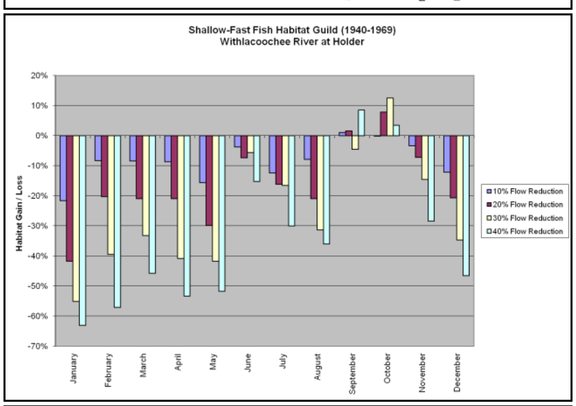

Withlacoochee River - Turner Fish Camp
Benthic Macroinvertebrates
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Community Diversity

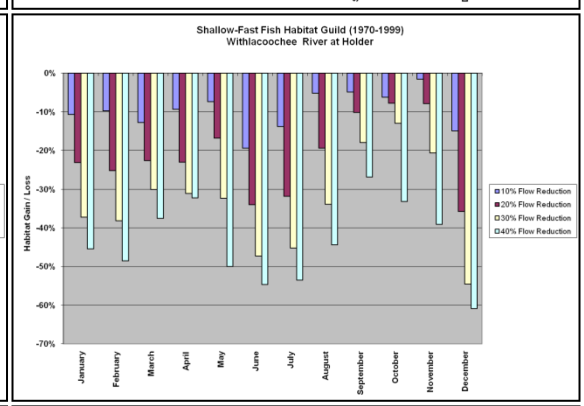


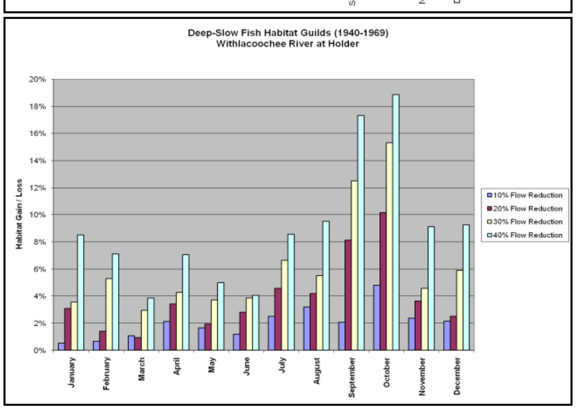
Withlacoochee River near Holder (near 200)

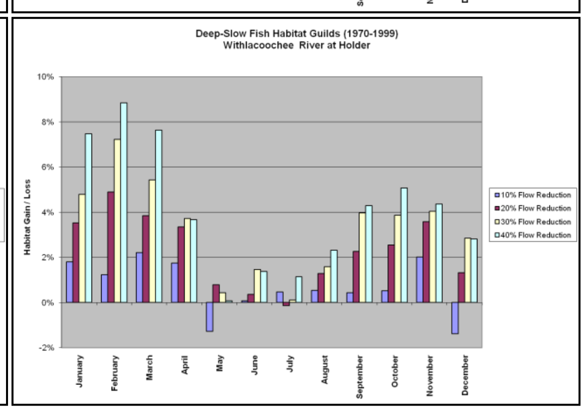


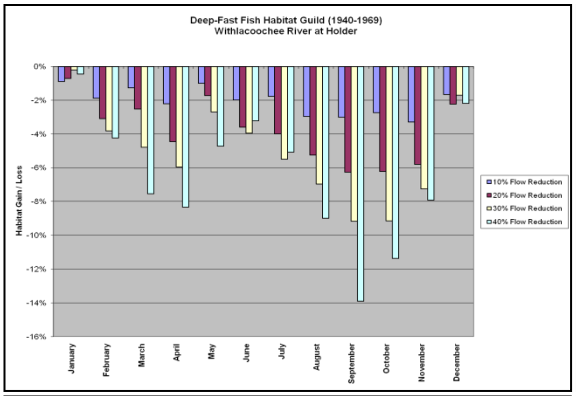


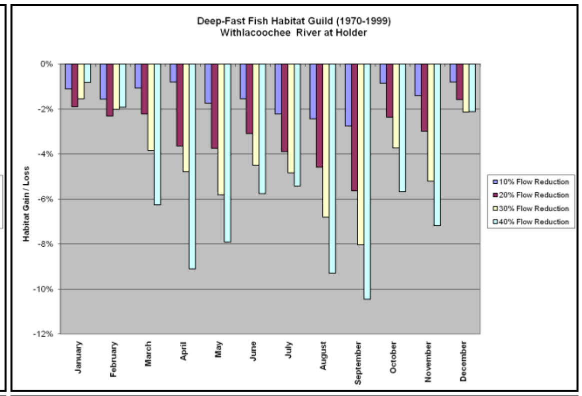


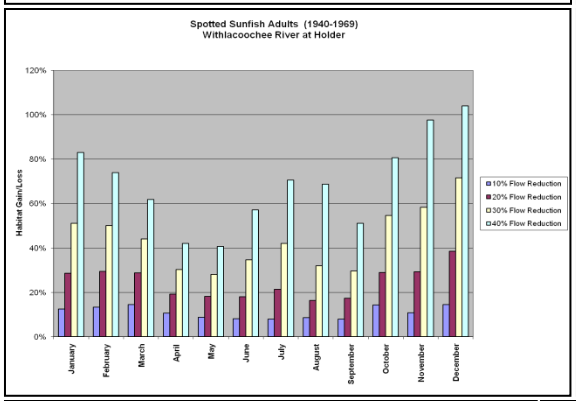


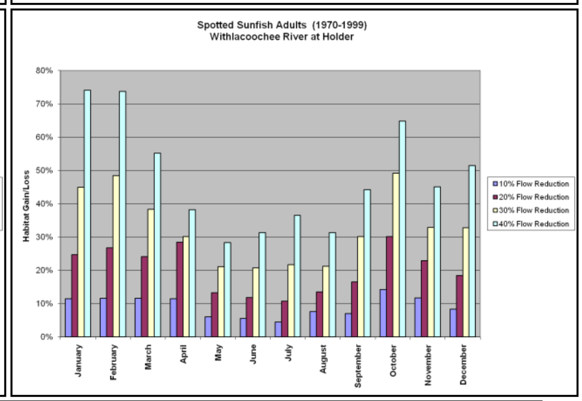


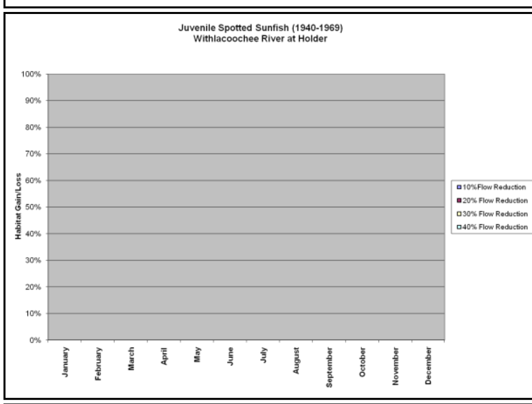


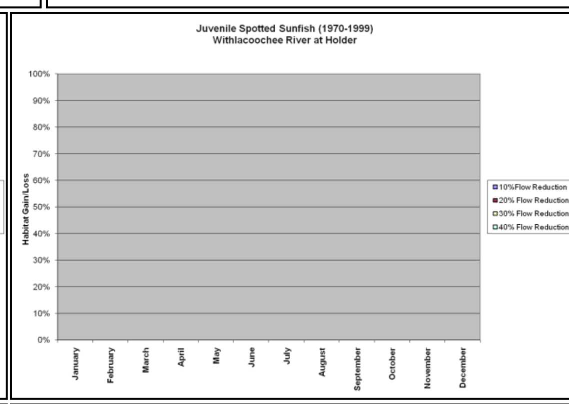

Deep-Fast Fish Habitat Guild (1940-1969)
Withlacoochee River at Holder
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

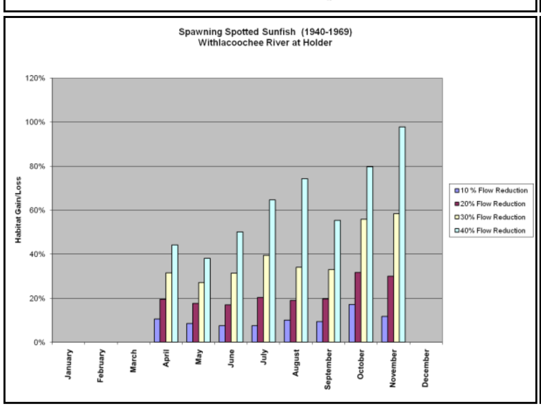

Deep-Fast Fish Habitat Guild (1970-1999)
Withlacoochee River at Holder
Habitat Gain / Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

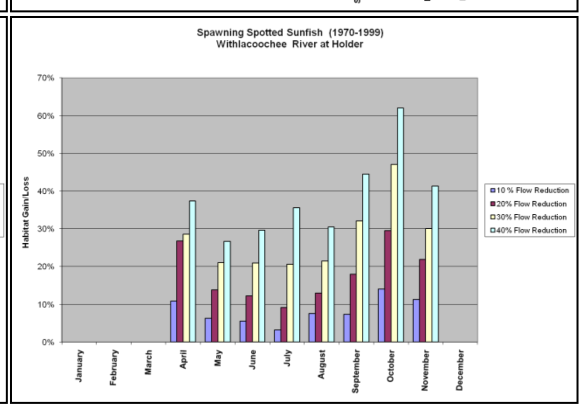

Spotted Sunfish Adults (1940-1969)
Withlacoochee River at Holder
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

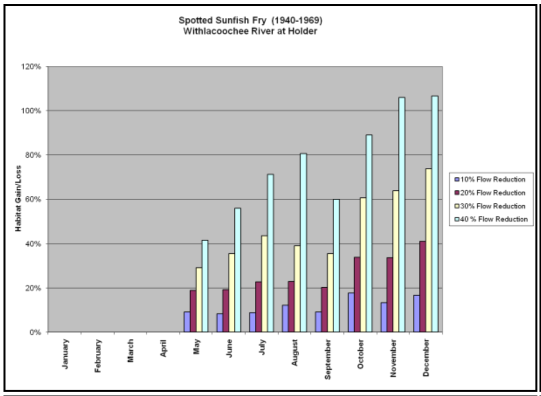

Spotted Sunfish Adults (1970-1999)
Withlacoochee River at Holder
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

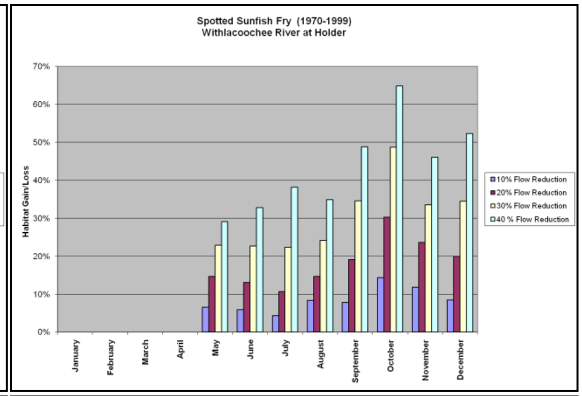

Juvenile Spotted Sunfish (1940-1969)
Withlacoochee River at Holder
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

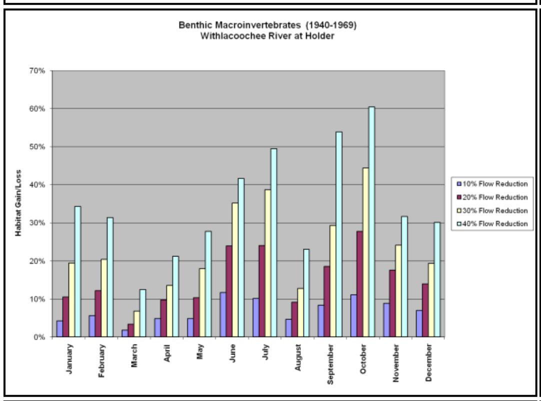

Juvenile Spotted Sunfish (1970-1999)
Withlacoochee River at Holder
Habitat Gain/Loss
10%Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

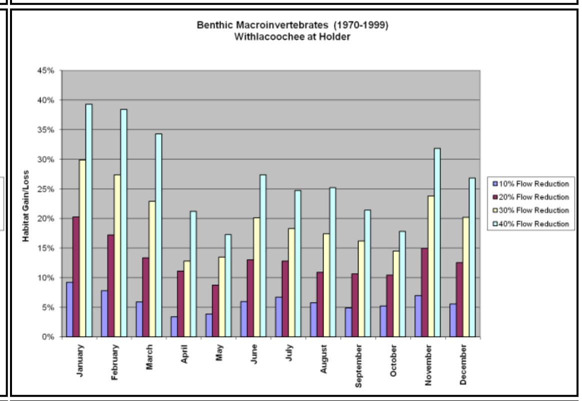

Spawning Spotted Sunfish (1940-1969)
Withlacoochee River at Holder
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

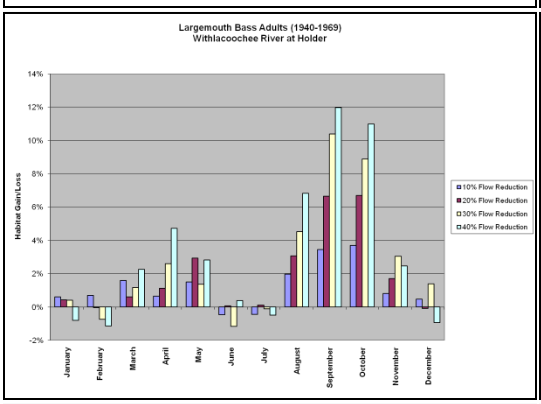

Spawning Spotted Sunfish (1970-1999)
Withlacoochee River at Holder
Habitat Gain/Loss
10 % Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

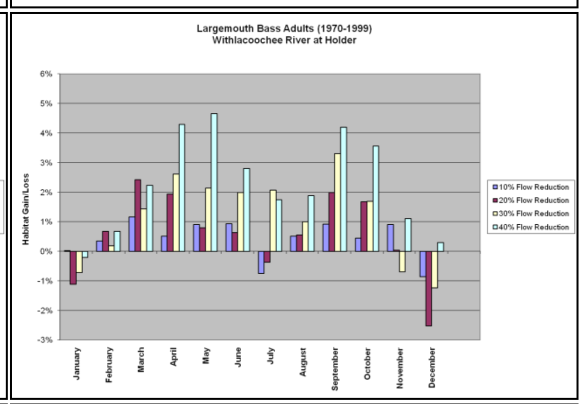

Spotted Sunfish Fry (1940-1969)
Withlacoochee River at Holder
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40 % Flow Reduction

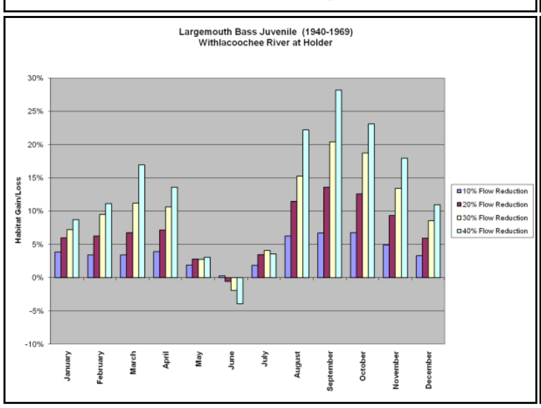

Spotted Sunfish Fry (1970-1999)
Withlacoochee River at Holder
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40 % Flow Reduction


Benthic Macroinvertebrates (1940-1969)
Withlacoochee River at Holder
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Benthic Macroinvertebrates (1970-1999)
Withlacoochee River at Holder
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Adults (1940-1969)
Withlacoochee River at Holder
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Adults (1970-1999)
Withlacoochee River at Holder
Habitat Gain/Loss
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Largemouth Bass Juvenile (1940-1969)
Withlacoochee River at Holder
Habitat Gain/Loss
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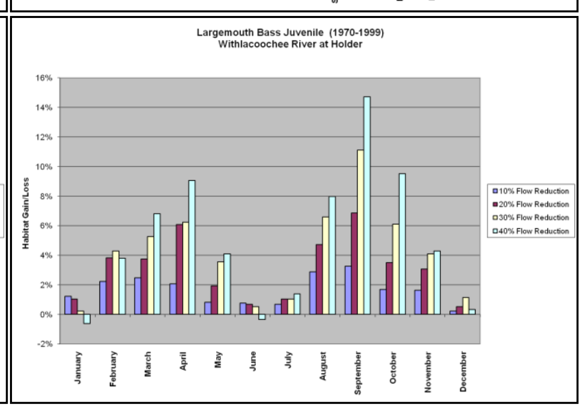
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction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Habitat Gain/Loss
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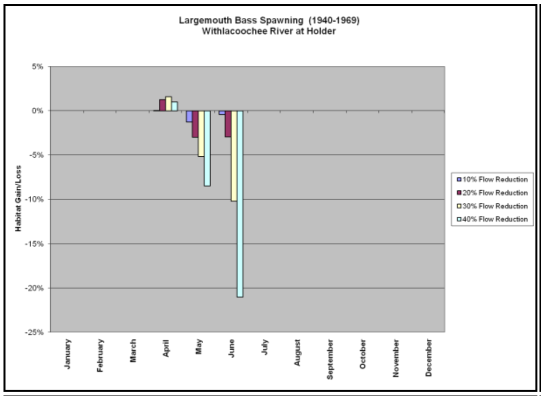
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Withlacoochee River at Holder
Habitat Gain/Loss
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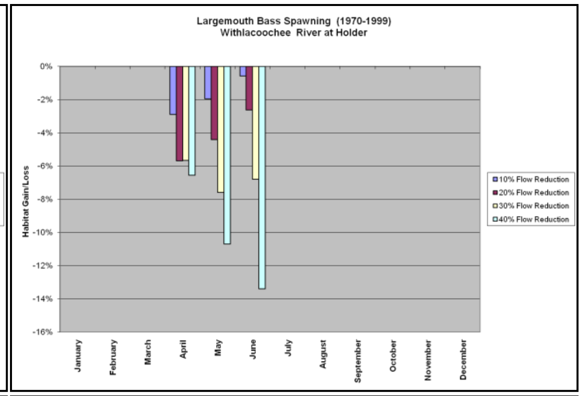
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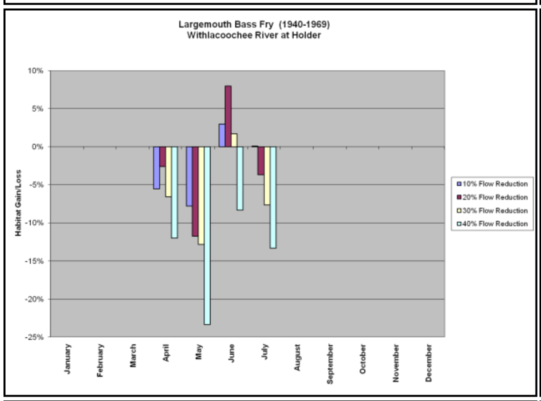
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Withlacoochee River at Holder
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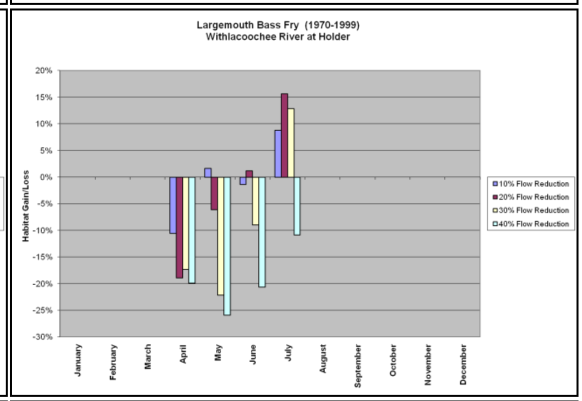
Largemouth Bass Fry (1970-1999)
Withlacoochee River at Holder
Habitat Gain/Loss
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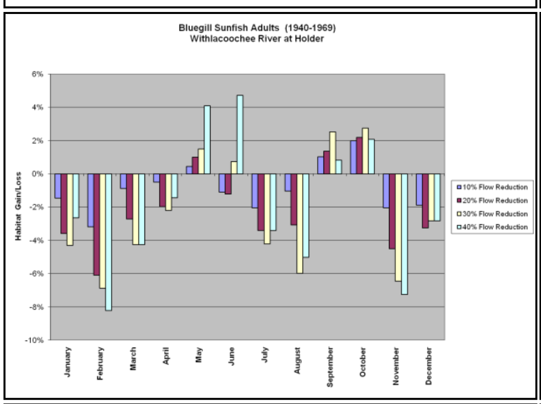
Bluegill Sunfish Adults (1940-1969)
Withlacoochee River at Holder
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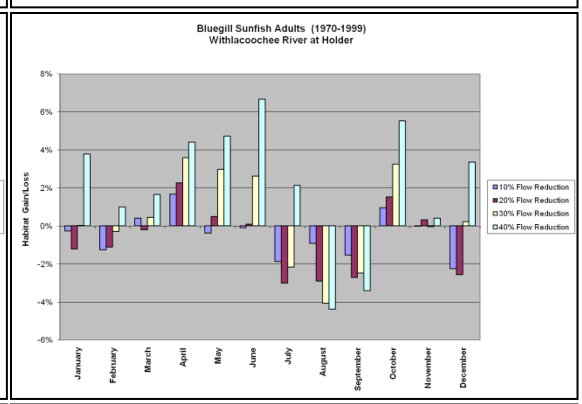
Bluegill Sunfish Adults (1970-1999)
Withlacoochee River at Holder
Habitat Gain/Loss
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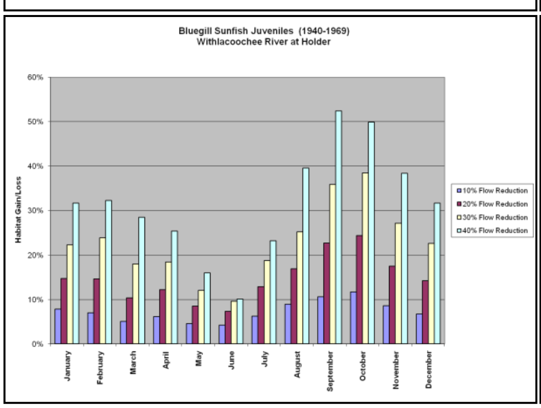
Bluegill Sunfish Juveniles (1940-1969)
Withlacoochee River at Holder
Habitat Gain/Loss
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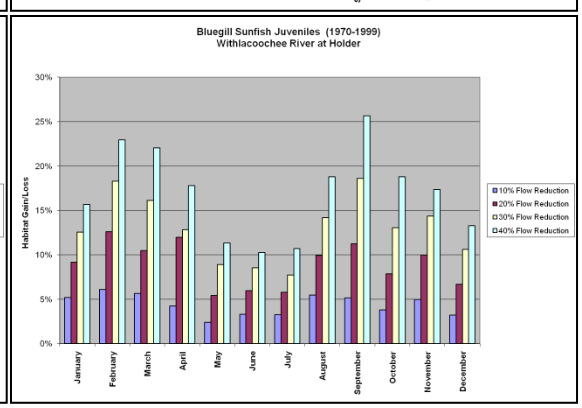
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Withlacoochee River at Holder
Habitat Gain/Loss
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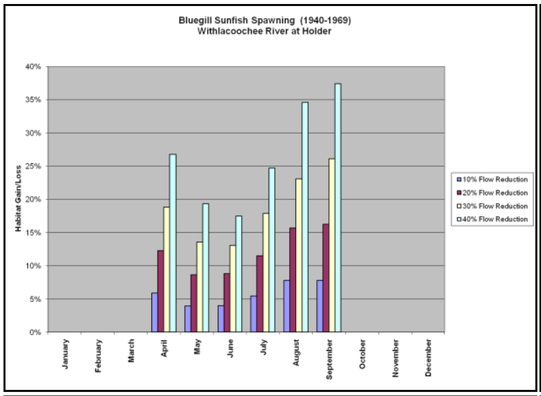
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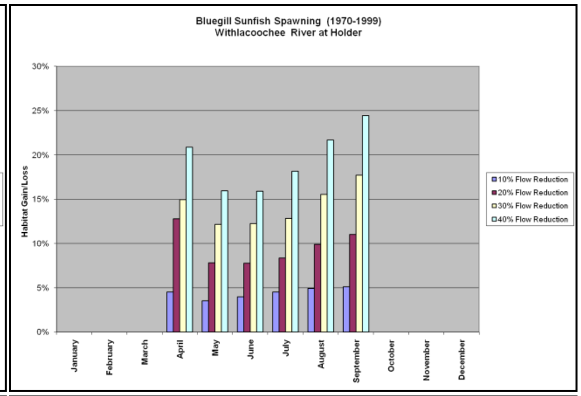
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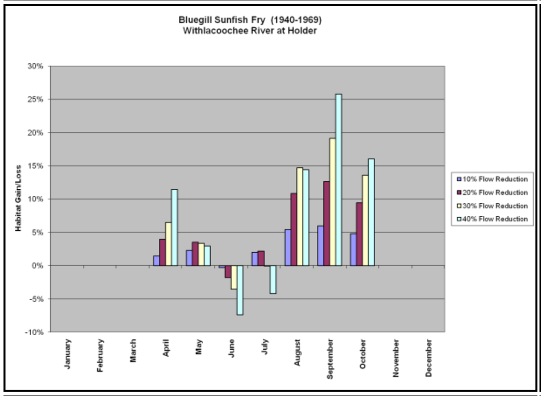
Withlacoochee River at Holder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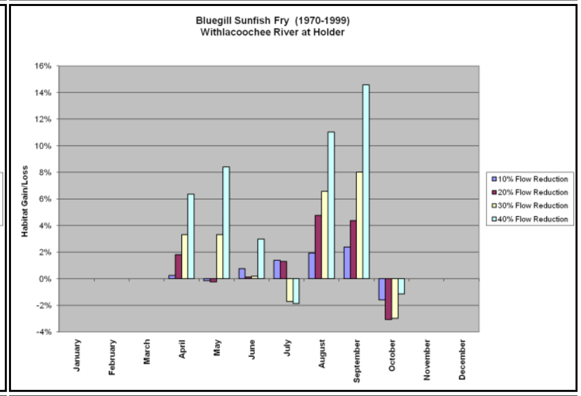
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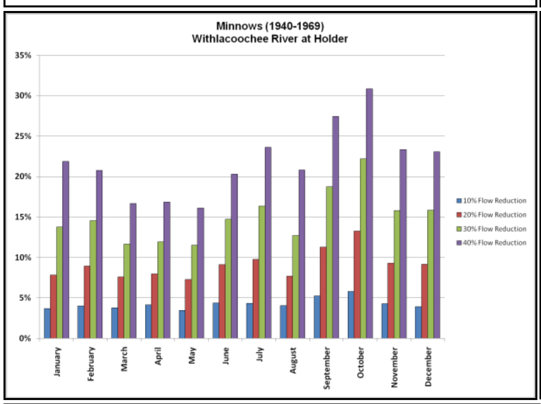
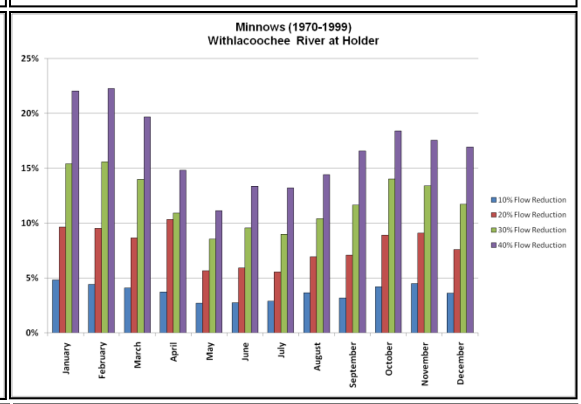

Minnows (1940-1969)
Withlacoochee River at Holder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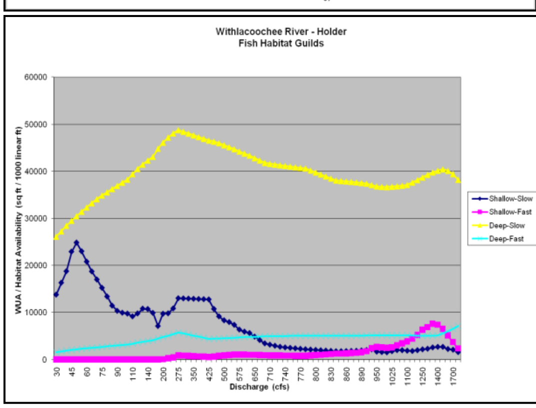
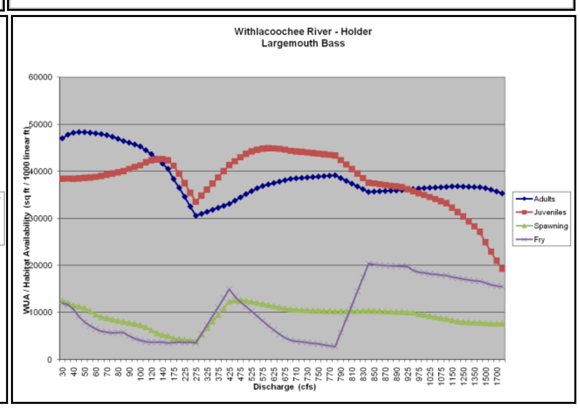
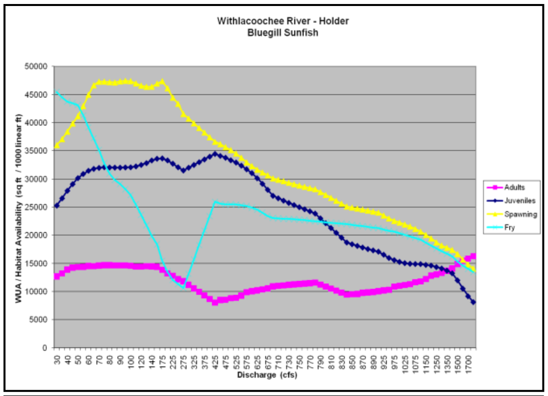
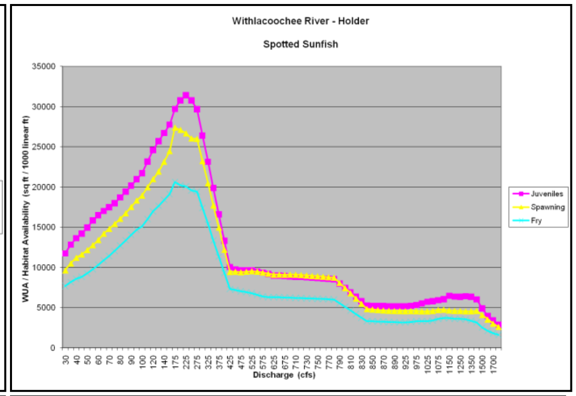
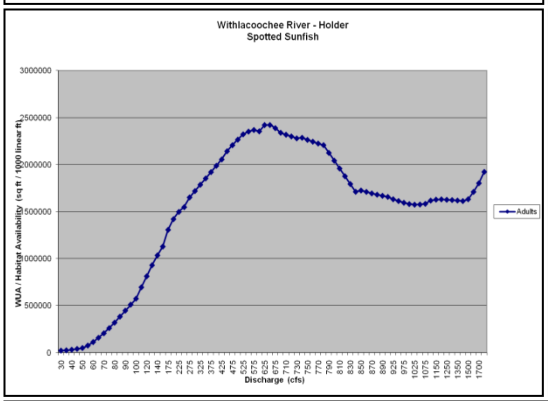
Withlacoochee River at Holder

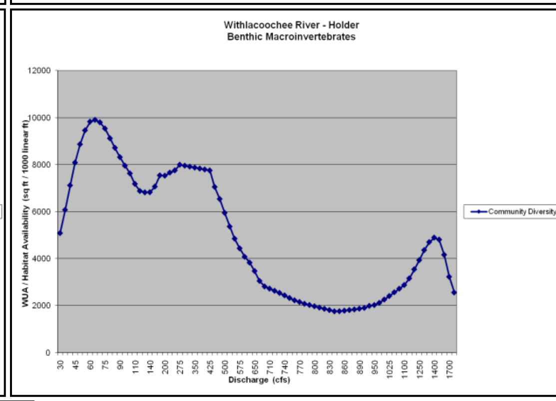

Withlacoochee River - Holder
Fish Habitat Guilds
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast
Discharge (cfs)

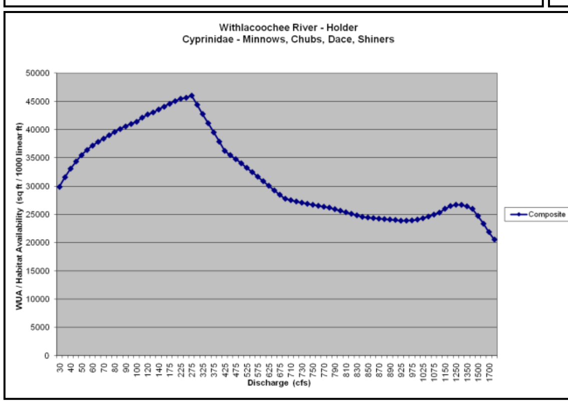

Withlacoochee River - Holder
Largemouth Bass
Adults
Juveniles
Spawning
Fry
Discharge (cfs)


Withlacoochee River - Holder
Bluegill Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults
Juveniles
Spawning
Fry


Withlacoochee River - Holder
Spotted Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Juveniles
Spawning
Fry


Withlacoochee River - Holder
Spotted Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Adults


Withlacoochee River - Holder
Benthic Macroinvertebrates
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Community Diversity


Withlacoochee River - Holder
Cyprinidae - Minnows, Chubs, Dace, Shiners
WUA / Habitat Availability (sq ft / 1000 linear ft)
Discharge (cfs)
Composite

VEGETATION APPENDIX

Characterization of Woody Wetland Vegetation Communities in the Corridors of the Freshwater Portions of the Upper and Middle Withlacoochee River

JULY 15, 2010

PREPARED BY

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Executive Summary

This study of the elevations, soils, hydrologic indicators and vegetation of the Withlacoochee River floodplain was conducted to assist the SWFWMD in establishing minimum flows and levels for this river system. The study included 26 transects with elevation profiles, 310 soil borings and 352 vegetation sampling points along 76 miles of the floodplain for the Withlacoochee River.

The statutory directive for minimum flows and levels (MFLs) was included in the Water Resources Act by the Florida Legislation in 1972. Section 373.042 Florida Statutes (F.S.) directs each water management district to establish MFLs for the surface water bodies, watercourses and aquifers within their respective jurisdictions. Under the statute, the minimum flow for a given watercourse is defined as the limit at which further withdrawals would be "significantly harmful" to the water resources or ecology of the area. In addition, the determination of the minimum flow must be based on the "best available" information and include the considerations for historical modifications such as water control structures.

ENTRIX, Inc. was contracted to characterize ecological communities of the Withlacoochee River by collecting elevation, soils, and vegetation data in wetlands along the river. Elevations, soils, plant species , and vegetative communities were evaluated for 26 transects along approximately 76 miles of the Upper and Middle sections of the Withlacoochee River. Field work was completed between spring and late summer of 2009.

From these evaluations, three generalized floodplain communities were identified: Cypress Swamps (semi-permanently flooded), Mixed Wetland Forests (seasonally flooded) and Hardwood Swamps (seasonally to intermittently flooded). Additional communities identified in lesser quantities included shrub and willow wetlands, herbaceous marshes and various upland communities located either as islands within the transects or at the floodplain limits. A total of 181 species of trees, shrubs, herbs, vines and ferns were identified within all the transects. Of these, 54 species of woody vegetation (trees, shrubs, vines) were identified.

The wetland plant communities tend to be highly similar and overlap substantially in species composition. While the greatest number of species of plants were identified within what was classified as the Mixed Wetland Forest, this community type was statistically the most likely to be classified incorrectly based on the this study, followed by the Hardwood Swamp. Uplands and Cypress were most likely to be classified correctly. These are typically the most extreme of the communities encountered along the Withlacoochee, and do typically provide a fairly clear delineation. Soils supported this as almost all of the soils in the Cypress Swamp were hydric, while all the soils in the uplands were non-hydric.

Strong lichen lines were evident over all of the transects and appeared consistent with a large storm event within the relatively recent past, as this lichen line was typically well above the saw palmetto lines and wetland edges by up to 6.3 feet. It is probable that the controlling event was near-high record water levels in September and October 2004. Some variation occurred while identifying wetland edges because of the presence of side channels and back swamps, whose connections were not always apparent from the transect location. Substantial additional exploration and elevation surveying would have been necessary to determine exact pop-off elevations for these back swamps to determine whether these were connected to the main floodplain or not. Decisions on connectivity were made using field knowledge in conjunction with aerial photographs and reasonable scientific judgment.

Soil borings helped explain the variation among wetland community types. Clays, when present, were more likely to be within a foot of the soil surface closer to the river, whereas the soils nearer the uplands were dominantly sandy soils. The presence of clays in many of these soils strongly affects the water holding capacity of these soils, and clayey soils retain moisture longer than sandy soils. Clays near the surface effectively allow the soil moisture to remain high longer than occurs with sandy soils even when the soils are at about the same relative elevations. Additionally, muck was present in 74% of the Cypress Swamp soil borings, 40% of the Mixed Wetland Forest and 20% of the Hardwood Swamp. Over half of the soil borings in Hardwood Swamps were non-hydric, indicating that this area has not maintained enough moisture to retain indicators of hydric conditions sufficient to be labeled as a hydric soil, and/or that these areas are better classified as bottomland forests within the floodplains but not wetlands.

Changes in water levels can be expected to have the greatest impact on the Cypress Swamp, based on the wetted perimeter calculations, followed by the Mixed Wetland Forest. Changes in wetter perimeter were less apparent for the Hardwood Swamp and even less for the upland communities.

Introduction

Purpose

Wetlands perform many vital functions to sustain and maintain the overall functioning and diversity of the natural regional ecosystem. Wetlands in river floodplains play a crucial role as they provide many of the same functions as isolated wetlands but on a much larger scale. Riverine floodplains provide a broad array of natural functions as the hydrology fluctuates between flood and low flow conditions. They provide water storage during flood conditions, provide water quality treatment and protect the flow-way of the stream itself. Additionally, floodplains serve as wildlife corridors and provide diverse habitats for a variety of plants and animals. Maintaining a healthy, functioning floodplain is integral to the health of the entire river ecosystem. Floodplain benefits have been discussed by numerous authors (Leitman et al. 1983, Light et al. 1993, Brinson 1981, Light et al. 2001). One way to evaluate the health of a river and its floodplains is to identify critical flows that can be assessed to identify ways in which regional activities affect the system. Such an evaluation can add additional insight that can be used by regulators tasked with determining the feasibility and sustainability of using the river for a regional water supply resource.

Chapter 373.042, F.S. directs each water management district to develop minimum flows for watercourses within its boundaries. Under the statute, the minimum flow for a given watercourse is defined as the limit beyond which further withdrawals would cause “significant harm” to the water resources or ecology of the area. In addition, the determination of the minimum flow must be based on the “best available information” and include the considerations for historical modifications such as water control structures.

The purpose of this study was to characterize elevations, soils, hydrological indicators, and wetland vegetation in the floodplain of the Upper and Middle sections of the Withlacoochee River. Data was collected for 26 transects located along approximately 76 miles of river. The data was then analyzed to provide an increased understanding of the floodplain swamps of the Withlacoochee River.

This report presents an analysis of the distribution of elevations, hydrologic indicators, soils, and vegetation in the floodplain swamps of the Withlacoochee River that may be used by the Southwest Florida Water Management District (SWFWMD, District) to establish minimum flows for the Upper and Middle sections of the Withlacoochee River.

Background

The Withlacoochee River in its entirety extends 160 miles, flowing from south to north. The Withlacoochee River crosses or forms the boundary of eight counties: Polk, Pasco, Lake, Sumter, Hernando, Citrus, Marion, and Levy, and drains an approximately 2100 square mile basin (SWFWMD 2001).The Florida Department of Environmental Regulation identified this river as an Outstanding Florida Water in 1989. For the purpose of this study, the project area was defined as 76 miles of river beginning southeast of Dade City in Pasco County and ending at Highway 200 in Citrus County.

The Withlacoochee River originates in the Green Swamp, around elevation 73ft (NGVD 88), and falls an average of 0.8-feet per mile of river over the length of the project area. Ultimately, the river flows in a north to northwest direction through Pasco, Sumter, Hernando and Citrus Counties before ultimately discharging into the Gulf of Mexico. One dam occurs within the study area at Carlson's Landing, just downstream of the Lake Panasoffkee Outlet. As the river flows north-northwest, it passes through the Tsala Apopka Plain before crossing the Brooksville Ridge at the Dunellon Gap. The peculiarities of the geology of these areas, such as the varying depths of the confining layers above the Floridan aquifer, give the Withlacoochee River its variable and complex interaction with the Floridan aquifer.

The surface water hydrology of the Withlacoochee River is unique among Florida rivers because of its capacity to alternate between recharging to and discharging from the Floridan aquifer (SWFWMD 2001). During wet years, the river receives net discharges from the Floridan aquifer, while during dry years, the river provides a net recharge to the Floridan aquifer. This unusual hydrology complicates a thorough understanding of its hydrologic regime. Flow along the river varies considerably from year to year. Additionally, river flows increase substantially over its length as springs, shallow rivers and creeks drain into the Withlacoochee River.

Natural vegetative communities dominate the vast majority of the Withlacoochee River floodplain, with little to no development adjacent to most of the river. Floodplain swamps dominate the natural communities with canopy and subcanopy species typically including cypress (*Taxodium distichum*), red maple (*Acer rubrum*), laurel oak (*Quercus laurifolia*), pop ash (*Fraxinus caroliniana*), sweetgum (*Liquidambar styraciflua*) and American elm (*Ulmus americana*). The floodplain swamps typically grade from cypress-dominated systems closest to the river to hardwood dominated systems farthest from the river.

Methods

Sampling methodologies were selected to provide the data necessary to characterize the wetlands along the Withlacoochee River. Vegetation data plant species distribution and various measures of diversity and dominance, soil characteristics and elevations were evaluated for 26 transects along approximately 76 miles of the Upper and Middle sections of the Withlacoochee River. The methods used in transect selection, data collection and data analyses are described in the following sections.

Transect Selection

ENTRIX coordinated with Southwest Florida Water Management District (District) staff to identify and to finalize, both in the office and in the field, transect location selections. Transects located on public land were preferentially selected to minimize access issues. Access coordination for transects on private lands was completed by the District. The following general procedure was used in transect identification and selection:

- A review of National Wetlands Inventory (NWI) and Florida Gap Analysis Project (GAP) data and maps in conjunction with available topographic data was conducted to establish usefulness of the NWI and GAP classification systems for this river system

- Wetland communities that best characterize the floodplain were mapped using the above data in order to distribute transects among communities based on their occurrence and prevalence along the stream

- The centerline along the length of the river channel was plotted with potential transects intersecting the river at 0.2 mile intervals. Potential transects were identified perpendicular to the stream channel and extending the width of the floodplain as defined by 0.5% water level exceedances

- The designated number of transects was randomly selected from within each community type

- The conditions of each transect were evaluated based on aerial photographs and Digital Ortho Quarter Quad (DOQQ) images to preliminarily remove disturbed transects from the selection process

- Each transect plus a minimum of two alternative transects were selected, mapped and numbered prior to field inspection to finalize exact transect locations

Refined transect selection criteria took into account historical alterations at the transect locations to ensure that non-disturbed plant communities were evaluated and to avoid biases caused by disturbed hydrologic or land use regimes. Transects were also located to maximize the inclusion of forested communities while attempting to minimize the number of herbaceous communities included within transects. Herbaceous communities were selected against due to their typical transient occurrence within the river flow-way itself and because many are artifacts of land management practices such as forestry and conversion to pasture.

Data and maps used to identify and select final transect locations include:

- NWI maps and vegetation communities classification based on Cowardin et al. (1979)

- National Resource Conservation Service (NRCS) soil surveys
- Aerial photography
- Land use

Thirty transect locations were identified along the upper and middle Withlacoochee River study corridor (Appendix F). The total number of transects evaluated was later reduced by District Staff to 26 because of time and access constraints. Each transect was oriented perpendicular to the river channel and extended across the river corridor and floodplain in order to identify and to characterize elevations, soils, physical features, and vegetation. Of the 26 total transects used for vegetative and soil evaluations, ten were located on only one side of the river, while the remaining 16 transects extended across both sides of the river spanning the entire floodplain.

Elevation

Transects concluded at the landward extent of wetlands adjacent to the Withlacoochee River. Individual transect lengths ranged from 35 feet to 3,358 feet in length, with the average transect length being approximately 470 feet for the east bank and 1,125 feet for the west bank. Elevations were surveyed typically every 100 linear feet, as well as at vegetation and soil evaluation points and where changes in elevation were conspicuous. Transects were located in the field and staked by District staff prior to ENTRIX conducting vegetation and soil evaluations. Locations of specific points for elevation surveys were then provided back to District staff, who arranged for the survey of the actual elevations. The elevations surveyed by District staff were then shared with ENTRIX for use in the project analyses.

Vegetation Characterization

Vegetative sampling was conducted at regular intervals along the 26 selected transects. Sampling point spacing ranged between 50 and 200 feet, depending on the length of each transect and the distribution of wetland plant communities within each transect. Vegetative sampling points were arranged, to the greatest extent possible, so that each transect contained a minimum of three sampling points within each plant community type. Trees, shrubs and ground cover plant species were evaluated for this project.

Trees and shrubs were sampled using the Point Centered Quarter (PCQ) method (Cottam and Curtis 1956). Sampling points were distributed along transects to capture conspicuous changes in topography, soils or vegetative composition. Sampling points were between 50 and 200 feet apart, depending on the length of the communities within the transects, and every attempt was made to overlap sampling points with existing survey stakes for ease of surveying. At each sampling point, four quadrants were established using two, 1-meter PVC rods at right angles to each other. In each quadrant, the closest tree and shrub were identified. Data collected included the distance from the center point, species identification and the diameter at breast height (dbh) of recorded trees. When needed for plant identification, samples were collected and submitted to the herbarium of the University of South Florida for verification or identification.

To evaluate the ground cover stratum, 1-meter square quadrats were used to sample at the same point where tree/shrub data were collected. A 1-meter square constructed of PVC pipe was used to delineate the quadrat, which was consistently placed just outside of the surveyed transect line (to avoid tramping that occurred along the line itself) at the southwestern “corner” of the PCQ center point. Vegetation occurring within the quadrat was recorded with percent cover and species name to determine a complete picture of species diversity.

Canopy species importance for this report was based on basal area and relative abundance. Relative abundance was determined by the number of individual trees identified within a specific area out of the total number of individual trees identified collectively. Relative dominance was considered to be a function of total basal area. Shrub species importance was based on relative abundance alone. Groundcover importance was based on relative percent cover, which was calculated based on percent cover of each species within the quadrants. A discussion of the dominant species is provided below.

Wetland Classification

There are a multitude of wetland classification systems in use throughout the United States. Common classification systems used in Florida include Cowardin classification (as used in the National Wetlands Inventory through the US Fish and Wildlife Service), Florida GAP assessment (produced by the Florida Fish and Wildlife Conservation Commission), and Florida Natural Areas Inventory (FNAI) Natural Community Guide, a Heritage System classification broadly used nationwide by environmental land managers. The Florida Land Use Cover and Forms Classification System (FLUCFCS; FDOT 1999) is commonly used to map community types for land development and environmental permitting activities and is based on overstory species composition. While ENTRIX believes that the FNAI Natural Community Guide is the most ecologically suitable classification system available, we have used the Cowardin system to classify plant communities occurring within the project area because it is consistent with previous river floodplain studies prepared for the District. Because of the cumbersome nature of the Cowardin nomenclature, FLUCFCS terminology has been associated with the Cowardin classifications to reference community types within discussion for simplicity. Table 1 below provides a “cross-walk” between the classification systems and terminology used herein. Table 2 provides the Cowardin definitions.

Table 1 Wetland Plant Community Classification Cross-Reference

Vegetation Class	Cowardin	FLUCFCS	Heritage System (FNAI)
Cypress	PF02F	621	Floodplain Swamp
Mixed Wetland Forest	PF01C/PF03C	630	Alluvial Forest, Hydric Hammock
Hardwood Swamp	PF06F	615	Alluvial Forest
Herbaceous	PEM1F	641	Floodplain Marsh
Shrubby Wetland	PSS1C	631	Floodplain Marsh
Willow	PSS1C	618	Floodplain Marsh
Upland	n/a	various	Bottomland Forest, Mesic Hammock, Mesic Hammock

Table 2 Cowardin descriptions of wetlands found along the Withlacoochee River.

Plant Community	Cowardin	Description
Cypress Swamp	PFO2F	Palustrine Forested Needle-leaved Deciduous, semi-permanently flooded

Plant Community	Cowardin	Description
Hardwood Swamp	PFO1/3C	Palustrine Forested Broad-leaved Deciduous/Broad-leaved Evergreen, Seasonally flooded
Mixed Wetland Forest	PFO2/3C	Palustrine Forested Needle-leaved Deciduous/Broad-leaved Evergreen Seasonally flooded
Herbaceous Wetland	PEM1F	Palustrine Emergent Persistent, Semipermanently flooded
Shrub Wetland	PSS1C	Palustrine, Scrub-shrub, broad-leaved Deciduous, Seasonally flooded
Willow Wetland	PSS1C	Palustrine, Scrub-shrub, broad-leaved Deciduous, Seasonally flooded
Upland	N/A	N/a*
*The Cowardin classification system does not address upland communities		

Soils Characterization

Soils were sampled to evaluate how they changed in relation elevations and plant communities. A hydric soil is defined as one that is formed under conditions of saturation, flooding or ponding that occurs for a long enough period of time during the growing season for anaerobic conditions to develop in the upper part of the soil profile (Federal Register 1994). Indicators of hydric soils typically result from accumulation or loss of iron, manganese, sulfur or carbon compounds in anaerobic and saturated environments (USDA 2010). Hydric indicators were assessed in the soils along the transects to determine whether a soil at a particular location met the hydric soil criteria for identification as a wetland soil.

Physical properties of soils, including horizon depth, soil color, texture and redoximorphic features, were recorded at each sample location. Soil pit locations were selected in the field on an “as suitable” basis to determine the most accurate profile of the floodplain soils. The soil profile was examined to a depth of approximately 50 cm (20 inches) at each sample location, where feasible. Soil pits were less than 50 cm where inundation, limestone or clays restricted access. Soil pits were excavated using a sharpshooter shovel, soil probe or hand auger, as necessary. Each soil horizon was described with the texture of each horizon manually estimated and recorded along with Munsell Color and presence or absence of redoximorphic features. Other physical properties recorded included presence or absence of muck (organic material) and which hydric soil indicator was met.

Over 300 soil pits were dug and evaluated across the 26 transects. Soil pits were typically dug at changes in vegetation and/or elevation. In addition to these excavations, soil evaluations were conducted as needed to determine consistency of soil features along the transects. Soils data were compiled and paired with the vegetation and elevation data for analysis. While multiple indicators can occur at by one soil pit, only the most obvious indicator was recorded as the primary question was whether the soil was hydric or not.

Field Indicators of Hydrology

Indicators of hydrology were identified in the field along the vegetative and soil transects. Key indicators of inundation were marked along transects, including the waterward occurrence of saw palmetto and lichen and/or moss lines on trees. The presence of saw palmetto typically coincides with the jurisdictional limits of wetlands; however, this is not always the case as jurisdictional wetlands may extend upward of the palmetto line in areas of groundwater seepage. Additionally, prior clearing of the historic plant community or other land management practices have affected palmetto distribution, so that the palmetto line is not solely a function of wetland hydrology. The hydrologic indicator data was then correlated back to the soils and vegetation data for analysis.

Data Analysis

Vegetation, soils and elevation data were analyzed and compared among and between wetland plant community types. Wetted perimeter graphs were created for each transect based on length of wetland plant community types versus ranges of elevation. Additionally, species richness and diversity were calculated.

Results/Discussion

The primary focus of this study was the analysis and evaluation of the wetland plant communities of the Middle and Upper sections of the Withlacoochee River floodplain relative the physical floodplain factors including elevation, soil characteristics, and seasonal high water indicators. These parameters collectively were analyzed to clarify how the water elevations within the floodplain relate to the extensive floodplain wetland plant communities.

Data collection began in April 2008 and was completed in September 2008. This extended sampling period predominantly affected the recorded groundcover vegetation, much of which is seasonal in visibility and dominance within a wetland plant community. Sampling conducted after the floodplain became inundated was limited by water depth (visibility of vegetation, ability to sample soils). There was a locational bias to the inundation effects as the upper floodplain was surveyed and sampled earlier than the downstream sections. While seasonality/inundation effects were unavoidable, ENTRIX believes that their effect on conclusions that can be drawn from the study is minimal.

Elevation

Each transect was evaluated and characterized for physical characteristics such as elevations as well as the biological and soil indicators. Table 3 provides the elevation parameters for each transect, including minimum channel elevation, minimum transect elevation and maximum transect elevation. The maximum elevation change across each transect ranges from 6.8 feet to 22.1 feet.

Table 3 Summary of elevation parameters for the Withlacoochee River transects

	Transect	Transect Distance (feet)	Transect Maximum Elevation (NAVD88)	Transect Minimum Elevation (NAVD88)	Channel Minimum Elevation (NAVD88)	Maximum Elevation Change	Top of Bank Elevation (NAVD 88)		N
							Left Bank	Right Bank	
Upstream	Near River Road	212	75.1	71.1	68.3	6.8	72.8	73.9	40
	1	499	72.9	66.1	60.7	12.2	71.6	73.4	49
	2	1127	74.2	68.2	60	14.2	74	74.6	67
	3	1876	71.5	67.4	64.4	7.1	68	69	65
	4	413	70	66.3	59.8	10.2	65.5	69	54
	5	808	70.1	65.4	59.7	10.4	n/a	65.6	65
	6	2077	70.1	64.5	58.5	11.6	68.5	70	81
	7	1737	64.7	60.5	52.6	12.1	60.6	63.7	45
	8	1537	64.4	55.1	50.4	14	59.7	60.3	67
	Trilby	313	58.6	53.8	47.8	10.8	56.4	n/a	27

Downstream	Croom	639	48.4	42.2	35.8	12.6	48.4	n/a	47
	9	1239	46.9	39.5	32.6	14.3	44.6	46	79
	10	1531	46.7	39.6	35.4	11.3	45.7	46	82
	11	1330	46.8	39.6	32.2	14.6	41.6	42.6	60
	12	1061	47.1	38.8	33.2	13.9	43.6	44.8	79
	13	533	45.4	37.4	30.5	14.9	40.9	n/a	73
	Above 476	684	49.6	38.1	34.4	15.2	40	44.1	91
	16	2500	39.91	29	28.63	11.28	n/a	35.5	92
	17	4199	47	32.4	24.9	22.1	34.3	36.3	123
	18	2455	43	33.6	28	15	n/a	35	87
	19	4173	40.8	33.2	28.1	12.7	34.3	36.4	87
	Turner Camp	3358	38.9	28.3	28.1	10.8	n/a	34.4	73
	20	2037	36.9	32.2	23.9	13	32.6	33.1	56
	21	1643	38	31.6	18.8	19.2	32.9	33.1	50
	22	1406	36.9	29.1	24	12.9	32.6	32.9	57
	200	2092	34.9	29.9	24.9	10	31.6	31.8	51

Herbaceous, Shrub and Willow wetlands occurred at the lowest elevations consistently (Table 4). Typically the Shrub and Willow wetlands occurred at lower elevations farther from the river, where depressions ponded water away from regular, direct contact with the river. The forested habitats were significantly different from each other and mostly consistent with the field transitions; Cypress occurred at the lowest elevations and uplands at the highest elevations. However, the Hardwood Swamp occurred, on average, at lower elevations than the Mixed Wetland Forest. This may result from the Hardwood Swamp occurring more frequently in the upper stretches of the river farther north and the Mixed Wetland Forest distributing more evenly across the whole river length and occurring more frequently in the lower river stretches.

Table 4 Summary of species located with each habitat type along the Withlacoochee River, Florida

	Cypress	Hardwood	Herb	Mix	Shrub	Willow	Upland
Sample Size	125	41	9	157	2	2	16
Elevation (NGVD88)	40.97 (11.75)	46.93 (11.11)	34.19 (1.83)	52.88 (15.20)	37.75 (0.35)	40.4 (0.14)	60.64 (13.24)
Soils Index	1.75 (0.46)	0.51 (0.66)	1.33 (0.82)	1.16 (0.72)	1.5 (0.71)	2.0 (0)	0 (0)
Distance from River Channel	698.93 (736.15)	828.39 (829.44)	795.44 (686.19)	692.62 (699.82)	3,064 (70.71)	1,014 (70.7)	510.06 (368.71)

Of the forested wetland habitats, Cypress typically occurred closer to the river banks, though this distance is variable depending on location along the river: as the river moves north, the Cypress fringe expands farther away from the river. The Mixed Wetland Forest appears to occur at similar distances from the river as the Cypress, though this distribution is a result of the variability in the transect widths as the river flows north (the transects and habitat bands get narrower and Mixed Hardwoods are more prevalent to the north); the

Hardwood Forest consistently occurs farthest from the river. The irregularity of the Upland Forest average distance from the river channel results from the upland points being a mix of berms adjacent to the river, interstitial upland habitat within the floodplain forests, and uplands at the terminal point of transects.

Floodplain Wetted Perimeter

Floodplain wetted perimeter was calculated for plant communities along each transect to provide an indication of potential changes in plant communities due to changes in water level elevations. Indirectly, these would also relate to changes in duration of flooding at each elevation (Appendix A). Graphs of the linear extent of each plant community (wetted perimeter) versus elevation indicate that the change in wetted perimeter relative to the change in elevation was greatest for the Cypress Swamp community, followed by the Mixed Wetland Forest (once outliers were accounted for). These ratios (linear feet of plant community per unit change in feet of elevation) indicate that changes in water level that occur in the Cypress Swamp will impact the greatest amount of the community when compared to other community types within this study (Table 5).

Table 5 Comparison of floodplain wetted perimeter (linear feet of community/change in elevation) in dominant vegetation communities along 26 transects of the Withlacoochee River

Community	Mean Ratio (linear feet of community/change in elevation)	Number of Transects
Cypress	394.70	19
Mixed Wetland Forest	275.41	24
Hardwood Swamp	163.3 (299.45)*	13 (14)*
Upland	66.40	26
*number in () is before the removal of an outlier		

Vegetation

The dominant plant communities along the Withlacoochee River floodplain were broadly divided into four categories: Cypress, Hardwood Swamp, Mixed Wetland Forest and Uplands. Additional communities sampled include herbaceous, shrub and willow wetlands.

Vegetation along the river is diverse with approximately 181 species of trees, shrubs, herbs, vines and ferns identified in this study. Trees accounted for 29 species. Table 6 provides a summary of species richness (count of number of species present) by community along the Upper and Middle sections of the Withlacoochee River floodplain. Of these, the Mixed Wetland Forest had the greatest overall species richness with the Cypress Swamp and Hardwood Swamp systems having slightly lower species richness.

Table 6 Number of plant species encountered by community type

Vegetation Type	N	Cypress Swamp	Hardwood Swamp	Mixed Wetland Forest	Shrubby Wetland	Willow	Herb	Upland
Herbs	121	65	56	102	6	2	17	21

Vegetation Type	N	Cypress Swamp	Hardwood Swamp	Mixed Wetland Forest	Shrubby Wetland	Willow	Herb	Upland
Trees	29	18	18	19	5	4	9	17
Shrubs	13	5	9	11	1	1	2	5
Vines	12	6	10	11	1	0	1	9
Ferns	6							
% of all species		52.2%	51.7%	79.4%	7.2%	3.9%	16.1%	28.9%

In terms of basal area, the canopy of the combined floodplain communities was dominated by two species: bald cypress (*Taxodium distichum*) and laurel oak (*Quercus laurifolia*) (Table 7). These two species accounted for 75 percent of the total basal area. In terms of abundance, the canopy of the combined floodplain communities was dominated by six species: bald cypress, laurel oak, pop ash (*Fraxinus caroliniana*), red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*) and American elm (*Ulmus americana*). However, the combined basal area of the last four species mentioned (pop ash, red maple, sweetgum, and American elm) is approximately half of the total basal area for cypress alone. Cypress is the most important tree present in terms of both numbers and size.

Table 7 Summary of Floodplain Wetland Canopy Composition (ordered by Total Basal Area)

Species	N	Total Basal Area (cm2)	Average Basal Area per Tree	Maximum Diameter (DBH, cm2)	Relative Dominance based on Basal Area
Taxodium distichum	311	676,208.5	2,174.3	186.9	61.6%
Quercus laurifolia	180	156,802.0	871.1	107.2	14.3%
Fraxinus caroliniana	174	51,223.5	294.4	59.9	4.7%
Quercus virginiana	16	43,655.2	2,728.5	90.0	4.0%
Acer rubrum	110	39,879.0	362.5	60.5	3.6%
Nyssa sylvatica var. biflora	32	32,814.0	1025.4	77.6	3.0%
Liquidambar styraciflua	93	22,803.8	245.2	43.5	2.1%
*Sabal palmetto**	15	20,422.5	1,361.5	60.5	1.9%
Ulmus americana	83	14,691.3	177.0	39.2	1.3%
Pinus taeda	7	9,500.3	1,357.2	51.2	0.9%
Carya aquatica	8	7,011.7	876.5	74.5	0.6%
Carpinus caroliniana	64	5,260.0	82.2	31.1	0.5%
Fraxinus pennsylvanica	5	4,299.1	859.8	42.1	0.4%
Quercus nigra	12	2,943.2	245.3	48.5	0.3%
Gleditsia aquatica	8	2,060.7	257.6	30.0	0.2%
Celtis laevigata	6	1,459.6	243.3	33.7	0.1%
Platanus occidentalis	2	1,225.9	612.9	38.0	0.1%
Persea borbonia/P. palustris	4	652.4	162.8	24.0	0.1%

Salix caroliniana	10	399.6	39.9	10.5	0.0%
Diospyros virginiana	4	60.6	15.1	6.1	0.0%
* Treated as canopy due to morphology and size					

In terms of size of individual trees, the largest tree evaluated within the study area was a cypress with a diameter at breast height (DBH) of approximately 187 cm located within the Cypress Swamp. The next largest tree in terms of dbh was a laurel oak at 107 cm located in the Mixed Wetland Forest.

On average, live oak and black gum both have large diameters and basal areas compared to their lesser relative abundances, when compared to the other prominent canopy species. This indicates that these two species occurred in the study as fewer trees of a larger size, compared to the remaining species that tend to be higher in numbers, but smaller in the typical size of individual trees. This observation is consistent with what was found along the Suwannee River in north Florida (Light et al. 2001).

Ironwood (*Carpinus caroliniana*), ranked 7th, in terms of relative abundance. However, its average basal area is consistent with its growth form as a small subcanopy tree that is prevalent throughout the Mixed Wetland Forest and Hardwood Swamp.

Shrubs and Herbs

The dominant plant communities along the Withlacoochee River floodplain were broadly divided into four categories: Cypress, Hardwood Swamp, Mixed Wetland Forest, and Uplands. Additional communities sampled include herbaceous, shrub and willow wetlands.

Thirty-one shrub-sized species were identified in the wetland communities along the transects of the Withlacoochee River. Of those 31 species, 13 species are shrub species, while the remaining 18 species were shrub-sized trees. Collectively, 777 individuals were surveyed. Buttonbush (*Cephalanthus occidentalis*) was the most prevalent shrub, accounting for 18.7% of all the shrubs surveyed. St. Johns wort (*Hypericum hypericoides*) was the next most commonly occurring, 13.6% of the total shrubs, surveyed. Tree saplings were also abundant with sweetgum, red maple, sabal palm and pop ash accounting for an additional 31.9% of the shrub layer abundance.

A total of 121 species of herbaceous (non-woody) species were identified along the transects. Approximately half of all herbaceous species occurred in the Cypress Swamp and Hardwood Swamp, 54% and 46% respectively. The Mixed Wetland Forest contained 84% of all herbaceous species surveyed.

Wetland Plant Communities

Plant communities were delineated in the field by visual inspection and on-the-spot evaluation by field ecologists. Plant communities were broadly segregated by canopy dominance into Cypress, Mixed Wetland Forest, Hardwood Swamp, Willow Swamp, Shrub Wetland, Freshwater Wetland and Upland Oak/Pine. Mixed Wetland Forest and Cypress were the dominant plant communities identified along the river. Hardwood Swamps were less prevalent, and lastly herbaceous, willow and shrubby wetlands were the least common, in the sample, largely because these communities were only sampled where they were encountered within transects selected primarily on the basis of their forest communities.

Cypress-dominated swamps typically occurred closest to the river, grading into a mixed wetland, then periodically a purely hardwood swamp before transitioning into the uplands. Variations in topography, presence of backwaters, side channels and creeks occurred which modified this layout slightly. Most transects contained cypress, mixed wetland and upland plant communities. Herbaceous wetlands were typically found in the backwaters and on what appeared to be sandbars in the river where the river was widest. Shrub and willow wetlands occurred rarely and typically in deeper pools farther away from the river. Table 8 below identifies the total number of transect points located within each plant community type along the floodplain transects.

Table 8 Wetland Plant Community Classifications and Prevalence in the Sample

Vegetation Classification	Cowardin	FLUCFCS code and FNAI community	No. Points
Cypress	PF02F	621 (Floodplain Swamp)	125
Mixed Wetland Forest	PF01C/PF03C	630 (Alluvial Forest/Hydric Hammock)	157
Hardwood Swamp	PF06F	615 (Alluvial Forest)	41
Herbaceous	PEM1F	641 (Floodplain Marsh)	9
Shrubby Wetland	PSS1C	631 (Floodplain Marsh)	2
Willow	PSS1C	618 (Floodplain Marsh)	2
Upland	n/a	400 (Bottomland Forest/Mesic Hammock)	16

Transects were originally selected at specific locations along the river to ensure that all significant community types were encompassed within this study. However, three additional wetland plant communities were encountered that were not detected via aerial imagery: herbaceous, shrub wetlands and willow wetland. Because these three plant community types were not anticipated, samples within these communities were limited to those encountered in the field. Given the limited occurrence of shrubby and herbaceous wetlands in the sample and the study intent to focus on the forested communities, most of the wetland plant community discussion is focused on tree-dominated wetlands, and the discussions on the herbaceous, shrub and willow wetlands are kept to a minimum.

Floodplain swamps are known to be diverse, biologically rich environments. In a previous study of species richness for the Suwannee River, species richness was found to be extraordinarily high with eight plant communities containing more than 30 canopy/subcanopy species and two communities containing more than 40 canopy/subcanopy species (Light et al. 2001). In 15 plant community types on five other Florida river floodplains, the highest number of species in a bottomland hardwood swamp was 31 canopy/subcanopy species in the Apalachicola River. Other river floodplain communities ranged from 6-25 species (Leitman et al. 1983, Light et al. 1993). For other riverine systems, this number rarely exceeds 25 species (Brinson 1981). The Withlacoochee River forested floodplain communities are consistent with this typical range of canopy/subcanopy species, and tend toward the higher end of the range, with 29 tree species identified along transects (Table 6).

Light et al. (2001) commented that compared to the riverine plant communities studied, upland oak/pine forests had the lowest average basal area and species diversity. This is consistent with the results for the Withlacoochee River. The Mixed Wetland Forest had the most species of all the groups and thus, the highest species richness of the primary communities evaluated. The values provided for the shrub, willow and herbaceous wetlands are not representative of the community on the whole because of the low sample size for those communities. There was no significant difference between the Cypress Swamp and Hardwood Swamp in terms of species richness.

Floodplain Communities by Transect

The following table is a breakdown of the community occurrence by transect. Mixed Wetland Forest and Cypress Swamp each accounted for more than 50% of 11 out of 26 transects. Where Mixed Wetland Forest accounted for more than half of the transect, the Cypress Swamp was typically the secondary community. Where Cypress Swamp was the primary community type, the secondary community was not dominated by either Mixed Wetland Forest or Hardwood Swamp. Of the 26 transects, two transects had an approximately equal mix of two of the three dominant community types..

Table 9 Percent occurrence of the dominant floodplain wetland communities by transect.

Transect IDs Sampling Points Transects*	Total Length (feet)	Cypress	MWF	Hardwood
		125	157	41
		73%	92%	54%
With Near River Road	212	0%	**100%**	0%
1	499	0%	**90%**	0%
2	1127	11%	**76%**	0%
3	1876	41%	**59%**	0%
4	413	0%	**93%**	0%
5	808	17%	**78%**	4%
6	2077	34%	**54%**	0%
7	1737	0%	**71%**	29%
8	1537	**63%**	0%	34%
With at Trilby	313	0%	**67%**	33%
Croom	639	39%	45%	10%
9	1239	37%	27%	0%
10	1531	18%	46%	35%

11	1330	10%	**89%**	1%
12	1061	**60%**	12%	29%
13	533	**88%**	0%	12%
WithAbout476	684	31%	29%	0%
16	2500	0%	**79%**	0%
17	2499	**97%**	3%	0%
18	2455	**71%**	9%	5%
19	4361	**55%**	27%	18%
With Near Turner Camp	3358	**82%**	9%	8%
20	2037	**63%**	14%	24%
21	1643	**92%**	0%	8%
22	1406	**71%**	21%	9%
With Above 200	2092	**65%**	16%	11%

*Percent occurrence across all transects; **bold** numbers are where a community type exceeds 50% occurrence

Cypress Swamp – PF02F

The Cypress Swamp is typically located closest to the river and is labeled as a Palustrine Forested Needle-leaved Deciduous, semi-permanently flooded wetland per Cowardin et al. (1979). This plant community is dominated by bald cypress, pop ash, red maple, blackgum, American elm and laurel oak, in descending order of relative abundance. While bald cypress alone accounts for 80% of the relative basal area within this community type, it only accounts for 38% of the relative abundance. This indicates that the individual cypress trees tend to be fewer of larger sizes, especially when compared to pop ash and red maple. Both pop ash and red maple are less represented via basal area compared to relative abundance, which indicates a prevalence of younger (smaller) trees (Table 10). Buttonbush is the most prevalent shrub species within this community.

A total of 94 species were identified within the Cypress Swamp: approximately 70% herbaceous species and 30% woody species. Of the total 181 species identified across all transects, 52% occurred within the Cypress Swamp. Of the 65 species of herbaceous plants within this wetland plant community, 12 species were found in no other community types and an additional 12 species were found over half the time in the Cypress Swamp.

Table 10 Summary of the canopy species and composition for Cypress Swamps along the Middle and Upper Withlacoochee River

Species	Total BA (cm²)	Count	Avg BA (cm²)	Relative BA (%)	Relative Abundance (%)	Largest BA (cm²)	Largest DBH (cm)
Canopy Layer							
Taxodium distichum	504,438	194	2,600	81	40	186.90	27,439
Fraxinus caroliniana	35,122	123	286	6	25	59.90	2,818
Nyssa sylvatica var. biflora	34,448	31	1,111	6	6	77.60	4,730
Acer rubrum	25,806	72	358	4	15	60.00	2,828

Species	Total BA (cm²)	Count	Avg BA (cm²)	Relative BA (%)	Relative Abundance (%)	Largest BA (cm²)	Largest DBH (cm)
Quercus laurifolia	14,343	21	683	2	4	66.30	3,453
Ulmus americana	3,468	30	116	1	6	31.20	765
Liquidambar styraciflua	2,890	9	321	0	2	43.50	1,486
Quercus virginiana	1,964	1	1,964	0	0	50.00	1,964
Fraxinus pennsylvanica	1,786	2	893	0	0	40.10	1,263
Carya aquatica	1,276	1	1,276	0	0	40.30	1,276
Salix caroliniana	79	1	79	0	0	10.00	79
Gleditsia aquatica	21	1	21	0	0	5.20	21
Total	**625,639**	**486**					

The Cypress Swamp had the lowest number of shrub species represented of the three forested wetland plant communities. Of 13 species of shrubs identified within the project area, only five occurred within the Cypress Swamp. Buttonbush (*Cephalanthus occidentalis*) was by far the most prevalent shrub within this community, accounting for over 29.1% of the shrub layer and 80% of species typically characterized as shrubs within this community.

The pattern of species distribution among the canopy, shrub and groundcover layers suggests that these are stable plant communities with some with limited reproduction of canopy species, especially cypress. Given the typical establishment pattern of cypress swamps (most reproduction would occur after disturbance); this would suggest that the cypress swamps are generally lacking in major recent disturbances and that the composition is relatively stable.

Mixed Wetland Forest – PFO2C/PFO3C

The Mixed Wetland Forest is transitional in character between the Cypress and Hardwood Swamps within the project area and is labeled as a Palustrine Forested Needle-leaved Deciduous/Broad-leaved Evergreen Seasonally flooded wetland per Cowardin et al. (1979). This community type is dominated by bald cypress, laurel oak and sweetgum, in descending order of relative abundance (Table 11). Sweetgum consistently ranks lower by relative basal area than by relative abundance indicating the prevalence of smaller (younger) trees. Pop ash, red maple and American elm are consistent with sweetgum in typical size class. Cypress and laurel oak consistently have a larger relative basal area verses relative abundance, indicating the prevalence of larger trees.

A total of 143 species were identified within the Mixed Wetland Forest, approximately 70% herbaceous species and 30% woody species, including 18 species of trees, 11 species of shrubs, 11 species of woody vines and 102 species of non-woody plants. Of the total 181 species identified across all transects, 79.4% occurred within the Mixed Wetland Forest. Of the 102 species of herbaceous plants within this wetland plant community, 24 species were found in no other wetland types and an additional 48 species were found over half the time in the Mixed Wetland Swamp.

Table 11 Summary of the canopy species and composition for Mixed Wetland Forests along the Middle and Upper Withlacoochee River

Species	Total BA (cm^2)	Count	Avg BA (cm^2)	Relative BA (%)	Relative Abundance (%)	Largest BA (cm^2)	Largest DBH (cm)
Canopy Layer							
Taxodium distichum	191,702	138	1389	47.9	25.7	116.50	10,661
Quercus laurifolia	122,285	129	948	30.6	24.1	107.25	9,035
Fraxinus caroliniana	30,112	60	502	7.5	11.2	124.90	12,254
Acer rubrum	15,172	44	345	3.8	8.2	60.50	2,875
Ulmus americana	13,305	46	289	3.3	8.6	40.50	1,288
Liquidambar styraciflua	11,521	59	195	2.9	11.0	42.50	1,419
Quercus virginiana	4,737	2	2369	1.2	0.4	57.50	2,597
Sabal palmetto	4,019	4	1005	1.0	0.7	48.50	1,848
Pinus elliottii	2,331	2	1166	0.6	0.4	43.50	1,486
Fraxinus pennsylvanica	1,392	1	1392	0.3	0.2	42.10	1,392
Carpinus caroliniana	1,292	23	56	0.3	4.3	15.40	186
Gleditsia aquatica	1,254	5	251	0.3	0.9	25.00	491
Quercus nigra	330	4	83	0.1	0.7	15.00	177
Nyssa sylvatica var. biflora	235	1	235	0.1	0.2	17.30	235
Viburnum obovatum	157	12	13	0.0	2.2	6.00	28
Ilex cassine	108	1	108	0.0	0.2	11.70	108
Diospyros virginiana	47	3	16	0.0	0.6	6.10	29
Salix caroliniana	27	2	14	0.0	0.4	4.20	14
Total	**400,028**	**536**					

The Mixed Wetland Swamp contains 11 of the 13 species of shrubs identified within the study area, the greatest of any of the community types (Table 6). Buttonbush was the most prevalent of the shrubs, accounting for almost 50% of the relative abundance.

The distribution of tree species among the layers suggests that this is a relatively stable forest with little reproduction by the most dominant overstory species. As with the cypress swamp, the successional trend appears consistent with a lack of recent disturbance and a greater prevalence of species capable of reproducing in a shady environment. The general successional trend would appear to be toward a hardwood-dominated swamp.

Hardwood Swamp – PFO1C/PFO3C

The Hardwood Swamp is typically the most landward of the forested wetland plant communities identified within the project area. This community is labeled as a Palustrine Forested Broad-leaved Deciduous/Broad-leaved Evergreen, seasonally flooded wetland per Cowardin et al. (1979). This community type is dominated by ironwood, laurel oak, sweetgum and American elm in descending order of relative abundance (Table 12). Laurel oak accounts for 34% of the relative basal area for this community type, but only 21% of the relative abundance. Ironwood contains the most number of individuals (n=33) and accounts for almost 22% of the relative abundance, but is only 2% of the relative basal area. Thus, while ironwood is prevalent in the canopy, it is primarily younger (smaller) trees. American elm and sweetgum also provide a low basal area in relation to their relative abundance across this community, indicating younger and smaller trees on average, though these trees occur less frequently than ironwood. In contrast, live oak and sabal palm, and water hickory to a lesser extent, account for more basal area than simple number of individuals alone, indicating the prevalence of larger individuals.

A total of 93 species were identified within the Hardwood Swamp, approximately 60% herbaceous species and 40% woody species, including 18 species of trees, 9 species generally considered to be shrubs, 10 species of woody vines, and 56 species of non-woody plants. Of the total 181 species identified across all transects, 51.7% occurred within the Hardwood Swamp. Of the 56 species of herbaceous plants within this wetland plant community, 11 species were found in no other wetland types and an additional five species were found over half the time in the Hardwood Swamp. These 16 species combined accounted for 85% of the species richness within this plant community (Table 6). An additional 40 species were identified within this community, but were less important in terms of numbers.

Table 12 Summary of the canopy species and composition for Hardwood Swamps along the Middle and Upper Withlacoochee River

Species	Total BA (cm^2)	Count	Avg BA (cm^2)	Relative BA (%)	Relative Abundance (%)	Largest BA (cm^2)	Largest DBH (cm)
Canopy Layer							
Quercus laurifolia	27,776	32	868	34	21	100.00	7,855
Quercus virginiana	20,665	6	3,444	26	4	90.00	6,363
Sabal palmetto	10,861	6	1,810	13	4	60.50	2,875
Liquidambar styraciflua	5,649	28	202	7	19	39.40	1,219
Carya aquatica	4,746	6	791	6	4	74.50	4,360
Quercus nigra	2,197	5	439	3	3	48.50	1,848
Pinus elliottii	2,059	1	2,059	3	1	51.20	2,059
Fraxinus caroliniana	1,791	5	358	2	3	34.40	930
Carpinus caroliniana	1,724	33	52	2	22	14.00	154
Pinus serotina	1,238	1	1,238	2	1	39.70	1,238
Ulmus americana	962	14	69	1	9	15.70	194
Taxodium distichum	730	3	243	1	2	25.00	491
Acer rubrum	319	3	106	0	2	18.50	269
Celtis laevigata	50	2	25	0	1	5.90	27
Diospyros virginiana	18	2	9	0	1	3.40	9
Total	**80,785**	**147**					

The Hardwood Swamp contained 10 of the 13 shrub species found within this project area. This value excludes shrub-sized trees present within sampling points. Of those 10 shrubs, buttonbush, Walter's viburnum (*Viburnum obovatum*), saw palmetto (*Serenoa repens*) and *Sideroxlyon reclinatum* accounted for 75% of the total shrub individuals.

The distribution of tree species among the layers suggests that this is a relatively stable forest with little reproduction by the most dominant overstory species. As with the cypress swamp, the successional trend appears consistent with a lack of recent disturbance and a greater prevalence of species capable of reproducing in a shady environment. The general successional trend would appear to be toward a hardwood-dominated swamp.

Herbaceous Wetland – PEM1F

The herbaceous wetlands were primarily located at shallow areas along the main river channel or adjacent to side channels. Only nine points were evaluated, therefore significant statistical analysis of this community is not appropriate. Five species of trees common in adjacent forested communities were identified within dominantly herbaceous communities (Table 13). All only occurred one time, except for Carolina willow, which occurred three times. Likewise, shrubs were not abundant and are only minor components of the community with buttonbush being the dominantly occurring shrub species. The most abundant groundcover species were coinwort (*Centella asiatica*), pennywort (*Hydrocotyle umbellata*) and smartweed (*Polygonum hydropiperoides*) which together accounted for 71% of the groundcover.

Table 13 Summary of the canopy species and composition within Herbaceous Wetlands along the Middle and Upper Withlacoochee River

Species	Total BA (cm^2)	Count	Avg BA (cm^2)	Relative BA (%)	Relative Abundance (%)	Largest DBH (cm)
Quercus laurifolia	222	1	222	40	14	16.8
Liquidambar styraciflua	113	1	113	20	14	12
Carpinus caroliniana	108	1	108	19	14	11.7
Salix caroliniana	99	3	33	18	43	7.5
Fraxinus caroliniana	13	1	13	2	14	4
Total	**553**	**7**				

Shrub Wetland – PSS1C

A single Shrub Wetland was sampled in a depressional area. Only two points were evaluated, therefore no statistical analysis of this community was conducted. Typical species identified within this community were *Azolla caroliniana, Hydrocotyle umbellata, Boehmeria cylindrica, Centella asiatica, Saururus cernuus, Thelypteris* spp.

Willow Wetland – PSS1C

A single Willow Wetland was sampled. Only two points were evaluated, therefore no statistical analysis of this community was conducted. Typical species within this community included coastal plain willow (*Salix caroliniana*), *Carex albolutescens* and *Hydrocotyle umbellata*.

Uplands

Upland plant community evaluation was not a goal of this research, however, sufficient transect points were identified as uplands to provide a general description of the typical upland plant communities found within and immediately adjacent to the floodplain. Collectively, 28.9% of the species identified within the project area were identified within the upland plant communities, including 21 species of herbaceous plants, 16 species of trees, 6 species of shrubs and 9 species of vines.

Live and laurel oaks combined contributed over 50% of the relative basal area for the limited areas of surveyed uplands along the Withlacoochee River floodplain. Ironwood and sweet gum were the most prevalent trees in terms of relative abundance, though these trees were typically very young or small trees. The largest tree identified within the surveyed uplands was a laurel oak, with an 80.3 cm dbh. Saw palmetto was the primary shrub identified.

Table 14 Summary of the canopy species and composition within upland communities along the Middle and Upper Withlacoochee River

Upland	BA cm2	Count	Avg BA (cm2)	Rel BA (%)	Rel Abun (%)	Largest DBH (cm)
Quercus virginiana	21,387	9	2,376	45	14	77
Quercus laurifolia	9,104	6	1,517	19	9	80.3
Pinus elliottii	4,080	5	816	9	8	44.5
Liquidambar styraciflua	3,681	11	335	8	17	42.3
Quercus nigra	3,184	8	398	7	12	45.5
Carpinus caroliniana	2,010	13	155	4	20	31.1
Sabal palmetto	1,555	1	1,555	3	2	44.5
Taxodium distichum	755	1	755	2	2	31
Persea borbonia	663	6	110	1	9	24
Fraxinus caroliniana	552	1	552	1	2	26.5
Salix caroliniana	99	3	33	0	5	7.5
Acer rubrum	17	2	9	0	3	3.5
Total	**47,088**	**66**				

Walter's viburnum was the most common shrub, comprising 40% of all shrub-sized individuals within the uplands followed by sparkleberry (*Vaccineum arboreum*) and buttonbush comprising 23% and 19% of the shrubs, respectively. The most prevalent herbaceous species present were *Hypericum hypericoides, Dichanthelium commutatum,* and *Galium tinctorium*. The most common vines were *Vitis rotundifolia, Gelsemium sempervirens, Smilax bona-nox* and *Smilax laurifolia*.

Soils

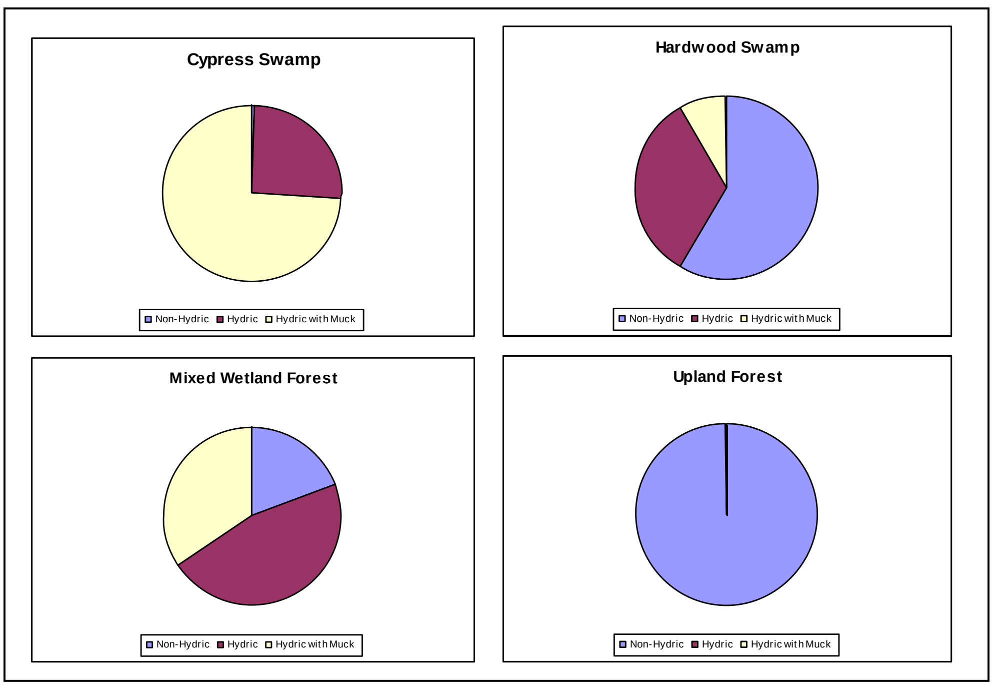
A total of 310 soil borings were made along the 26 transects to determine the presence or absence of hydric soils. The number of borings per transect varied depending on the topographic relief present and the variability of the habitat types present. The ability to evaluate soils was limited in later transects as water levels rose and portions of the swamps became inundated, thus precluding soil borings. Approximately 25%

of the soil borings made were non-hydric in nature, based on the hydric soil indicators. The remaining 75% were hydric, based on meeting at least one of the hydric soil indicators.

Soils closer to the river banks tended to be finer materials than soils farther from the river banks, where coarser sandy material typically dominated the surface horizons. Soil samples were taken from several transects along the lower river and analyzed in a lab in order to calibrate the finer textured materials. Results came back as mainly sandy clay loams or coarser.

The most prominent hydric soil indicator was Muck Presence (A8), followed by 5cm Mucky Mineral (A7), and Dark Surface (S7). Other hydric soil indicators identified at least once along the transects include Redox Dark Surface (F6), Depleted Matrix (F3), Thin Dark Surface (S9), Sandy Redox (S5), Stripped Matrix (S6), and Organic Bodies (A6) (Figure 1). For evaluation of the hydric nature of the project area soils, Shrub, Herb and Willow wetlands were removed from the analysis due to low sample size. The Upland Forest had entirely non-hydric soils, consistent with what was expected for this habitat. Cypress Swamp soils were entirely hydric, with muck presence accounting for 74% of the soils. Mixed Wetland Forest was 80% hydric soils with approximately 40% containing muck. The Hardwood Swamp was only 40% hydric soils, with only 20% of those hydric soil pits containing muck. The remaining 60% of the Hardwood Swamp pits were non-hydric.

Figure 1. Frequency of hydric, hydric with muck, and non-hydric indicators by Community



Mean elevations of hydric soils were significantly lower than non-hydric soils, with mucky soils occurring at significantly lower elevations than non-mucky hydric soils (P<0.01). Mean elevations of the habitats were also significantly different from one another (Table 15), and consistent with the transition of habitats in the field.

Table 15 Average elevations of soil pits based on presence/absence of hydric soil indicators

	Non-Hydric	N	Hydric	N	Hydric w/ muck	N
With Near River Road	72.1	2	n/a	0	n/a	0
1	71.5	4	70.9	3	n/a	0
2	72.6	8	72.4	1	70.8	3
3	71.3	2	70	2	68.9	2
4	68.7	3	67.5	3	66.3	1
5	68.7	2	67.5	1	65.8	3
6	68.9	6	67.4	4	66.8	3
7	63.6	4	61.7	2	61.7	3
8	62.3	5	59	4	56.6	1
With at Trilby	58.6	1	55.7	4	n/a	0
Croom	46.6	4	44.6	5	n/a	0
9	45.8	5	44.4	7	41.3	5
10	46.3	2	43.8	8	40.3	2
11	45.8	3	42.2	3	40.5	3
12	44.5	5	42.9	10	40.6	2
13	44.5	2	41.3	3	39.6	2
WithAbout476	46	6	42.1	4	39.2	1
16	39.4	1	37.8	3	34.9	13
17	n/a	0	37.7	9	34.3	12
18	39.8	2	38.4	2	36	16
19	35.2	2	35.1	3	35.2	19

With Near Turner Camp	n/a	0	37.4	5	34.3	11
20	36	3	34.9	6	33.4	7
21	37.6	3	34.4	1	32.4	9
22	35.5	1	33.8	2	31.5	9
With Above 200	34.7	3	32.7	4	32.7	7
Total Average Elevation	52.3	79	48.6	99	45.6	134

Hydrologic Indicators

The width of the river floodplain swamps ranged between approximately 200 feet to just over 4000 feet in width (excluding river width) within the study area. Within these areas, hydrologic indicators were evaluated to determine how these indicators compared with other vegetative and elevation data. Elevations were determined for both palmetto edge lines, and moss collars and lichen lines, where present. Lichen lines were typically several feet higher than the wetland edge elevations indicating substantial difference between recent inundation conditions (Figure 2) and the water elevations that caused the formation of the lichen lines. Foliose lichens are sensitive to even brief inundation, inundation too brief to cause changes in wetland lines. Near record high water levels occurred in September and October 2004 (SWFWMD data as obtained from the USGS web site), and the lichen lines are believed to have resulted from flood conditions at that time. Lichen lines across all transects were very precise, typically within 1-2 tenths of a foot along a transect, though they were not consistent with the wetland edge elevations. The difference between the jurisdictional wetland limits and the lichen lines ranged from 3.4 feet below the wetland limits to 6.3 feet above the wetland limits (Figure 3). Other hydrological indicators, such as adventitious rooting and "shoulders" on tree buttresses, were noticeably lacking.

Figure 2. Lichen line versus wetland edge elevations along the Withlacoochee River floodplain

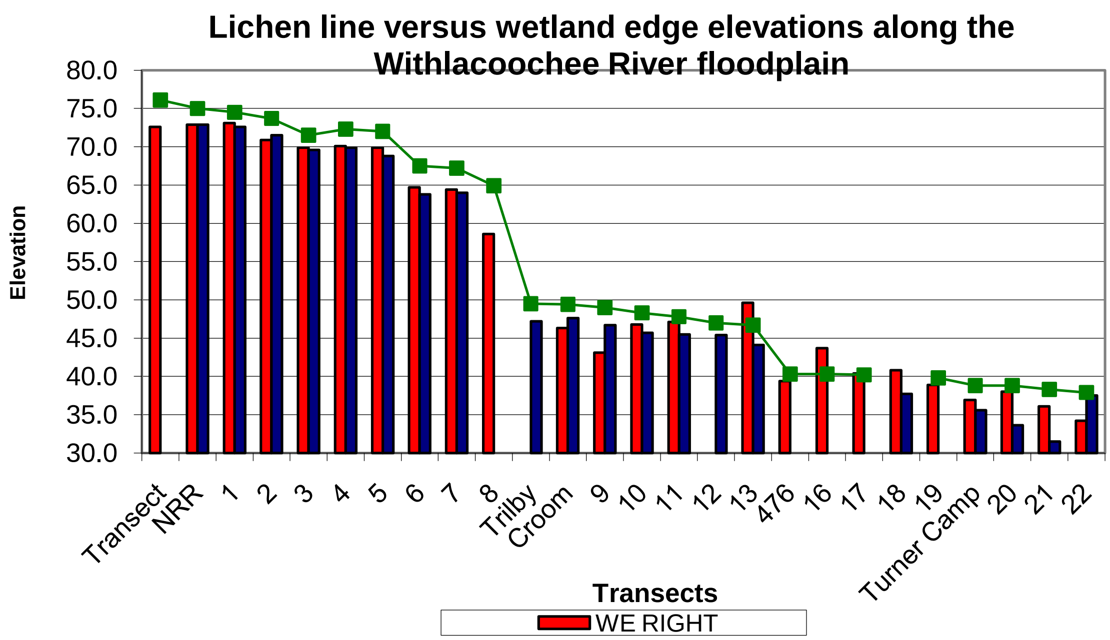
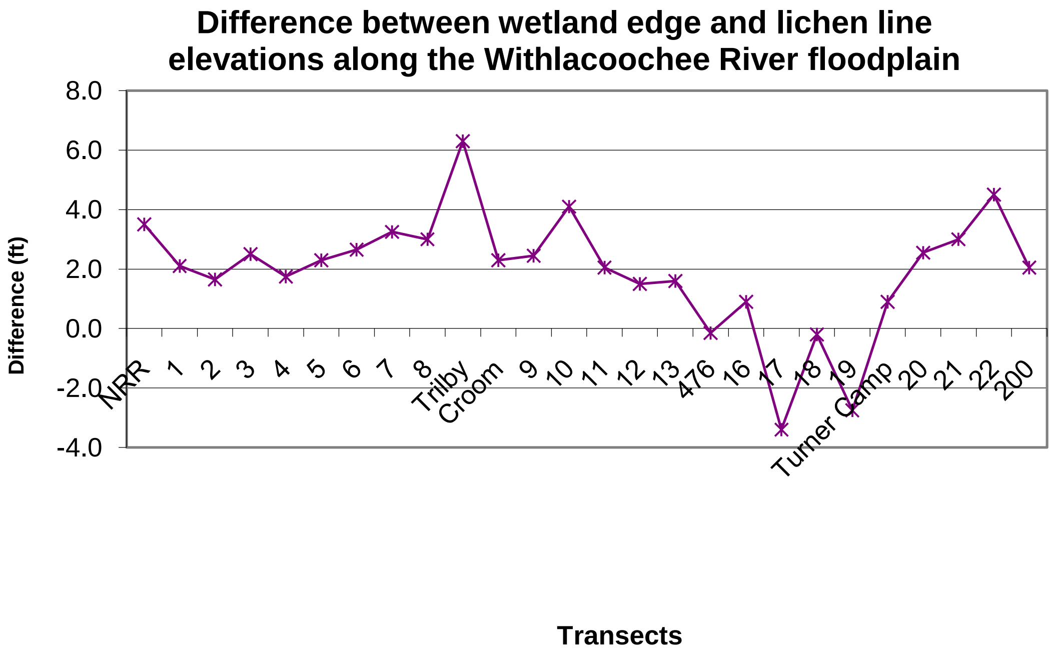


Figure 3. **Difference between wetland edge and lichen line elevations along the Withlacoochee River floodplain**



Discriminant Function Analysis (DFA)

A discriminant function analysis was conducted to evaluate the extent to which the occurrence vegetative communities could be associated with physical transect characteristics and soils. Several variables were identified in order to determine accuracy of the community classification, including vegetation ranking, distance to wetland edge, location (northing and easting as a proxy for latitude and longitude), soil variables including muck presence and clays, elevation, and others. Each of these variables was determined in relation to each PCQ point along the transect so that each point had a discrete value for each variable. The location of each point in terms of longitude and latitude (northing and easting) was surveyed. In addition, the elevation and location at the base of the trunk of saw palmetto identified as the upland limits of the wetland communities was recorded for each transect. The distance from each PCQ point to the saw palmetto was identified for each point. Lastly, each species of plant identified was ranked in terms of its typical hydrologic regime from 1 to 5, with "1" being regularly inundated to "5" being upland. For every PCQ point, the ranking was assigned for each species of plant, and the plant ranks were then averaged to provide a single ranked score for each PCQ point.

Vegetation ranking, relative elevation to wetland edge as indicated by saw palmetto elevation, latitude and distance downstream as represented by northing, soil index, soil organic matter, and clay contribute significantly to the model that discriminates between vegetation communities (Wilks lambda = 0.48, F = 14.014, p<0.0001). Other variables were considered but not determined to be important in the final analysis because they were either collinear with other variables that were stronger in the discriminant model or they were not significant contributors to the model at all. The R-squares for the included variables were fairly similar suggesting that the variables contribute about equally to the overall discrimination of the vegetative communities (Table 16). Vegetation ranking had a slightly higher R-square. Wilks' lambda is used to test which independents contribute significantly to the discriminant function. The smaller the variable Wilks' lambda for an independent variable, the more that variable contributes to the discriminant function. Again, the vegetation ranking, an indirect measure of inundation frequency and duration, had the greatest contribution to the discriminant function.

Table 16 Summary of significant variables from Discriminant Function Analysis for vegetation communities on the Withlacoochee River.

Variable	R-square	Partial Wilks' Lambda	F	p
Vegetation Ranking	0.43	0.66	38.96	0.00
Relative Elevation (to wetland edge)	0.30	0.95	4.15	0.00
Northing	0.32	0.90	8.73	0.00
Soil Index	0.31	0.94	5.18	0.00
Organic Matter	0.30	0.95	4.18	0.00
Clay	0.31	0.94	5.05	0.00
*Removed vegetation type (willow) from analysis for sample size <3				

Table 17 and Figure 2 show the classifications and misclassifications of the DFA. The first column gives the field-identified vegetative community classification. The remaining columns give the classifications as predicted by the DFA. For example, for Mixed Wetland Forest, 47.7 percent (63 of the total of 132) were classified correctly as Mixed Wetland Forest, and the remaining 52.3 % were misclassified as Upland, Cypress, Hardwood Forest Mixed, or Herbaceous. For Cypress, 77.6% (97 of the total of 125) were classified correctly, none were mistakenly classified as uplands or Hardwood Forest Mixed, and while 12.8% (16) were inappropriately classified as Mixed Wetland Forest.

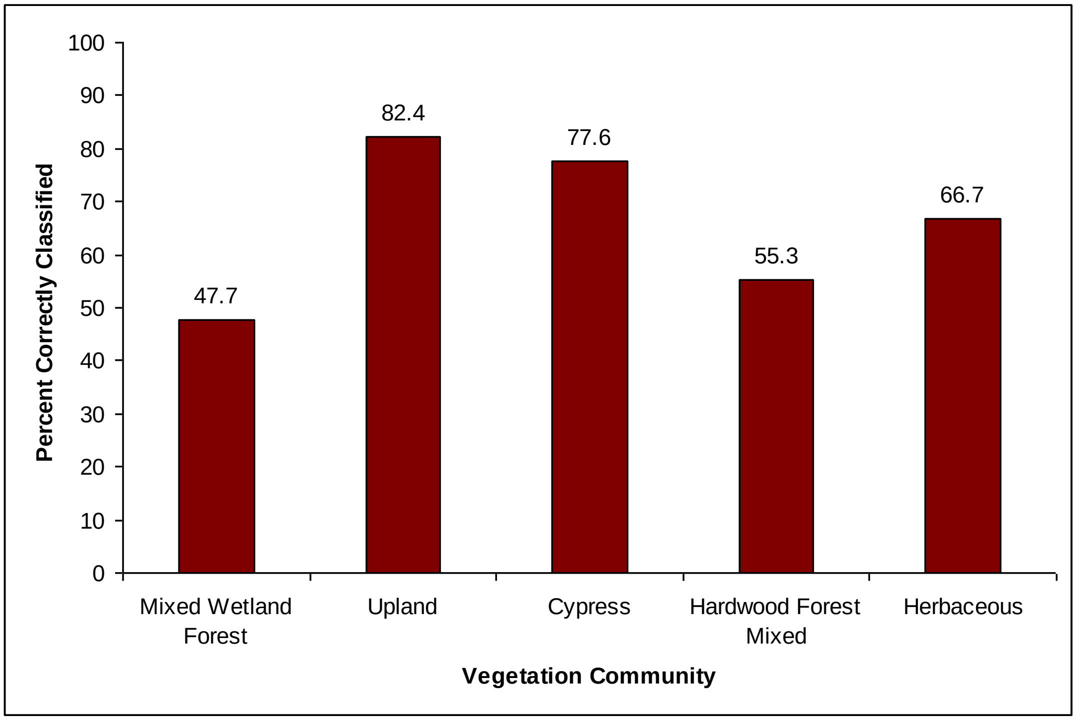
Of the vegetative communities, Uplands were correctly classified most frequently (82.4% of the time) followed in decreasing order of accuracy by Cypress (77.6%), Herbaceous (66.7%), Hardwood Forest Mixed (55.3%), and Mixed Wetland Forest (47.7%). Ignoring Herbaceous for which the sample size was extremely small, Cypress was most likely to be misclassified as Mixed Wetland Forest and was never misclassified as Upland or Hardwood Forest Mixed. Hardwood Forest Mixed was most likely to be misclassified as Upland or Mixed Wetland Forest, never as Cypress. This pattern of misclassification supports the observed species composition of the vegetative communities that shows considerable overlap in species composition. It also suggests that there is a predictable overall continuum of "wetter" to "drier" communities of Cypress (wetter) – Mixed Wetland Forest – Hardwood Forest Mixed – Upland and that most misclassifications are restricted to community types adjacent along this continuum.

Table 17 Results of DFA analysis for classification and misclassification of vegetative communities on the Withlacoochee River.

	Percent and Number of Communities Correctly Identified					
Vegetation Class (field)	Mixed Wetland Forest	Upland	Cypress	Hardwood Swamp	Herbaceous	Total
Mixed Wetland Forest	47.7 (63)	16.7 (22)	19.7 (26)	11.4 (15)	4.5 (6)	100 (132)

Vegetation Class (field)	Percent and Number of Communities Correctly Identified: Mixed Wetland Forest	Upland	Cypress	Hardwood Swamp	Herbaceous	Total
Upland	0 (0)	82.4 (14)	0 (0)	17.6 (3)	0 (0)	100 (17)
Cypress	12.8 (16)	0 (0)	77.6 (97)	0 (0)	9.6 (12)	100 (125)
Hardwood Swamps	15.8 (6)	28.9 (11)	0 (0)	55.3 (21)	0 (0)	100 (38)
Herbaceous	0 (0)	0 (0)	16.7 (1)	16.7 (1)	66.7 (4)	100 (6)
Total	26.7 (85)	14.8 (47)	39 (124)	12.6 (40)	6.9 (22)	100 (318)

Figure 4. Percent of observations correctly classified for each observed vegetation type.



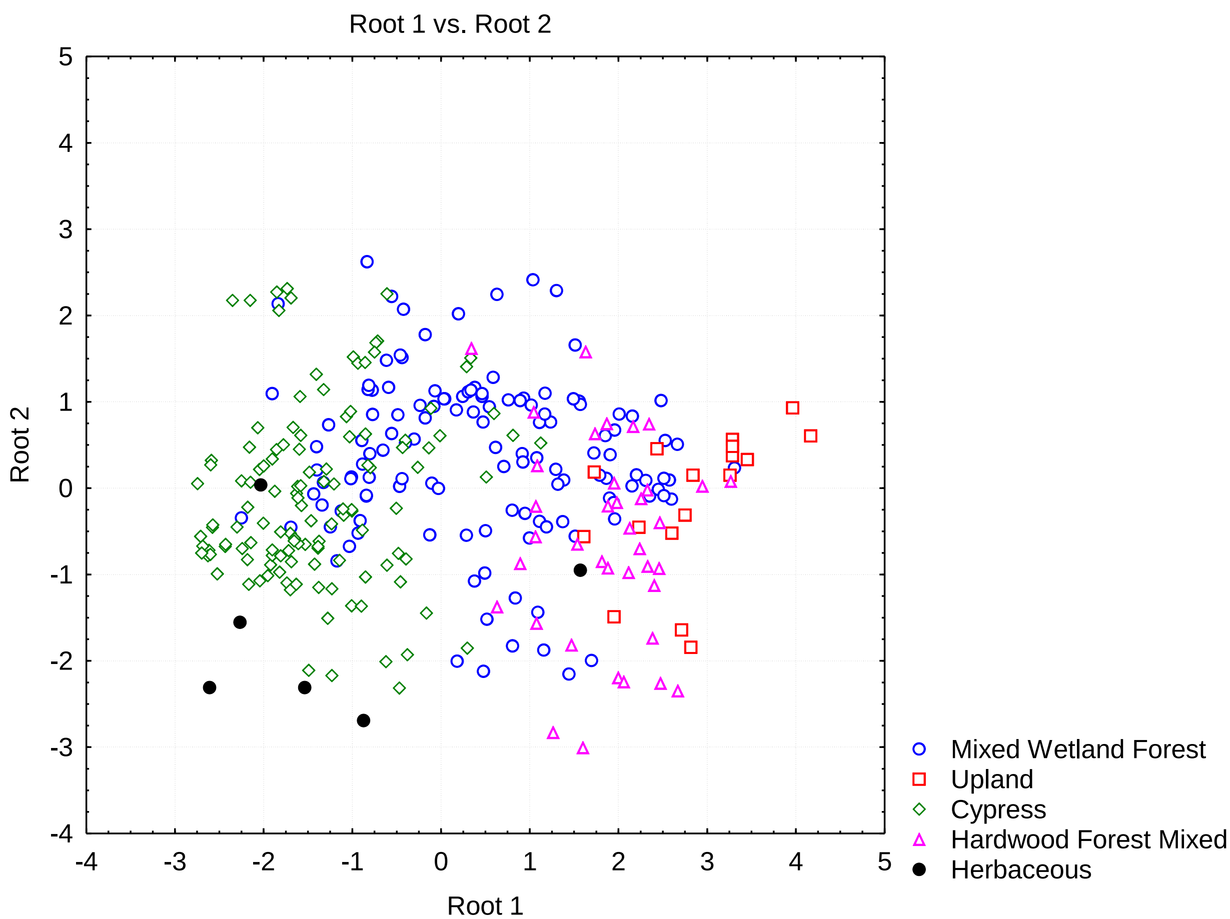
A canonical factor analysis (Table 18, Figure 3) revealed that Root 1 (which was heavily weighted to the vegetation ranking, soil index, and relative elevation) explained 88% of the differences between classes. Root 2, which was weighted toward location (northing, which was collinear with absolute elevation), explained an additional 8%. The last two roots added little discrimination between vegetation classes.

Figure 3 shows the separations between wetland vegetative communities on the basis of the first two factors. Consistent with the classification/misclassification table (Table 17), Upland and Cypress cluster clearly on the graph, as do the limited number of Herbaceous points. Herbaceous points tended to have a soil index of 1, an organic matter index of 1, a low vegetation ranking (1-2) and a low elevation relative to the wetland edge (egg., they are deep). Cypress tended to have a soil index of 2 and an organic matter index of 2, or a soil index of 1 and relatively low elevation. Cypress also tended to have a low vegetation ranking (1-2).

Table 18 Standardized Coefficients of Canonical Factor Analysis from DFA.

	Root 1	Root 2	Root 3	Root 4
Vegetation Ranking	0.89	-0.11	-0.38	0.74
Relative Elevation (to Saw Palmetto)	-0.07	-0.50	-0.73	0.39
Northing	0.13	-0.93	0.14	0.18
Soil Index	-0.44	0.47	-0.47	0.22
Organic Matter	0.38	0.38	0.76	0.99
Clay	0.32	0.63	-0.02	0.51
Eigen Value	1.76	0.16	0.06	0.03
Cumulative Proportion	0.88	0.96	0.99	1.00

Figure 5 Plot of observed vegetation classes along Root 1 (~vegetative ranking, soil index, relative elevation) and Root 2 (location).



Conclusions

This study of the vegetation, soils, elevations and hydrologic indicators of the Withlacoochee River floodplain was conducted to assist the SWFWMD in establishing minimum flows and levels for this river system. The study included 352 vegetation sampling points and 310 soil borings along 26 transects over 76 miles of the river.

From these evaluations, three generalized floodplain communities were identified: Cypress Swamps (semi-permanently flooded), Mixed Wetland Forests (seasonally flooded) and Hardwood Swamps (seasonally to intermittently flooded). Additional communities identified in lesser quantities which were not the focus of this study included shrub and willow wetlands, herbaceous marshes and various upland communities located either as islands within transects or at the floodplain limits. A total of 181 species of trees, shrubs, herbs, vines and ferns were identified amongst all the transects. Of these, 54 species of woody vegetation (trees, shrubs, vines) were identified.

The wetland plant communities tend to be highly similar and overlap substantially in species composition. While the greatest number of species of plants were identified within what was classified as the Mixed Wetland Forest, this community type was statistically the most likely to be classified incorrectly, followed by the Hardwood Swamp. Uplands and Cypress were most likely to be classified correctly. These are typically the most extreme of the communities encountered along the Withlacoochee, and do typically provide a fairly clear delineation. Soils supported this as almost all of the soils in the Cypress Swamp were hydric, while all the soils in the uplands were non-hydric. Some of the challenges in the proper classification of communities in the field are identification and use of an appropriate classification system and the difficulties in determining a single point in the field to delineate a community boundary.

Strong lichen lines were evident over all of the transects and appeared consistent with a large storm event within the recent past, as this lichen line was typically well above the saw palmetto lines and wetland edges by up to 6.3 feet, a likely result of near-record high water levels that occurred in September and October 2004. Some variation occurred while identifying wetland edges because of the presence of side channels and back swamps which were not always apparent connections while in the field. Substantial additional field exploration and elevation surveying would have been necessary to determine exact pop-off elevations for these back swamps to determine whether these were connected to the main floodplain or not. Decisions on connectivity were made using field knowledge in conjunction with aerial photographs and reasonable scientific judgment.

Soil borings helped explain the variation among wetland community types. Clays, when present, were more likely to be within a foot of the soil surface closer to the river, whereas the soils nearer the uplands were dominantly sandy soils. The presence of clays in many of these soils strongly affects the water holding capacity of these soils, and clayey soils retain moisture longer than sandy soils. Clays near the surface effectively allow the soil moisture to remain high longer than occurs with sandy soils even when the soils are at about the same relative elevations. Additionally, muck was present in 74% of the Cypress Swamp soil borings, 40% of the Mixed Wetland Forest and 20% of the Hardwood Swamp. Over half of the soil borings in Hardwood Swamps were non-hydric, indicating that this area has not maintained enough moisture to retain indicators of hydric conditions sufficient to be labeled as a hydric soil, and/or that these areas are better classified as bottomland forests within the floodplains but not wetlands.

Changes in water levels can be expected to have the greatest impact on the Cypress Swamp, based on the wetted perimeter calculations, followed by the Mixed Wetland Forest. Changes in wetter perimeter were less apparent for the Hardwood Swamp and lastly, the upland communities.

In conclusion, the Withlacoochee River is a very diverse river in terms of species richness, and matches the richness and diversity of the more diverse floodplain systems previously evaluated in Florida based on studies conducted by others (Light et al. 2001, Leitman et al. 1984, Light et al. 1993, and Brinson 1990).

Literature Cited

Brinson, M.M., Swift, B.L., Plantico, R.C., and Barclay, J.S., 1981, Riparian ecosystems: Their ecology and status: Kearneysville, W.Va., U.S. Fish and Wildlife Service, FWS/OBS-81/17, 155 p.

Carr, David W. and T. F. Rochow. 2004. Comparison of six biologic indicators of hydrology in isolated Taxodium acsendens domes. Southwest Florida Water Management District Technical Memorandum, 19 April 2004. 4 pages.

Conservation Service. 2010. Field Indicators of Hydric Soils in the United States, Version 7.0. L.M. Vasilas, G.W. Hurt, and C.V. Noble (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

Cottam, G. and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 37(3): 451-460.

Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and Deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/1998/classwet/classwet.htm (Version 04DEC98).

Cox, J., Kautz, R., MacLaughlin, M. and T. Gilbert. 1994. Closing the gaps in Florida's Wildlife Habitat Conservation System, prepared for Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, 239 p

Environmental Laboratory. 1987. Corps of Engineers Wetland Delineation Manual, Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Federal Register. July 13, 1994. Changes in Hydric Soils of the United States.

Florida Department of Transportation (FDOT). 1999. Florida Land Use, Cover and Forms Classification System (FLUCFCS).

Florida Natural Areas Inventory and Florida Department of Natural Resources. 1990. Guide to Natural Communities of Florida. 116 p.

Leitman, H.M., Sohm, J.E., and Franklin, M.A., 1983, Wetland hydrology and tree distribution of the

Apalachicola River flood plain, Florida: U.S. Geological Survey Water-Supply Paper 2196-A, 52 p.

Light, H.M., M.R., Darst, M.T. MacLaughlin, and S.W. Sprecher. 1993. Hydrology, vegetation, and soils of four north Florida river flood plains with an evaluation of State and Federal wetland delineations. U.S. Geological Survey Water Resources Investigations Report 93-4033, 94 pages.

Light, H.M., M.R., Darst, L.J., Lewis, and D.A. Howell. 2001. Hydrology, Vegetation, and Soils of Riverine and Tidal Floodplain Forests of the Lower Suwannee River, Florida, and Potential Impacts of Flow Reductions. U.S. Geological Survey Professional Paper 1656A. 124 pages.

Mitchell, K. 2007. Quantitative analysis by the Point-Centered Quarter method. Hobart and William Smith Colleges, Geneva, NY. http://people.hws.edu/mitchell/PCQM.pdf. 34 p.

Schitoskey, Frank, Jr., and Linder R.L., 1979, Use of wetlands by upland wildlife, in Greeson, P.E., Clark J.R., and Clark, J.E., eds., Wetland functions and values: The state of our understanding—Proceedings of the national symposium on wetlands, Lake Buena Vista, Florida, November 1978: Minneapolis, American Water Resources Association, Technical Publication Series TPS79-2, p. 307-311

Soil Conservation Service, U.S.D.A., Soil Survey of Citrus County, Florida. 1988.

Soil Conservation Service, U.S.D.A., Soil Survey of Hernando County, Florida. 1977.

Soil Conservation Service, U.S.D.A., Soil Survey of Pasco County, Florida. 1982.

Soil Conservation Service, U.S.D.A., Soil Survey of Sumter County, Florida. 1988.

Soil Survey Staff. 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. USDA Natural Resources Conservation Service, Agric. Hdbk. 436, U.S. Government Printing Office, Washington, D.C. 869 pp.

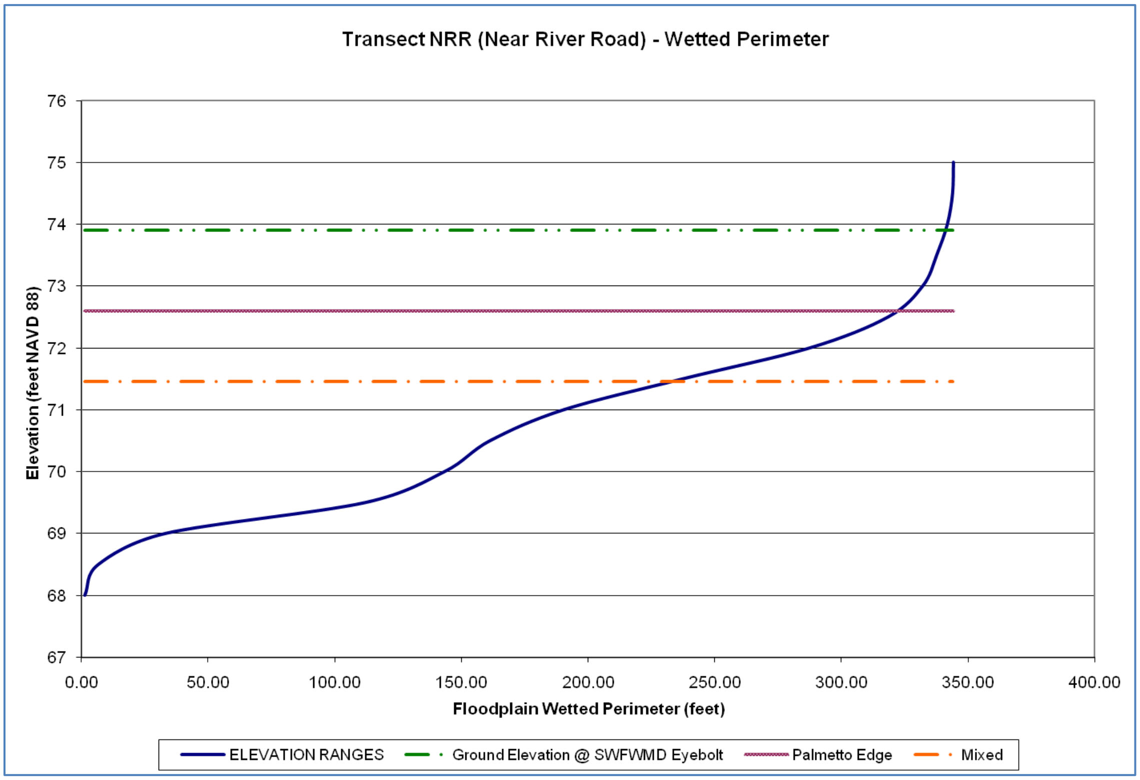
Southwest Florida Water Management District. 2001. Withlacoochee River Comprehensive Watershed Management Plan. 107 p.

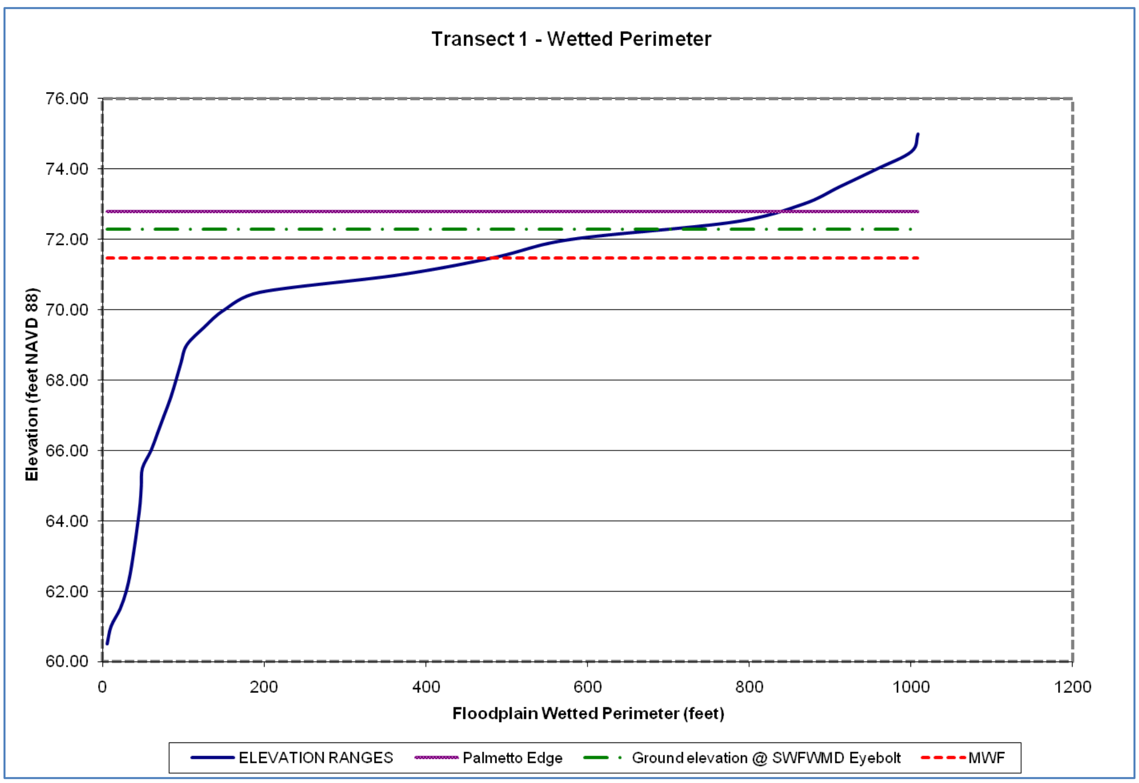
United States Department of Agriculture, Natural Resources Conservation Service. 2010. Field Indicators of Hydric Soils in the United States, Version 7.0. L.M. Vasilas, G.W. Hurt, and C.V. Noble (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

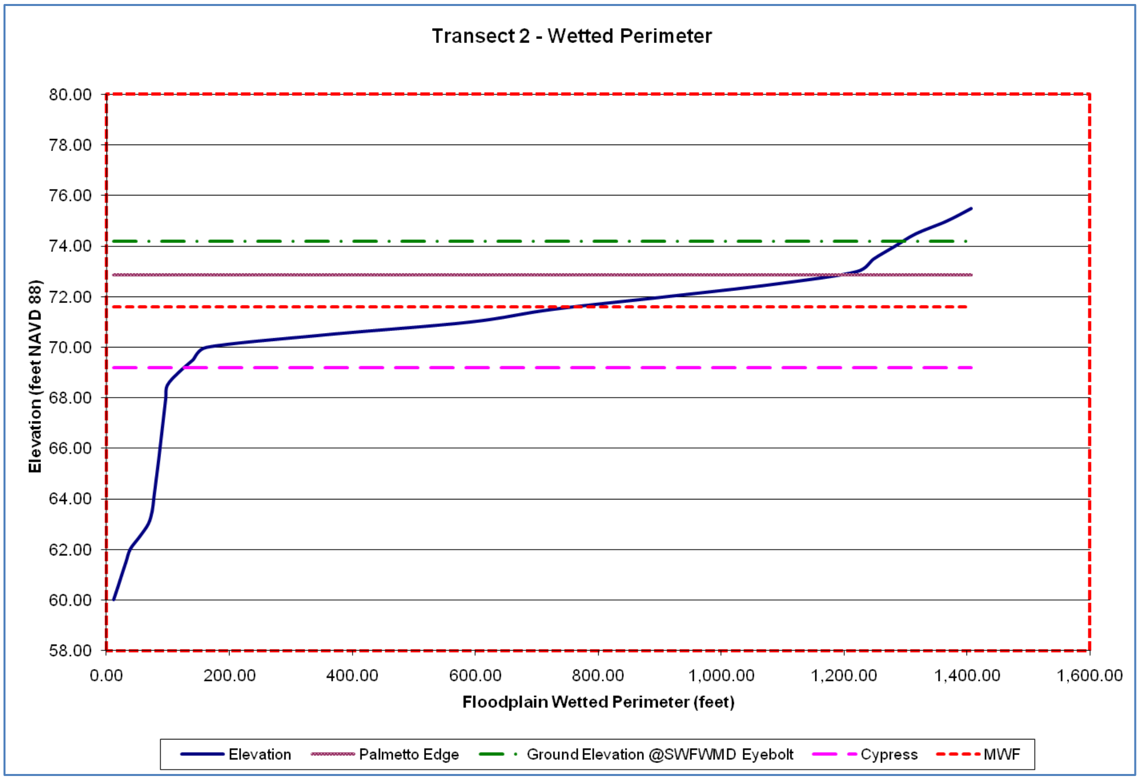
Uranowski, C., Lin, Z., DelCharco, M., Huegel, C., Garcia, J., Bartsch, I., Flannery, M. S., Miller, S. J., Bacheler, J., and Ainslie, W. (2003). .A Regional Guidebook for applying the hydrogeomorphic approach to assessing wetland functions of low-gradient, Blackwater riverine wetlands in peninsular Florida,. ERDC/EL TR-03-3, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Wharton, C.H., Kitchens, W.M., Pendleton, E.C., and Sipe, T.W. 1982. The ecology of bottomland hardwood swamps of the southeast: A community profile. U.S. Fish and Wildlife Service FWS/OBS-81/37. 133 p.

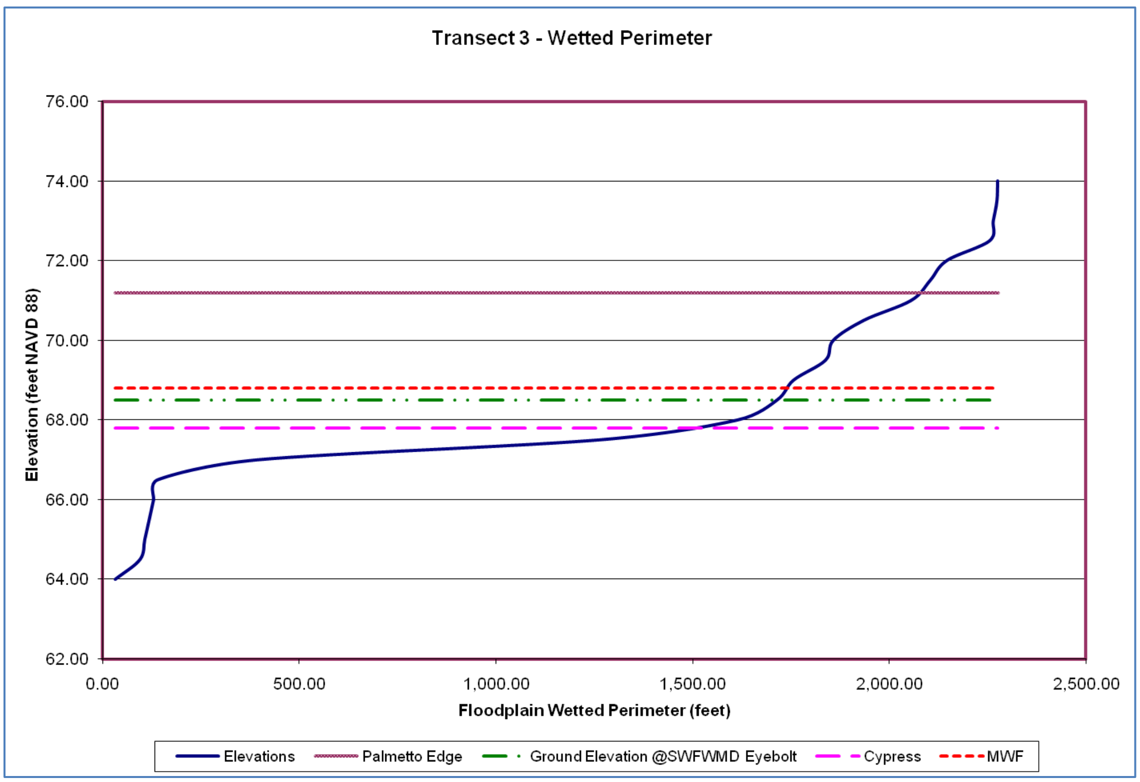
Vegetation Appendix A – Wetted Perimeters



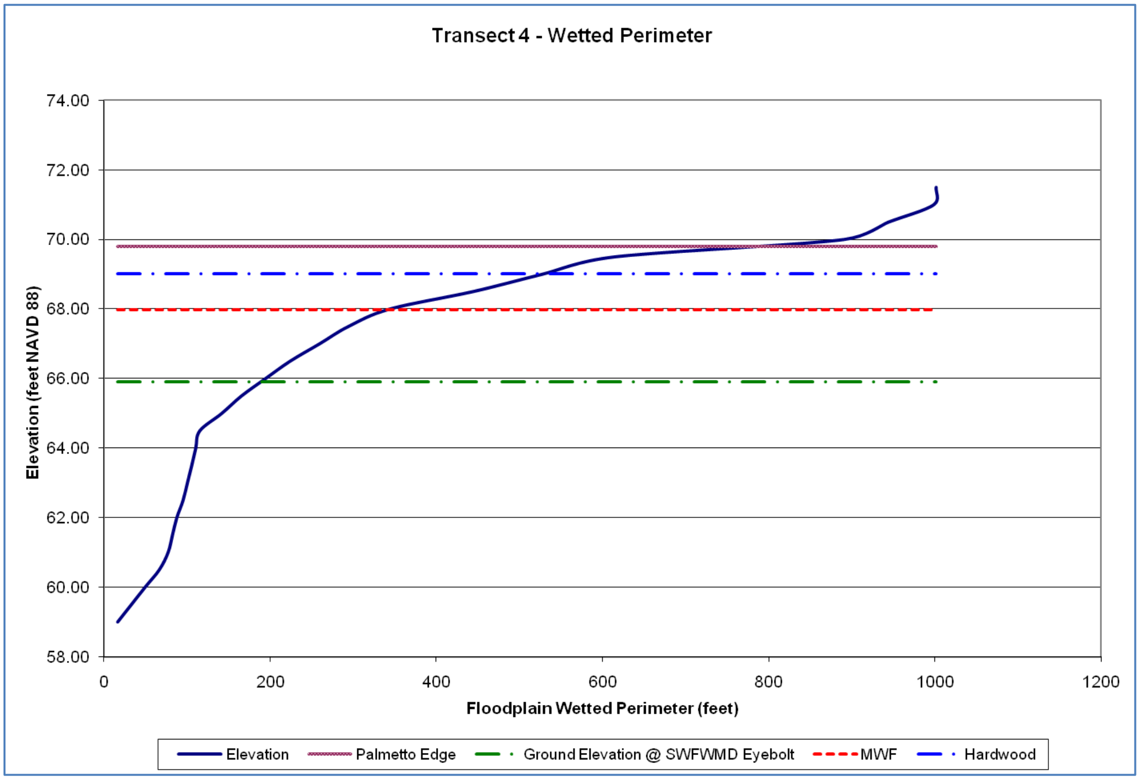


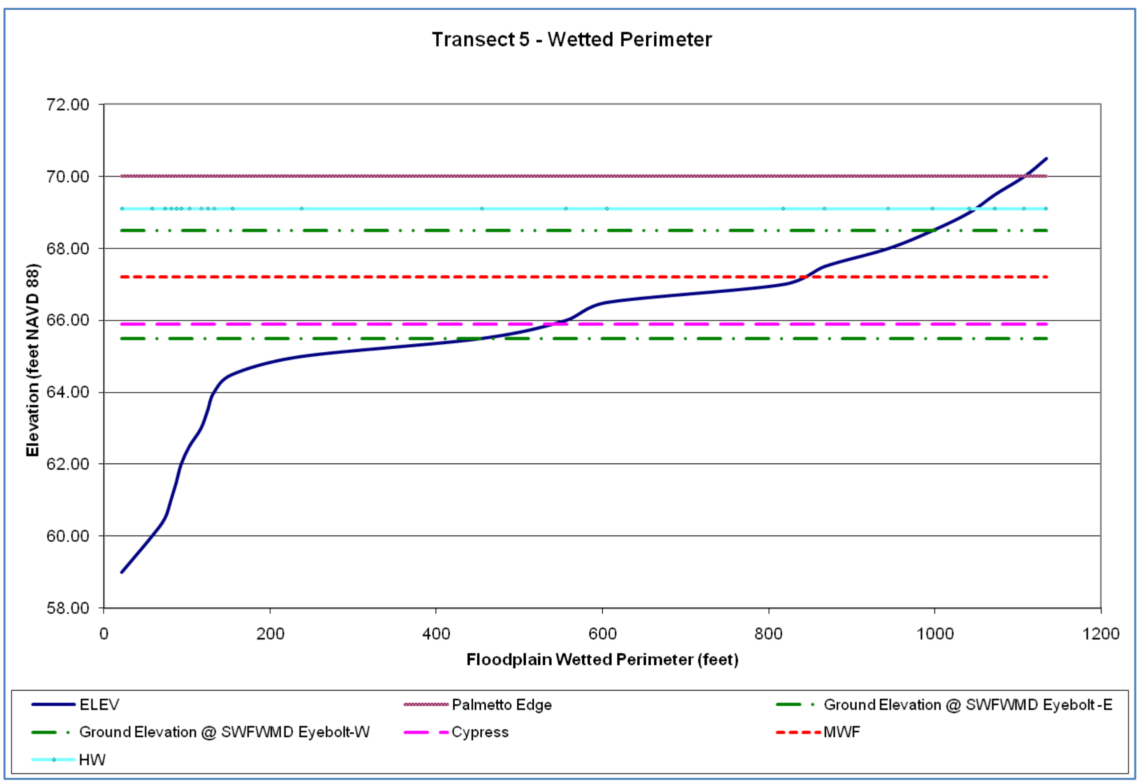


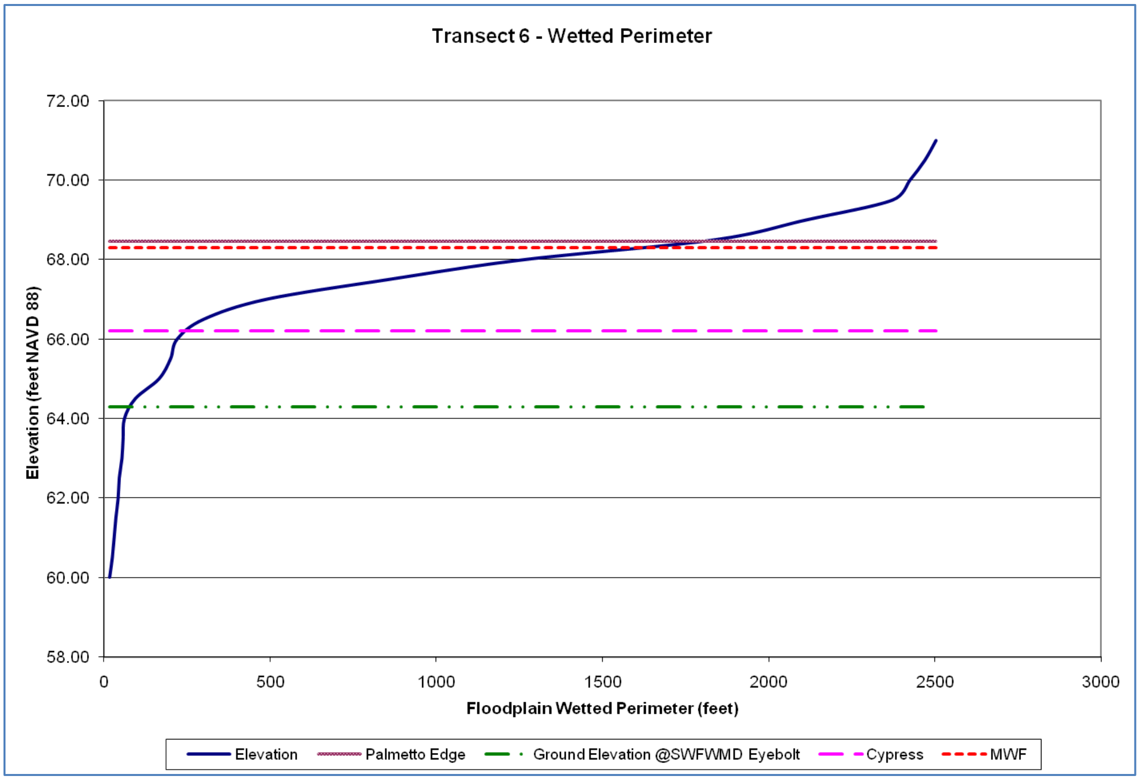
Transect 2 - Wetted Perimeter
Elevation (feet NAVD 88)
80.00
78.00
76.00
74.00
72.00
70.00
68.00
66.00
64.00
62.00
60.00
58.00
0.00
200.00
400.00
600.00
800.00
1,000.00
1,200.00
1,400.00
1,600.00
Floodplain Wetted Perimeter (feet)
Elevation
Palmetto Edge
Ground Elevation @SWFWMD Eyebolt
Cypress
MWF

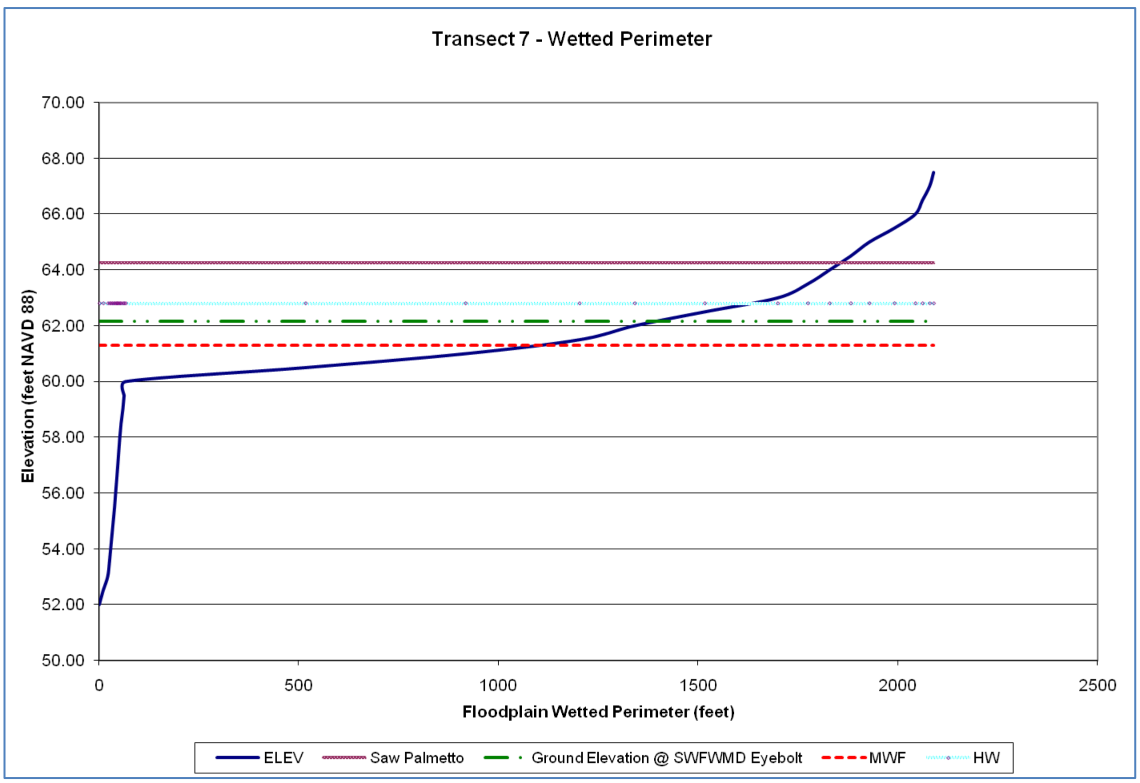


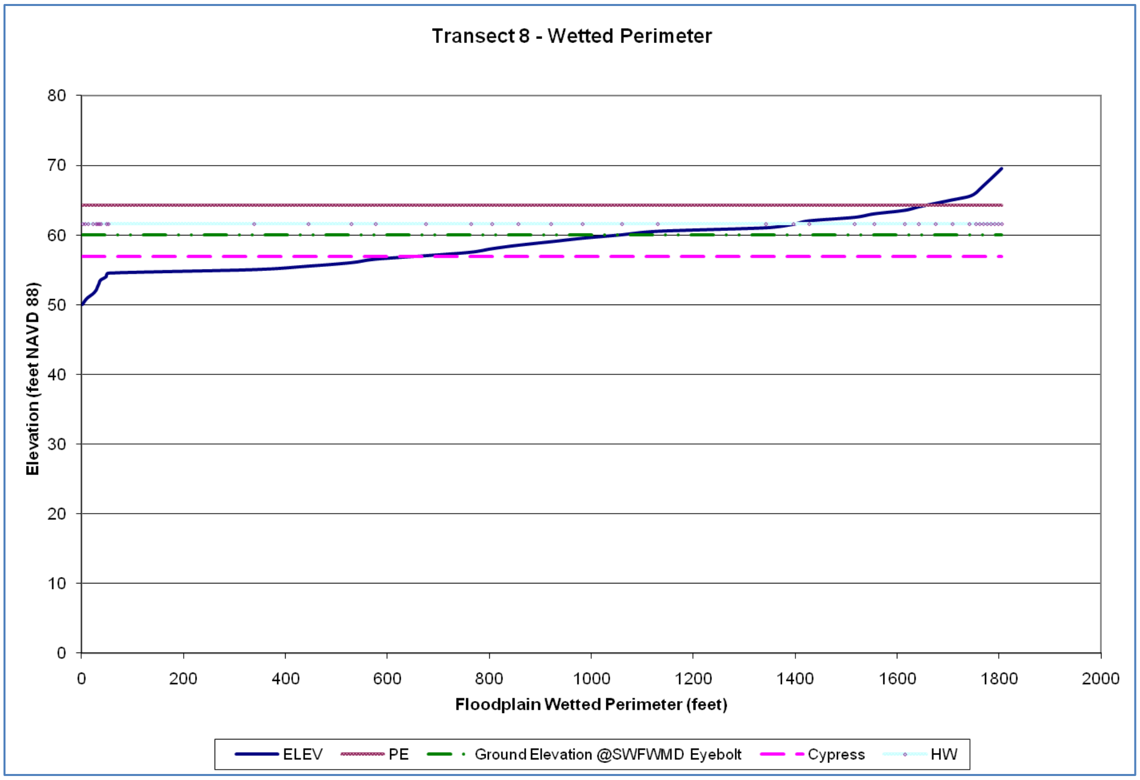
Transect 3 - Wetted Perimeter
Elevation (feet NAVD 88)
76.00
74.00
72.00
70.00
68.00
66.00
64.00
62.00
0.00
500.00
1,000.00
1,500.00
2,000.00
2,500.00
Floodplain Wetted Perimeter (feet)
Elevations
Palmetto Edge
Ground Elevation @SWFWMD Eyebolt
Cypress
MWF

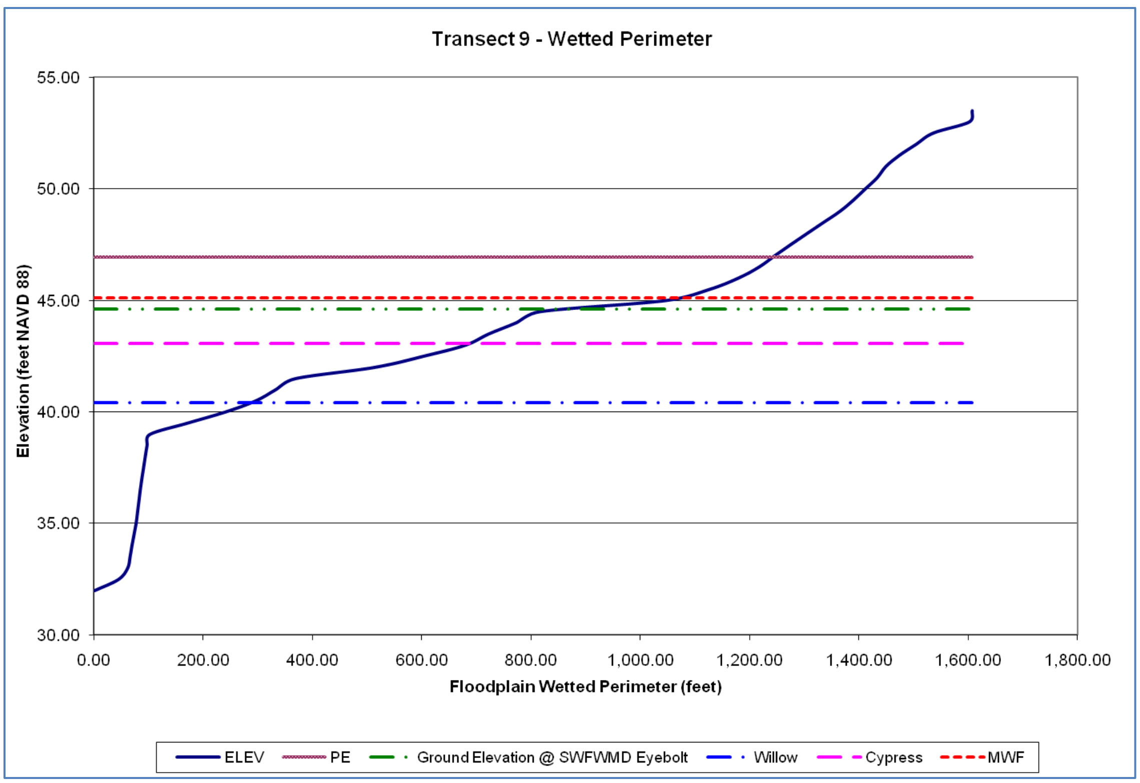

Transect 4 - Wetted Perimeter
Elevation (feet NAVD 88)
74.00
72.00
70.00
68.00
66.00
64.00
62.00
60.00
58.00
0
200
400
600
800
1000
1200
Floodplain Wetted Perimeter (feet)
Elevation
Palmetto Edge
Ground Elevation @ SWFWMD Eyebolt
MWF
Hardwood

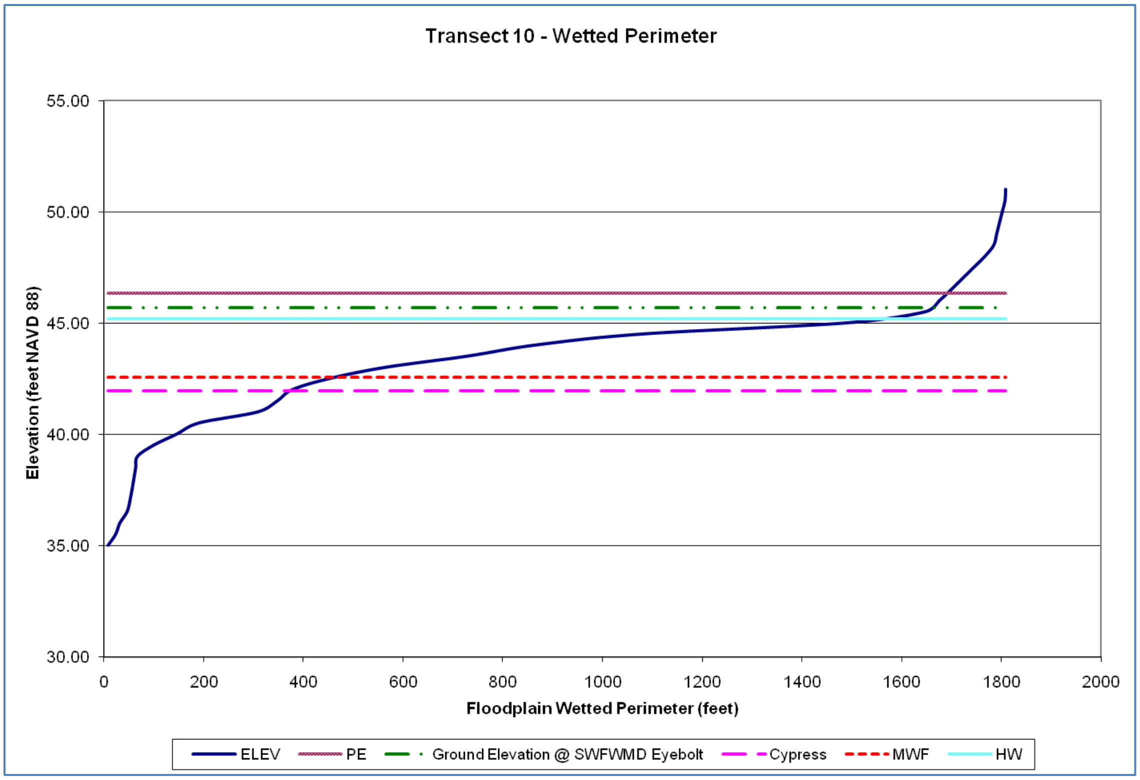

Transect 5 - Wetted Perimeter
Elevation (feet NAVD 88)
72.00
70.00
68.00
66.00
64.00
62.00
60.00
58.00
0
200
400
600
800
1000
1200
Floodplain Wetted Perimeter (feet)
ELEV
Palmetto Edge
Ground Elevation @ SWFWMD Eyebolt-E
Ground Elevation @ SWFWMD Eyebolt-W
Cypress
MWF
HW

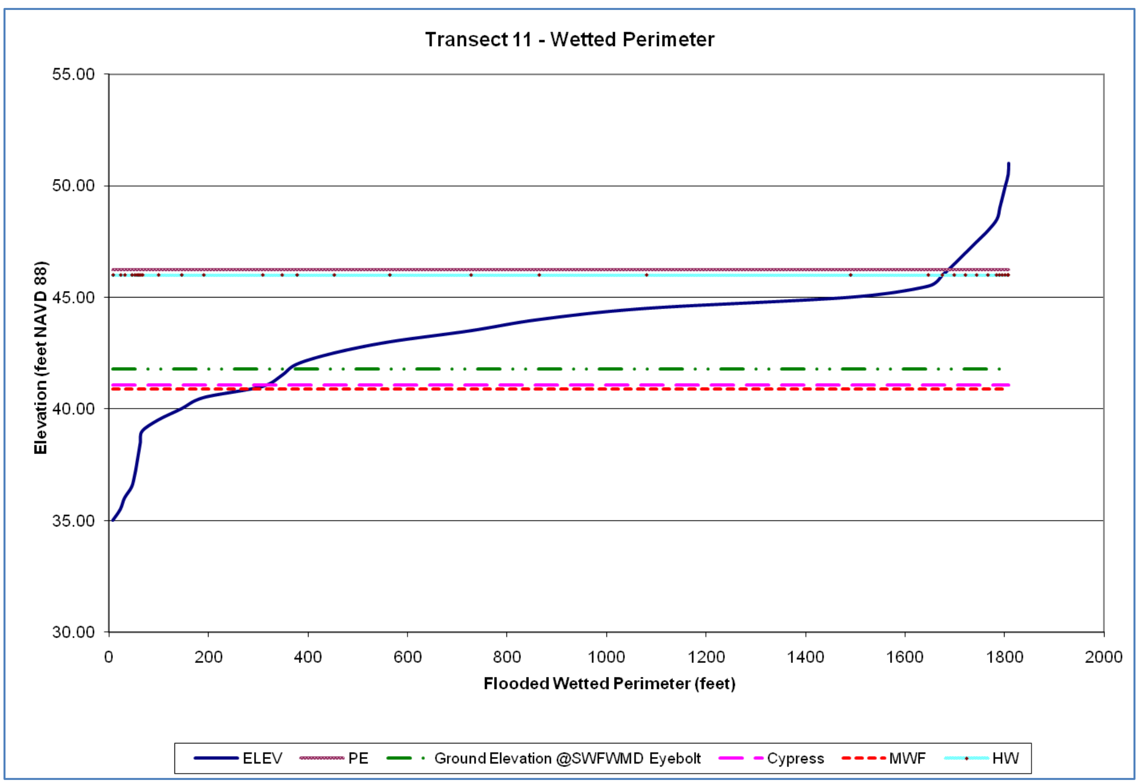

Transect 6 - Wetted Perimeter
72.00
70.00
68.00
66.00
64.00
62.00
60.00
58.00
Elevation (feet NAVD 88)
0
500
1000
1500
2000
2500
3000
Floodplain Wetted Perimeter (feet)
Elevation
Palmetto Edge
Ground Elevation @SWFWMD Eyebolt
Cypress
MWF

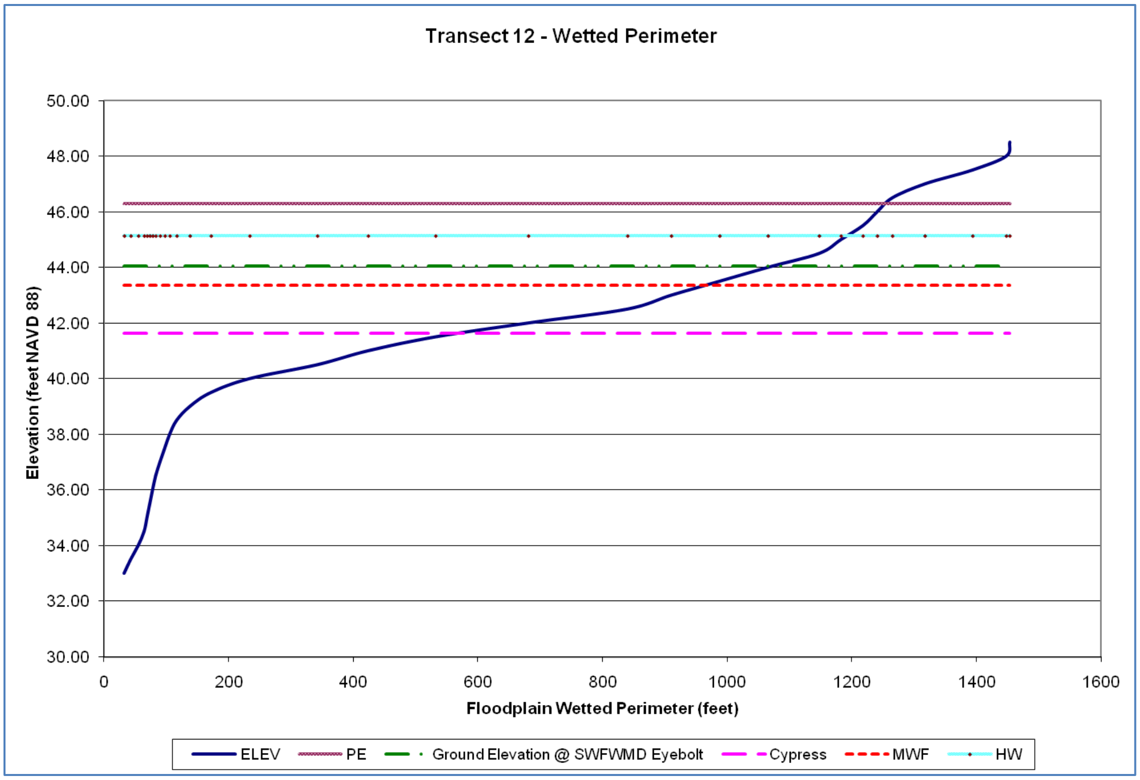

Transect 7 - Wetted Perimeter
70.00
68.00
66.00
64.00
62.00
60.00
58.00
56.00
54.00
52.00
50.00
Elevation (feet NAVD 88)
0
500
1000
1500
2000
2500
Floodplain Wetted Perimeter (feet)
ELEV
Saw Palmetto
Ground Elevation @ SWFWMD Eyebolt
MWF
HW


Transect 8 - Wetted Perimeter
Elevation (feet NAVD 88)
Floodplain Wetted Perimeter (feet)
0
10
20
30
40
50
60
70
80
0
200
400
600
800
1000
1200
1400
1600
1800
2000
ELEV
PE
Ground Elevation @SWFWMD Eyebolt
Cypress
HW

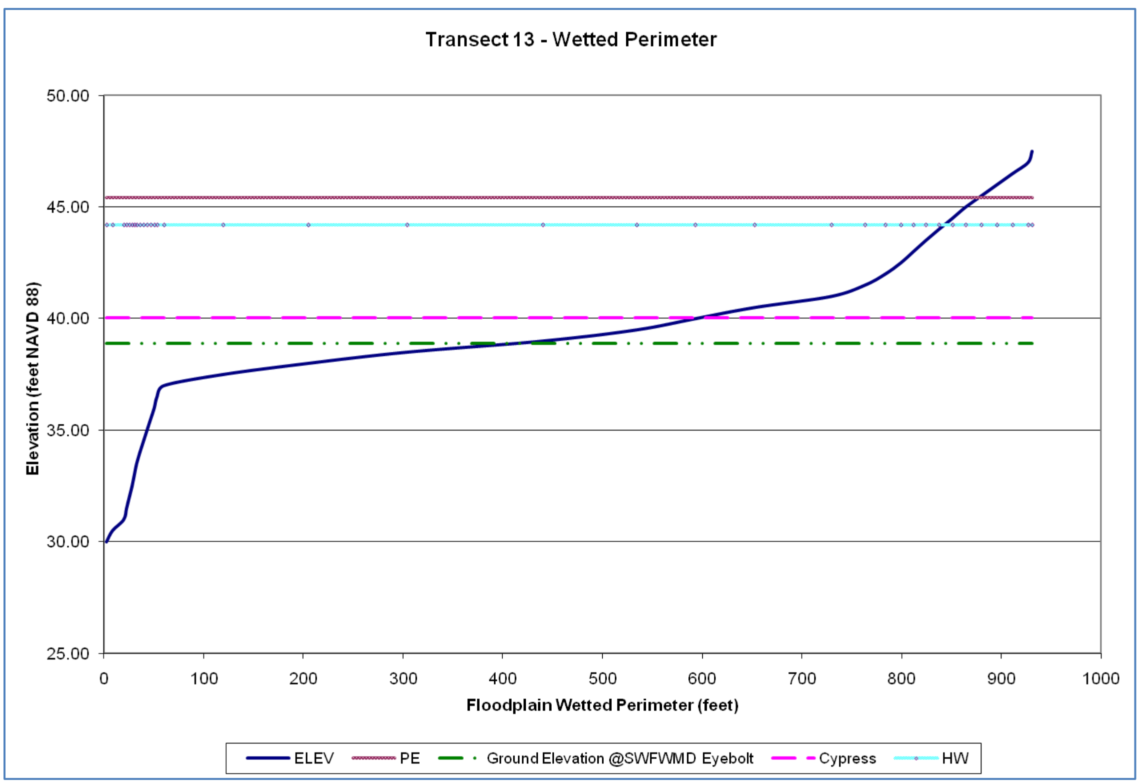

Transect 9 - Wetted Perimeter
Elevation (feet NAVD 88)
Floodplain Wetted Perimeter (feet)
30.00
35.00
40.00
45.00
50.00
55.00
0.00
200.00
400.00
600.00
800.00
1,000.00
1,200.00
1,400.00
1,600.00
1,800.00
ELEV
PE
Ground Elevation @ SWFWMD Eyebolt
Willow
Cypress
MWF


Transect 10 - Wetted Perimeter
55.00
50.00
45.00
40.00
35.00
30.00
Elevation (feet NAVD 88)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Floodplain Wetted Perimeter (feet)
ELEV
PE
Ground Elevation @ SWFWMD Eyebolt
Cypress
MWF
HW

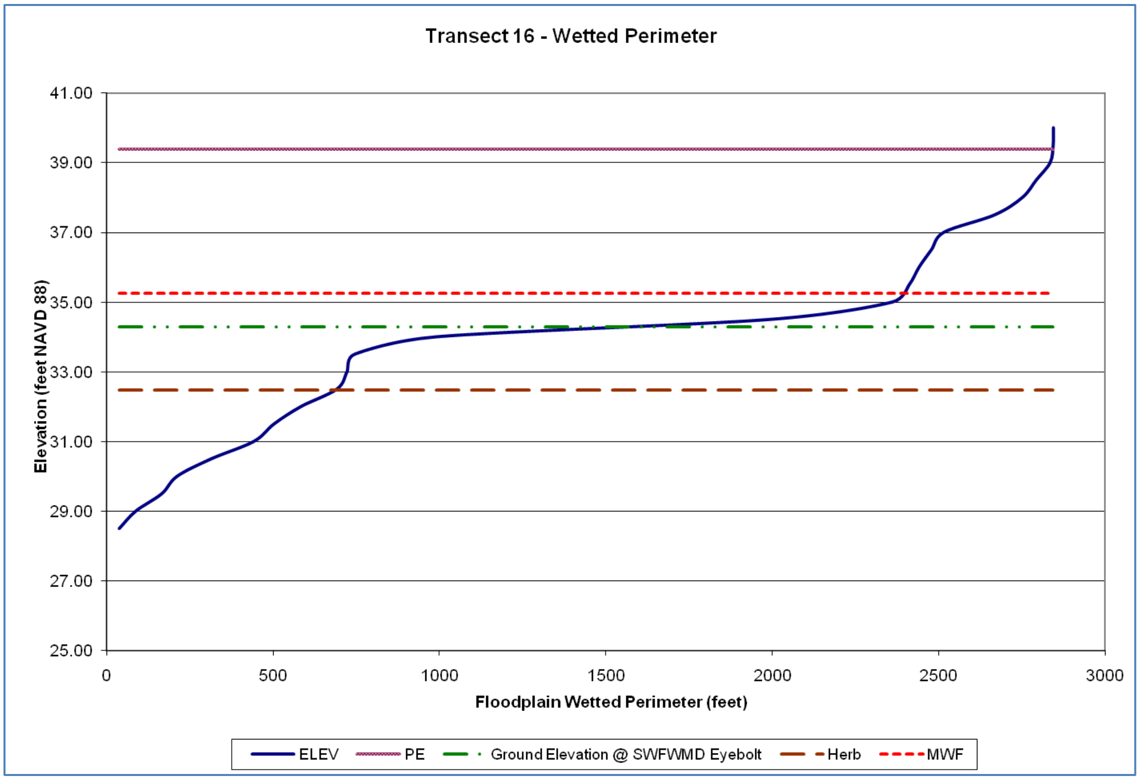

Transect 11 - Wetted Perimeter
55.00
50.00
45.00
40.00
35.00
30.00
Elevation (feet NAVD 88)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Flooded Wetted Perimeter (feet)
ELEV
PE
Ground Elevation @SWFWMD Eyebolt
Cypress
MWF
HW



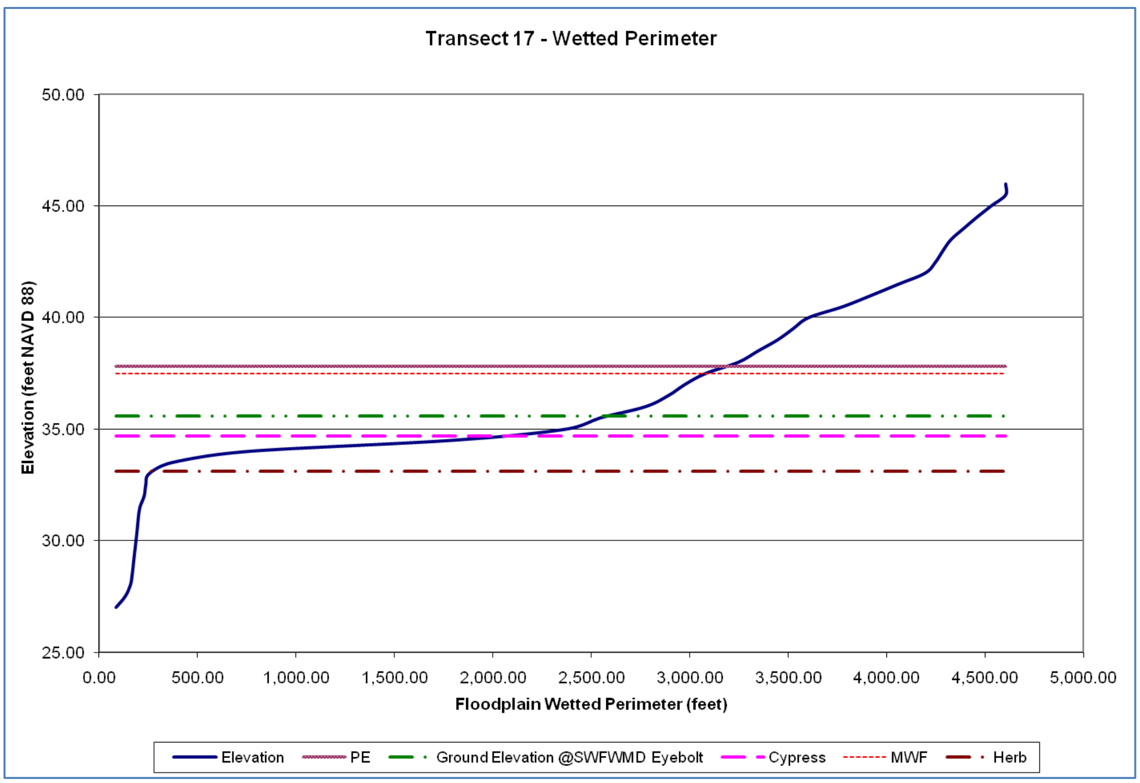
Transect 12 - Wetted Perimeter
Elevation (feet NAVD 88)
50.00
48.00
46.00
44.00
42.00
40.00
38.00
36.00
34.00
32.00
30.00
0
200
400
600
800
1000
1200
1400
1600
Floodplain Wetted Perimeter (feet)
ELEV
PE
Ground Elevation @ SWFWMD Eyebolt
Cypress
MWF
HW



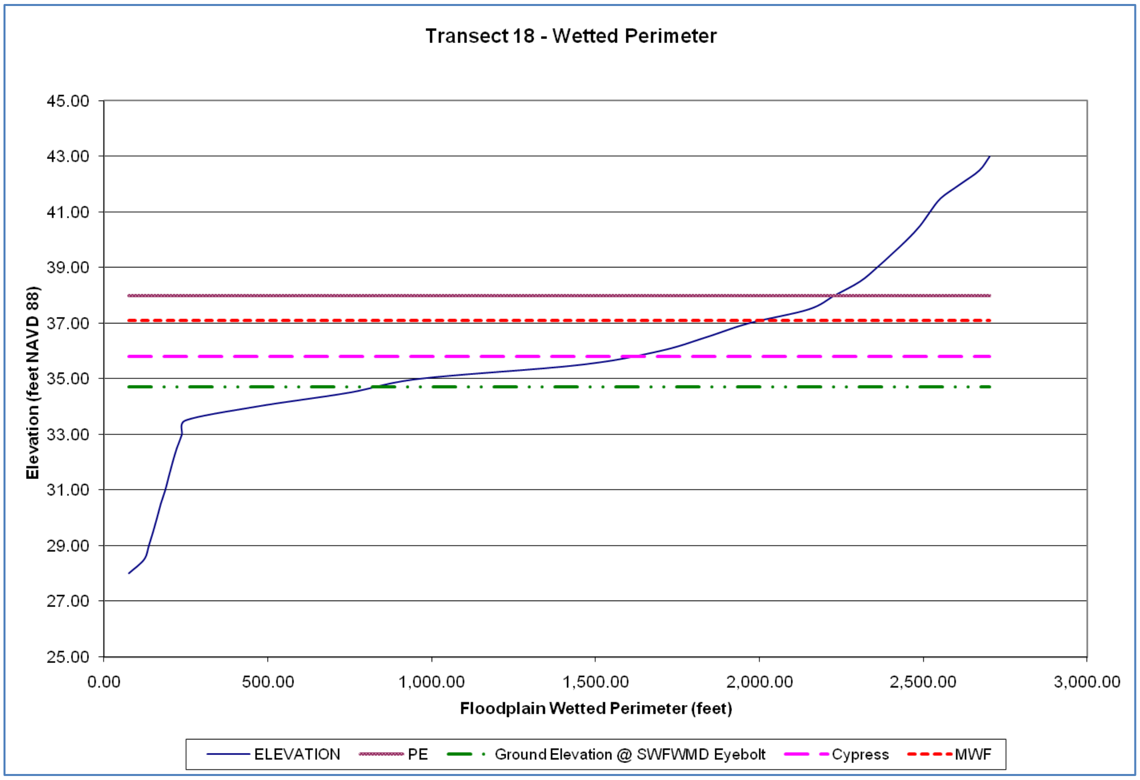
Transect 13 - Wetted Perimeter
Elevation (feet NAVD 88)
50.00
45.00
40.00
35.00
30.00
25.00
0
100
200
300
400
500
600
700
800
900
1000
Floodplain Wetted Perimeter (feet)
ELEV
PE
Ground Elevation @SWFWMD Eyebolt
Cypress
HW

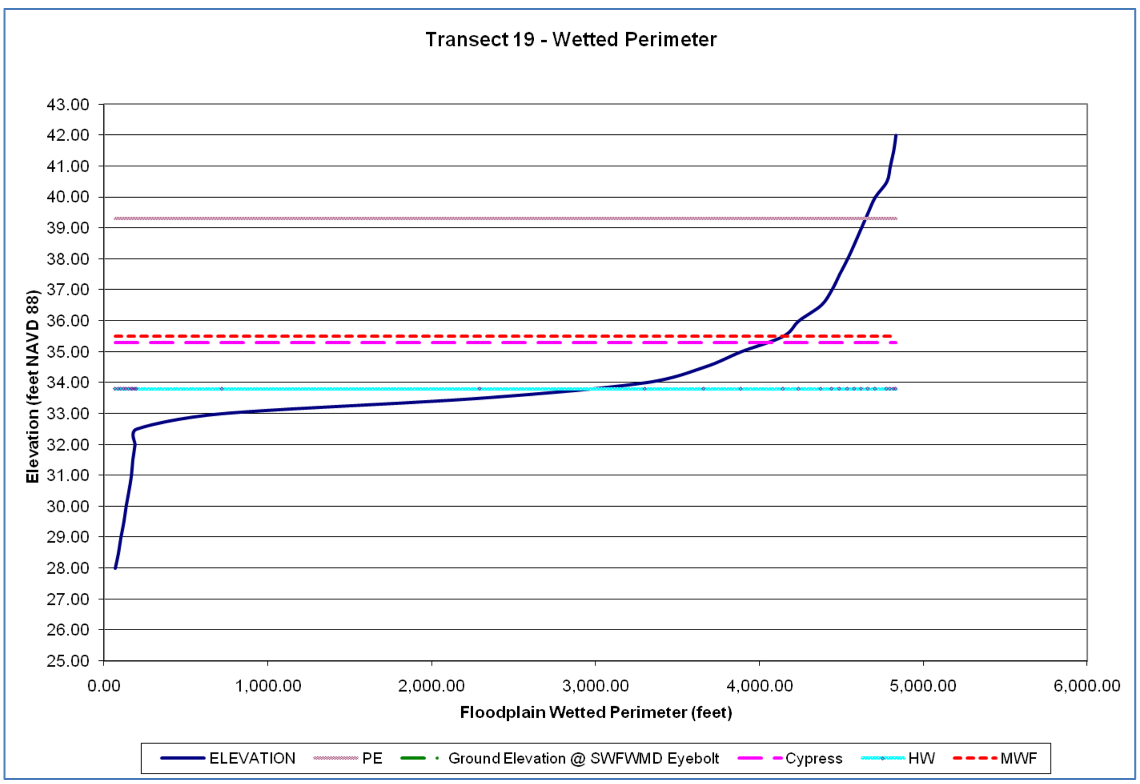


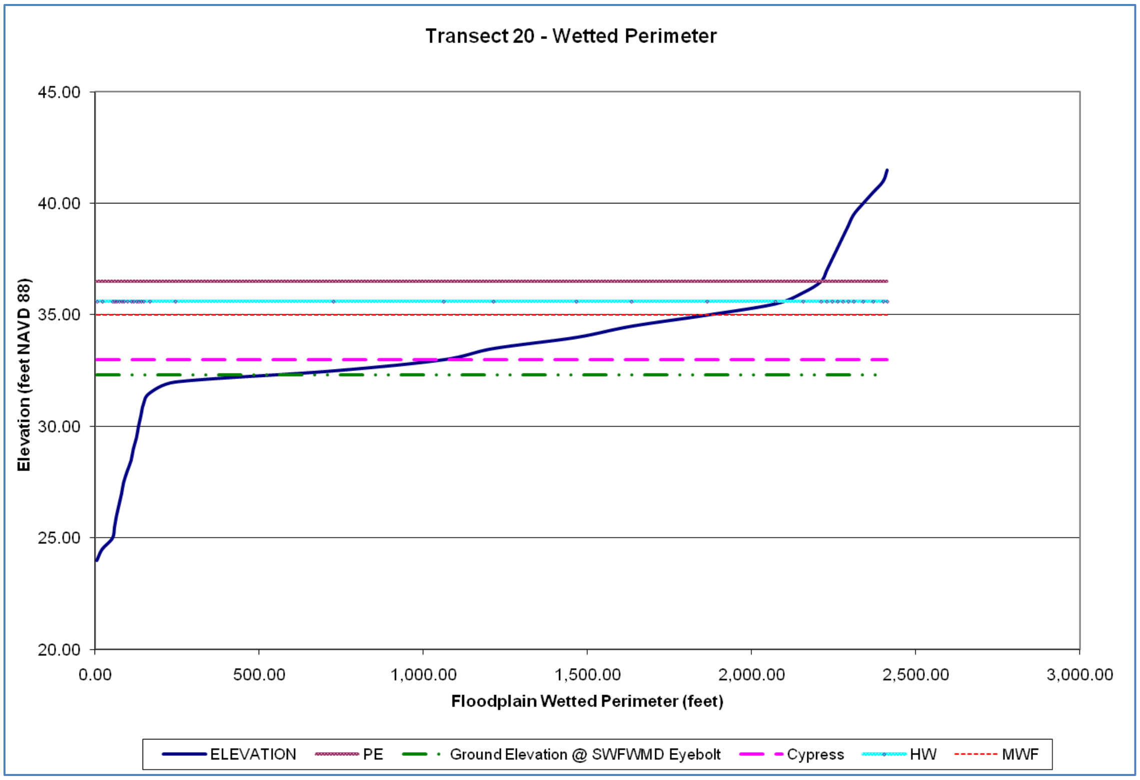
Transect 16 - Wetted Perimeter
Elevation (feet NAVD 88)
Floodplain Wetted Perimeter (feet)
41.00
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
0
500
1000
1500
2000
2500
3000
ELEV
PE
Ground Elevation @ SWFWMD Eyebolt
Herb
MWF

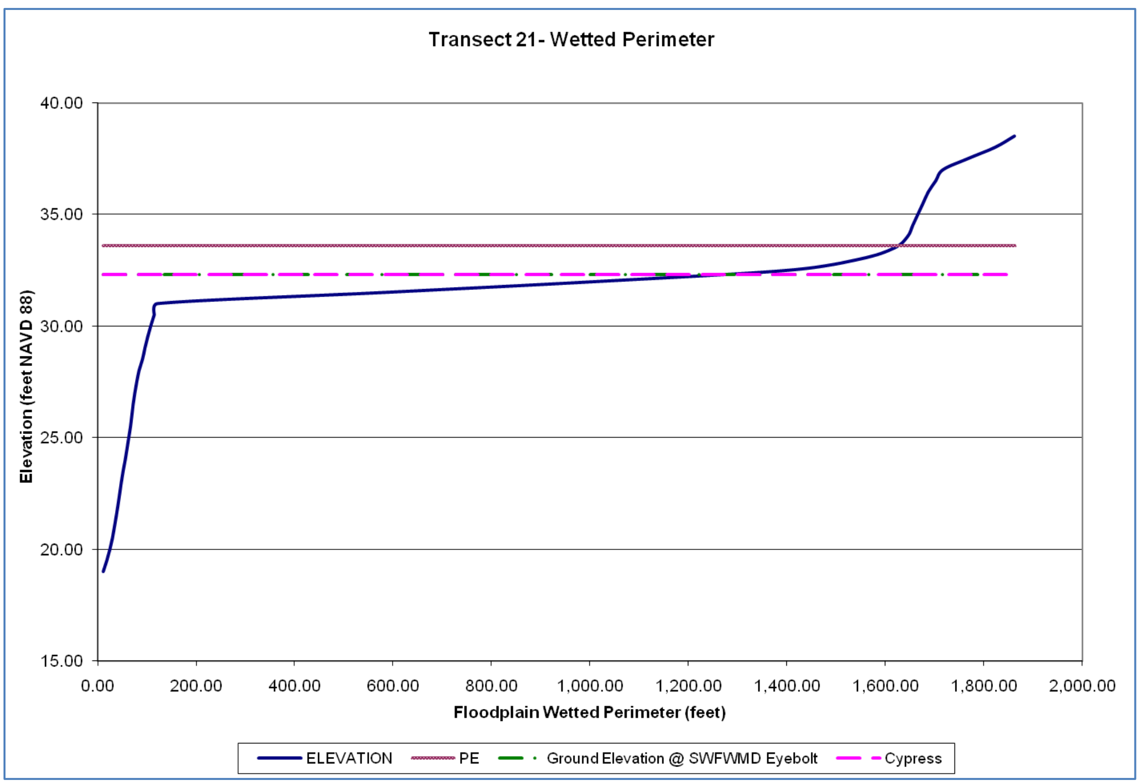


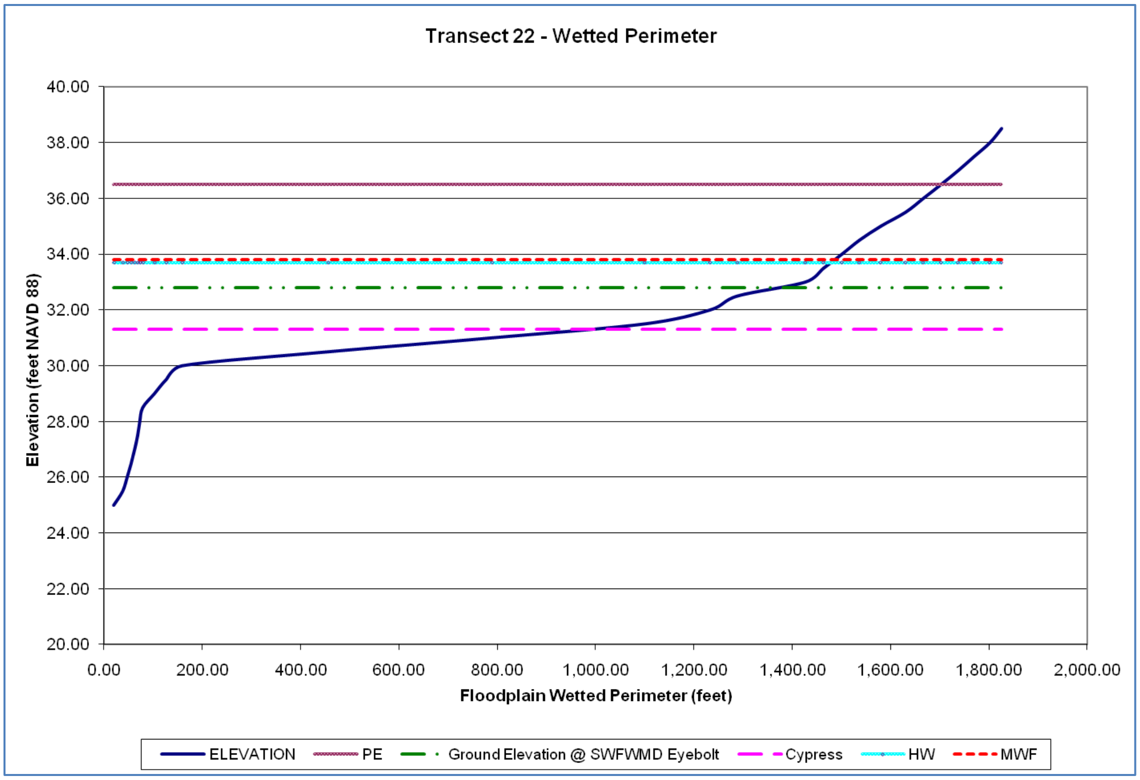
Transect 17 - Wetted Perimeter
Elevation (feet NAVD 88)
Floodplain Wetted Perimeter (feet)
50.00
45.00
40.00
35.00
30.00
25.00
0.00
500.00
1,000.00
1,500.00
2,000.00
2,500.00
3,000.00
3,500.00
4,000.00
4,500.00
5,000.00
Elevation
PE
Ground Elevation @SWFWMD Eyebolt
Cypress
MWF
Herb

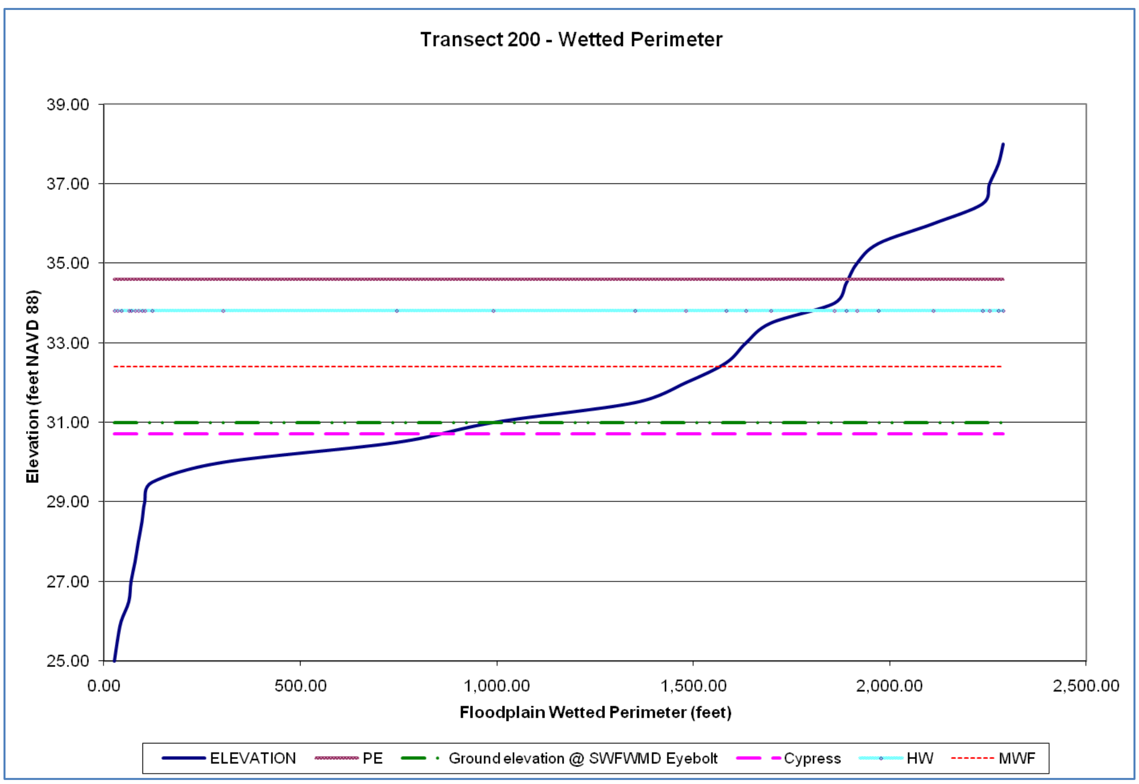

Transect 18 - Wetted Perimeter
Elevation (feet NAVD 88)
45.00
43.00
41.00
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
0.00
500.00
1,000.00
1,500.00
2,000.00
2,500.00
3,000.00
Floodplain Wetted Perimeter (feet)
ELEVATION
PE
Ground Elevation @ SWFWMD Eyebolt
Cypress
MWF

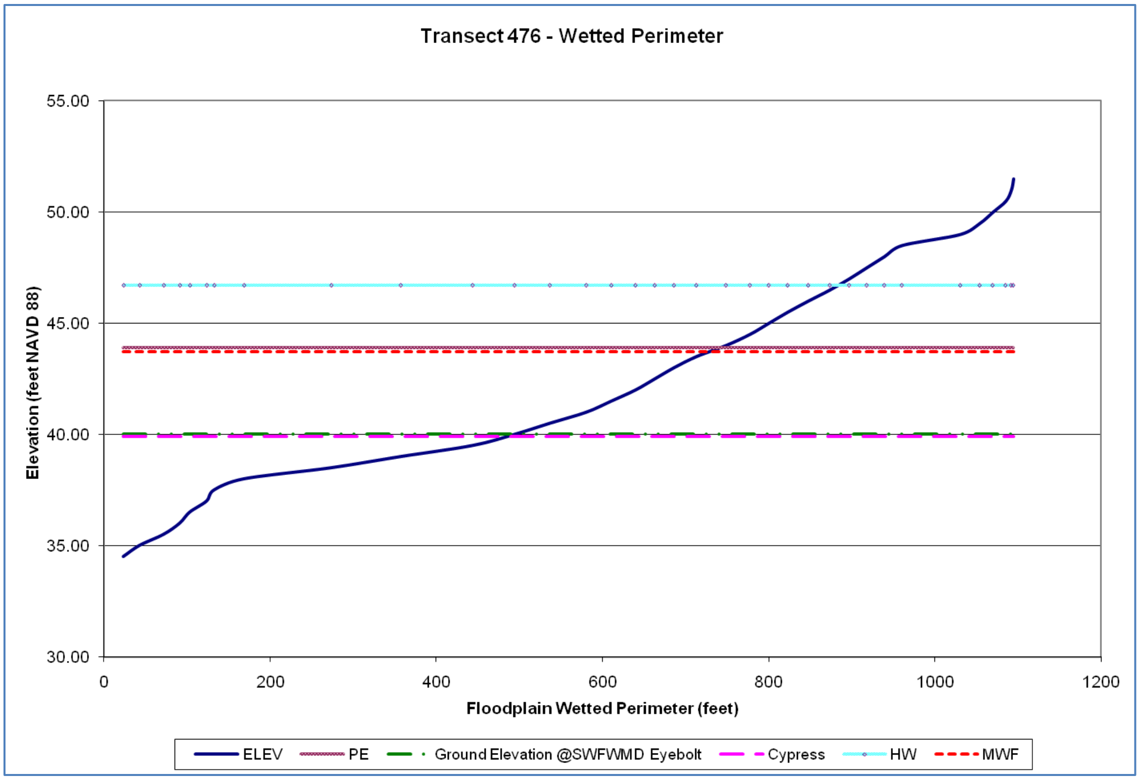

Transect 19 - Wetted Perimeter
Elevation (feet NAVD 88)
43.00
42.00
41.00
40.00
39.00
38.00
37.00
36.00
35.00
34.00
33.00
32.00
31.00
30.00
29.00
28.00
27.00
26.00
25.00
0.00
1,000.00
2,000.00
3,000.00
4,000.00
5,000.00
6,000.00
Floodplain Wetted Perimeter (feet)
ELEVATION
PE
Ground Elevation @ SWFWMD Eyebolt
Cypress
HW
MWF

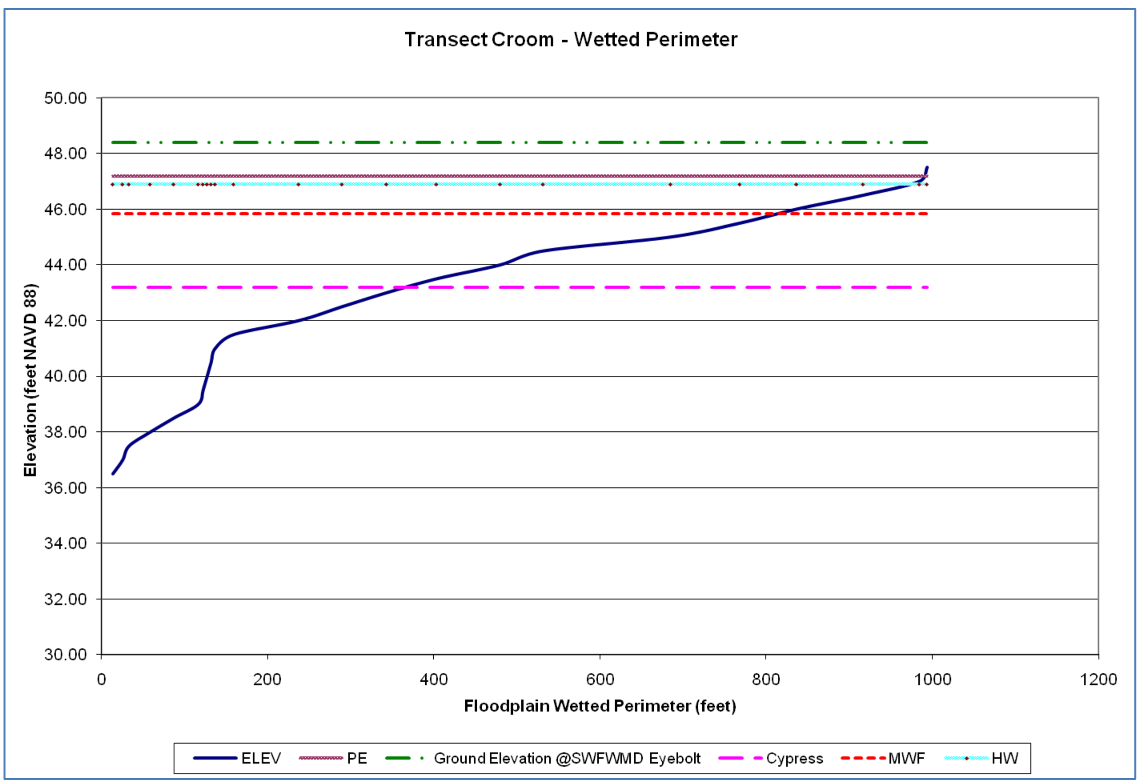

Transect 20 - Wetted Perimeter
Elevation (feet NAVD 88)
45.00
40.00
35.00
30.00
25.00
20.00
0.00
500.00
1,000.00
1,500.00
2,000.00
2,500.00
3,000.00
Floodplain Wetted Perimeter (feet)
ELEVATION
PE
Ground Elevation @ SWFWMD Eyebolt
Cypress
HW
MWF

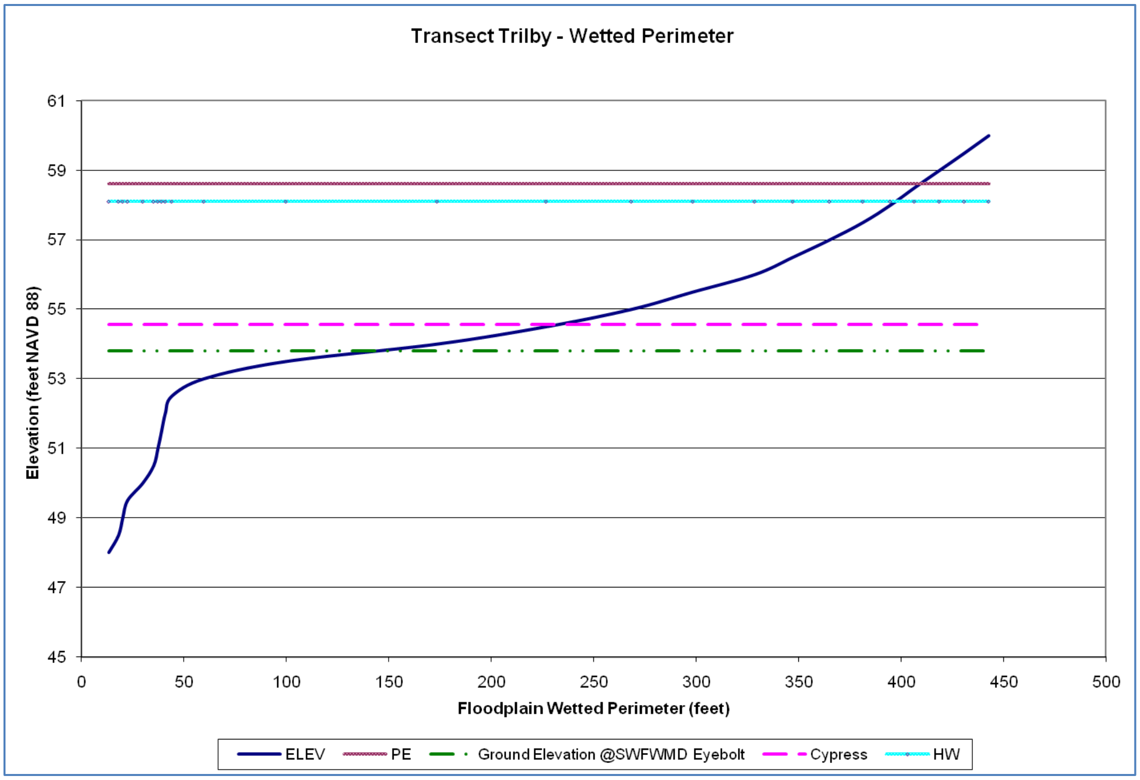

Transect 21- Wetted Perimeter
Elevation (feet NAVD 88)
40.00
35.00
30.00
25.00
20.00
15.00
0.00
200.00
400.00
600.00
800.00
1,000.00
1,200.00
1,400.00
1,600.00
1,800.00
2,000.00
Floodplain Wetted Perimeter (feet)
ELEVATION
PE
Ground Elevation @ SWFWMD Eyebolt
Cypress

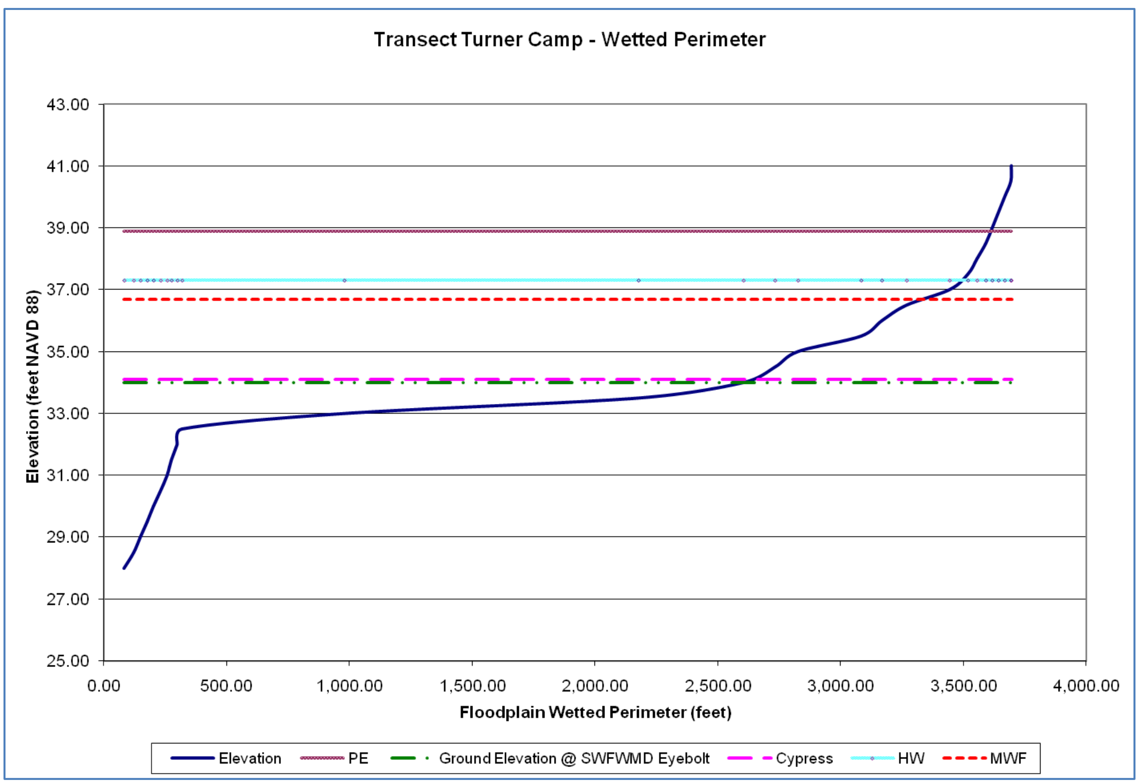

Transect 22 - Wetted Perimeter
40.00
38.00
36.00
34.00
32.00
30.00
28.00
26.00
24.00
22.00
20.00
Elevation (feet NAVD 88)
0.00
200.00
400.00
600.00
800.00
1,000.00
1,200.00
1,400.00
1,600.00
1,800.00
2,000.00
Floodplain Wetted Perimeter (feet)
ELEVATION
PE
Ground Elevation @ SWFWMD Eyebolt
Cypress
HW
MWF


Transect 200 - Wetted Perimeter
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
Elevation (feet NAVD 88)
0.00
500.00
1,000.00
1,500.00
2,000.00
2,500.00
Floodplain Wetted Perimeter (feet)
ELEVATION
PE
Ground elevation @ SWFWMD Eyebolt
Cypress
HW
MWF

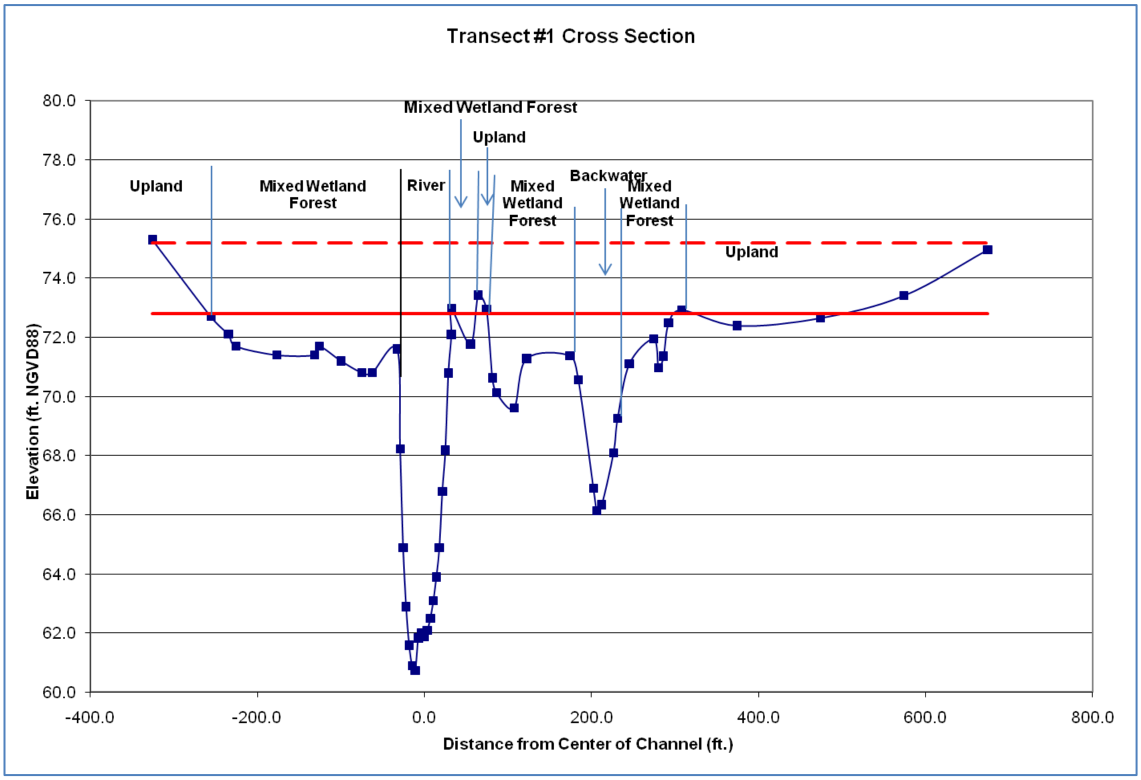

Transect 476 - Wetted Perimeter
55.00
50.00
45.00
40.00
35.00
30.00
Elevation (feet NAVD 88)
0
200
400
600
800
1000
1200
Floodplain Wetted Perimeter (feet)
ELEV
PE
Ground Elevation @SWFWMD Eyebolt
Cypress
HW
MWF

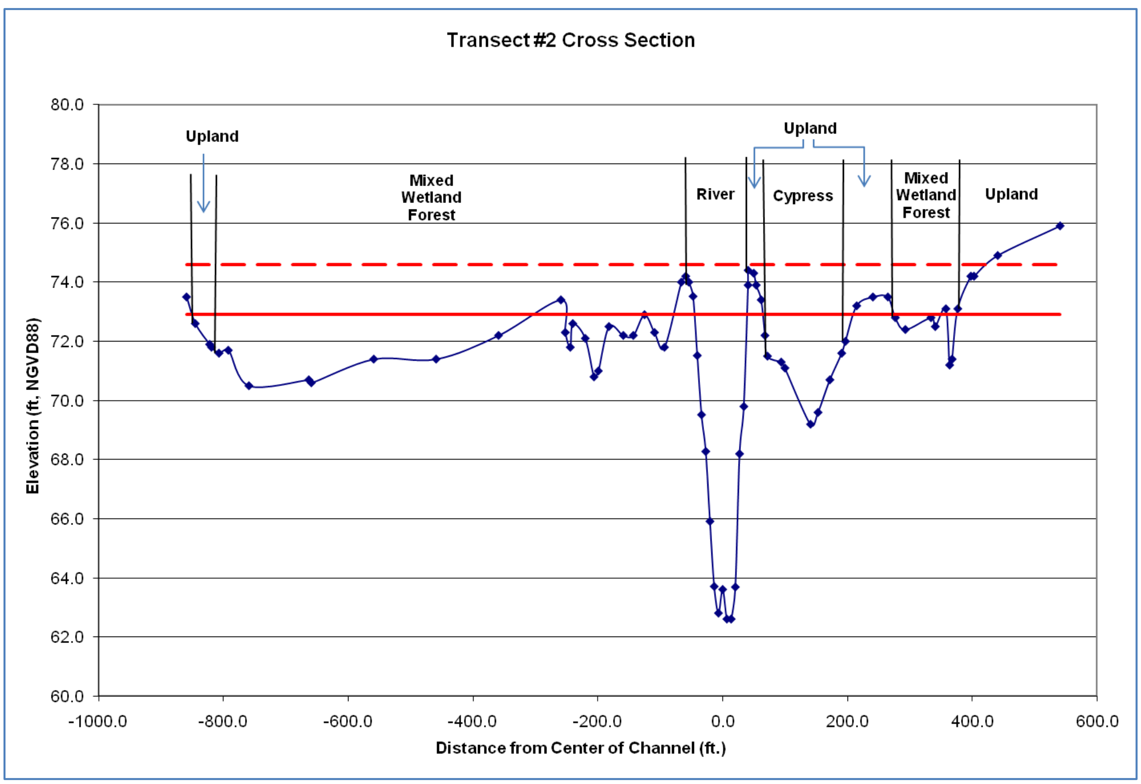

Transect Croom - Wetted Perimeter
50.00
48.00
46.00
44.00
42.00
40.00
38.00
36.00
34.00
32.00
30.00
Elevation (feet NAVD 88)
0
200
400
600
800
1000
1200
Floodplain Wetted Perimeter (feet)
ELEV
PE
Ground Elevation @SWFWMD Eyebolt
Cypress
MWF
HW

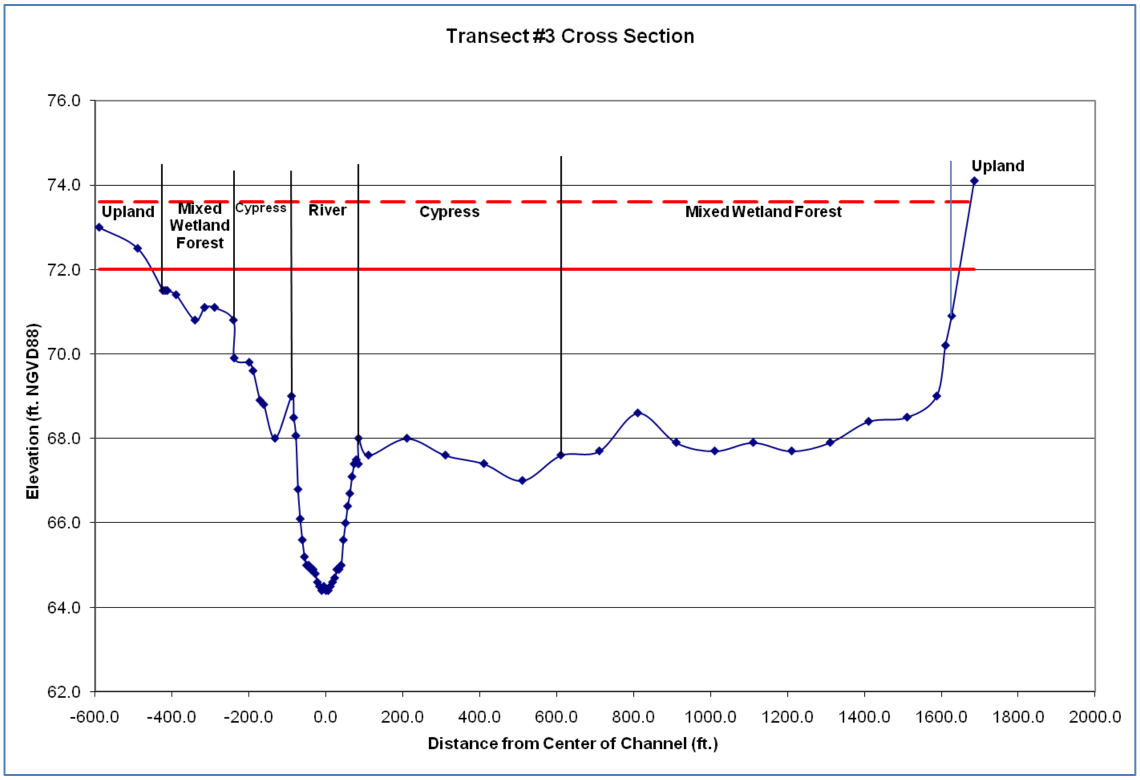

Transect Trilby - Wetted Perimeter
Elevation (feet NAVD 88)
61
59
57
55
53
51
49
47
45
0
50
100
150
200
250
300
350
400
450
500
Floodplain Wetted Perimeter (feet)
ELEV
PE
Ground Elevation @SWFWMD Eyebolt
Cypress
HW

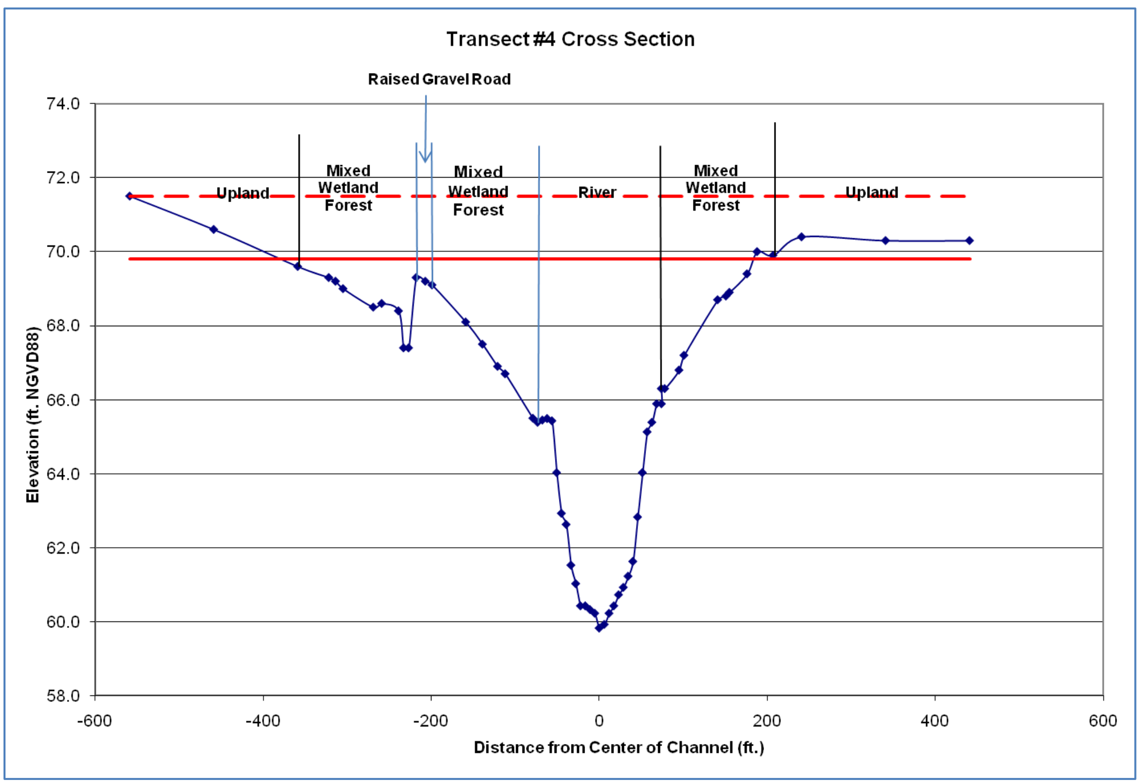

Transect Turner Camp - Wetted Perimeter
Elevation (feet NAVD 88)
43.00
41.00
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
0.00
500.00
1,000.00
1,500.00
2,000.00
2,500.00
3,000.00
3,500.00
4,000.00
Floodplain Wetted Perimeter (feet)
Elevation
PE
Ground Elevation @ SWFWMD Eyebolt
Cypress
HW
MWF

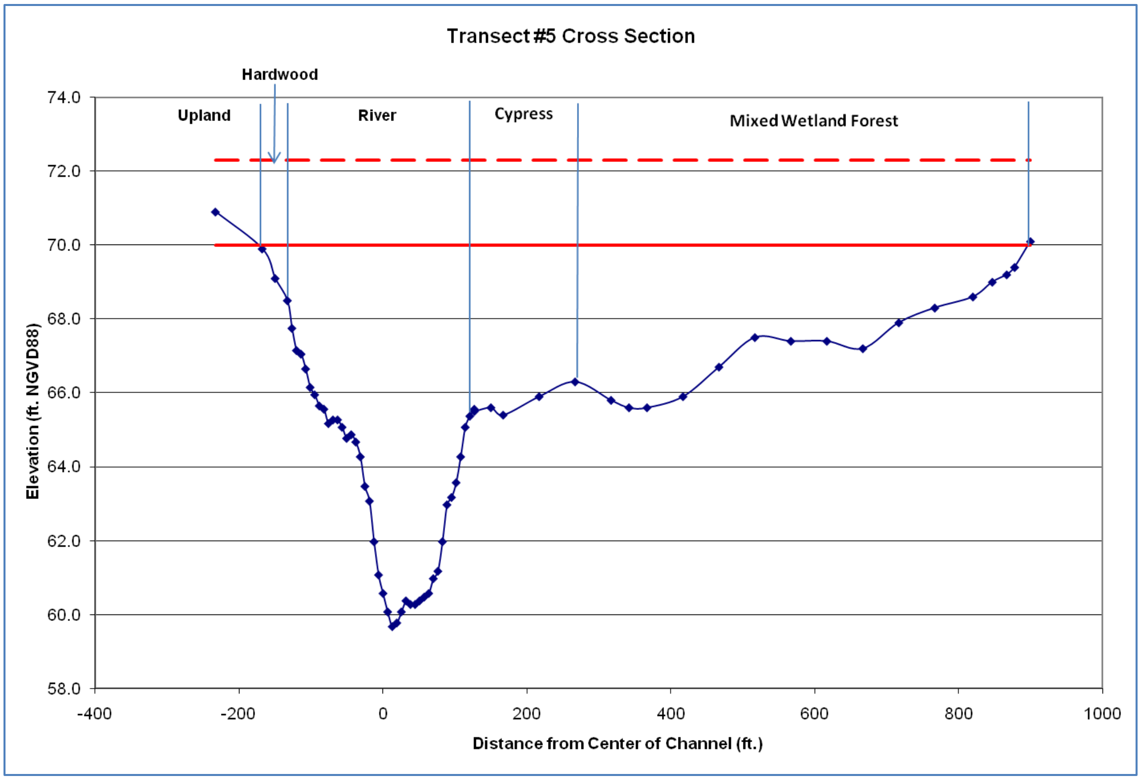
Vegetation Appendix B – Wetted Perimeters



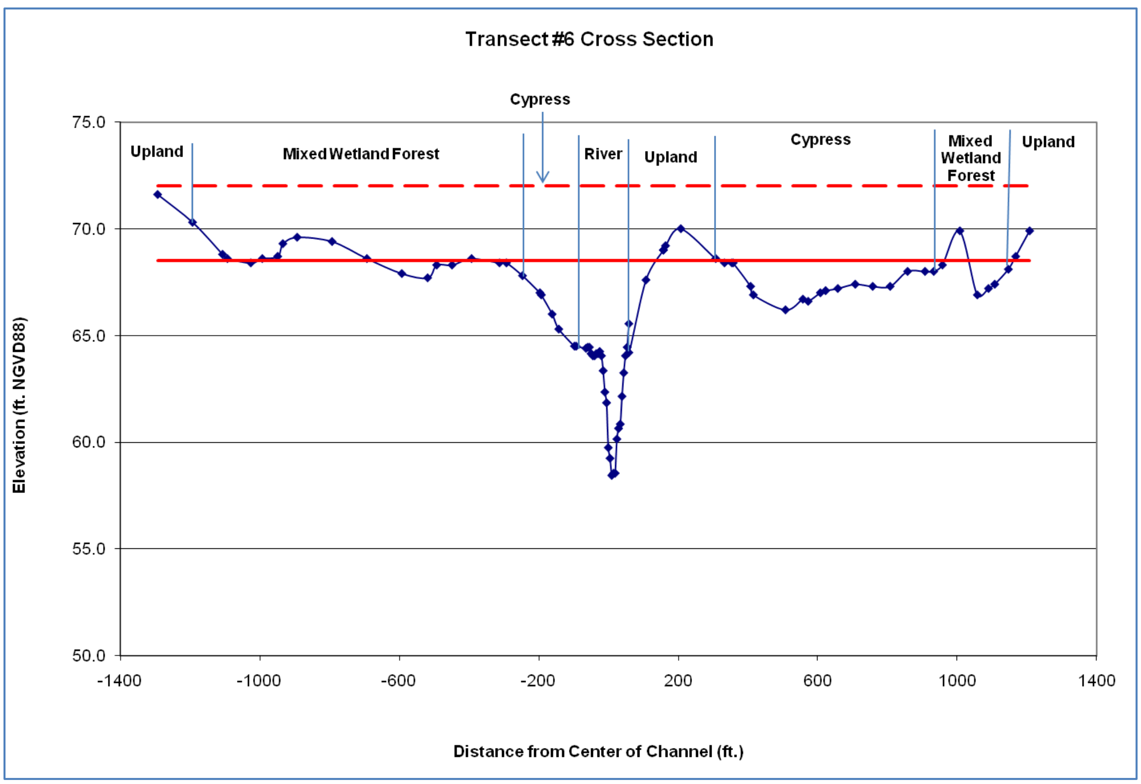



Transect #3 Cross Section
Upland
Mixed Wetland Forest
Cypress
River
Cypress
Mixed Wetland Forest
Upland
Elevation (ft. NGVD88)
76.0
74.0
72.0
70.0
68.0
66.0
64.0
62.0
-600.0
-400.0
-200.0
0.0
200.0
400.0
600.0
800.0
1000.0
1200.0
1400.0
1600.0
1800.0
2000.0
Distance from Center of Channel (ft.)

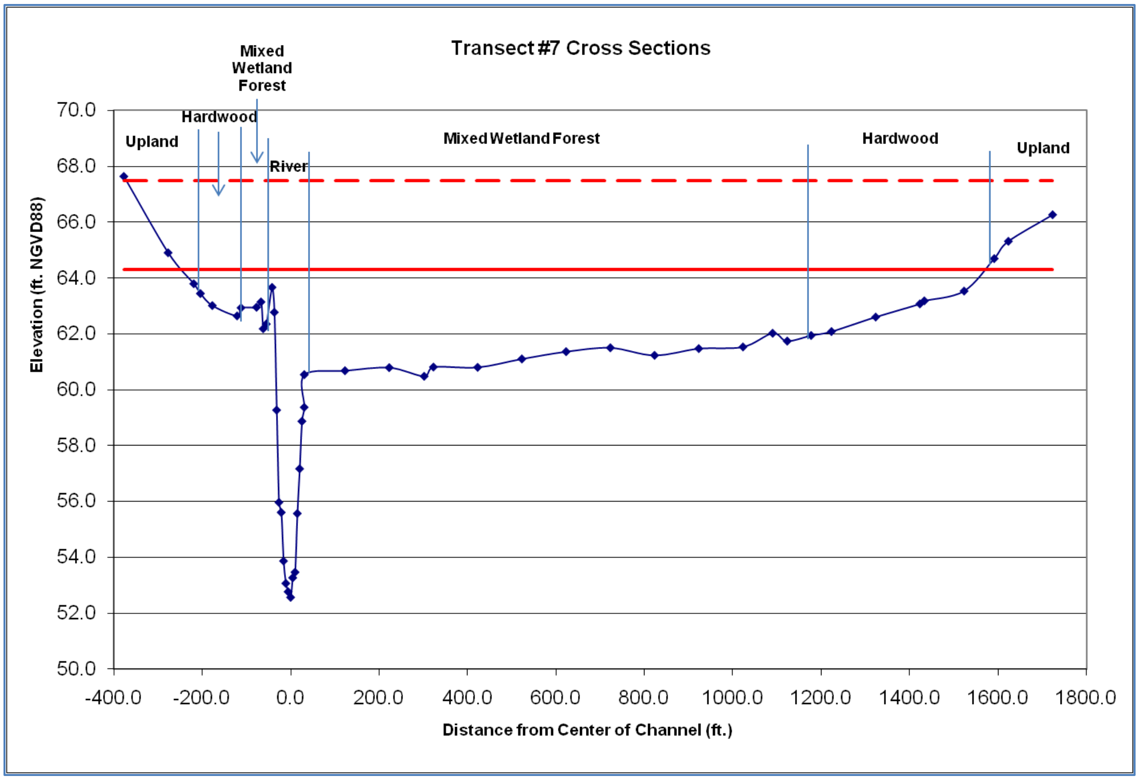

Transect #4 Cross Section
Raised Gravel Road
Upland
Mixed Wetland Forest
Mixed Wetland Forest
River
Mixed Wetland Forest
Upland
Elevation (ft. NGVD88)
74.0
72.0
70.0
68.0
66.0
64.0
62.0
60.0
58.0
-600
-400
-200
0
200
400
600
Distance from Center of Channel (ft.)



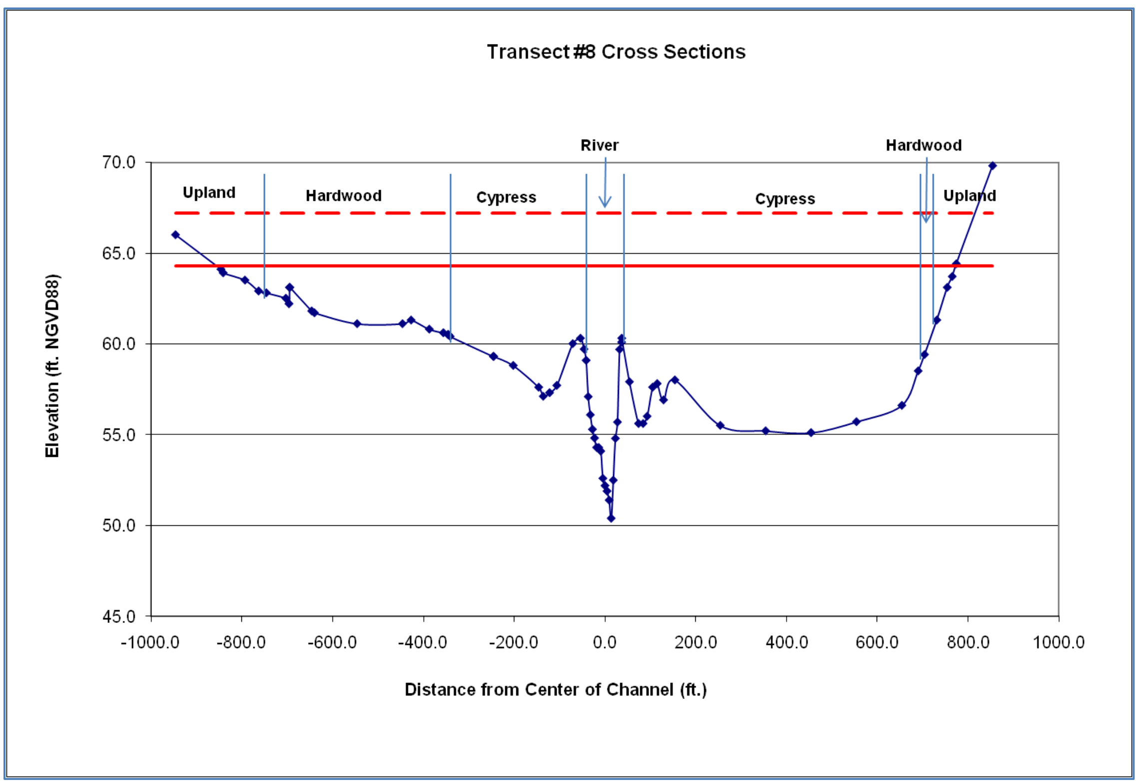
Transect #5 Cross Section
Hardwood
Upland
River
Cypress
Mixed Wetland Forest
74.0
72.0
70.0
68.0
66.0
64.0
62.0
60.0
58.0
Elevation (ft. NGVD88)
-400
-200
0
200
400
600
800
1000
Distance from Center of Channel (ft.)



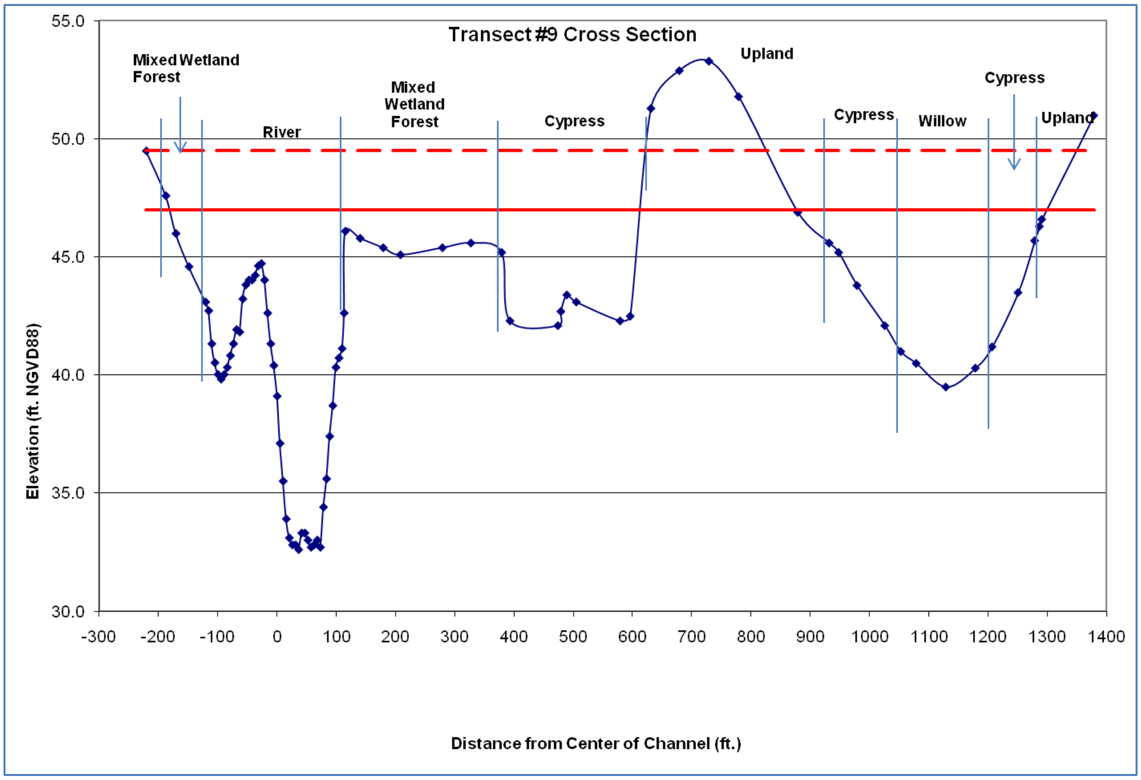
Transect #6 Cross Section
Cypress
Upland
Mixed Wetland Forest
River
Upland
Cypress
Mixed Wetland Forest
Upland
75.0
70.0
65.0
60.0
55.0
50.0
Elevation (ft. NGVD88)
-1400
-1000
-600
-200
200
600
1000
1400
Distance from Center of Channel (ft.)

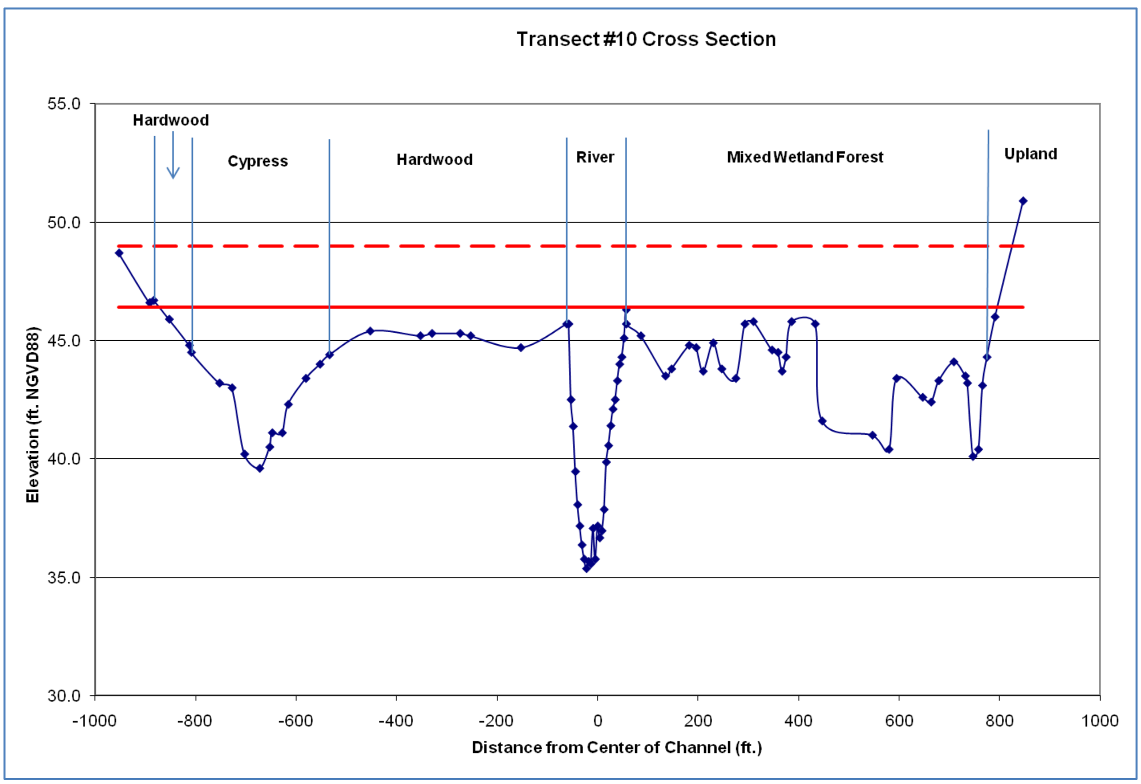


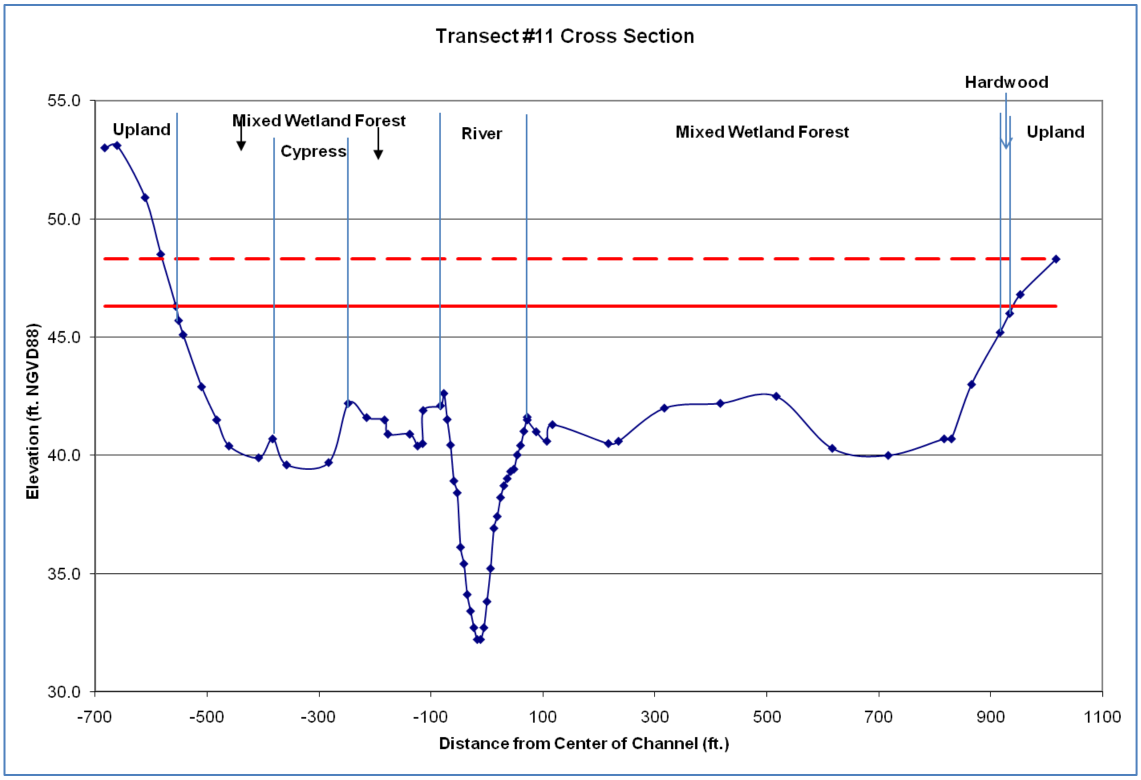
Transect #7 Cross Sections
Mixed
Wetland
Forest
Upland
Hardwood
River
Mixed Wetland Forest
Hardwood
Upland
70.0
68.0
66.0
64.0
62.0
60.0
58.0
56.0
54.0
52.0
50.0
Elevation (ft. NGVD88)
-400.0
-200.0
0.0
200.0
400.0
600.0
800.0
1000.0
1200.0
1400.0
1600.0
1800.0
Distance from Center of Channel (ft.)

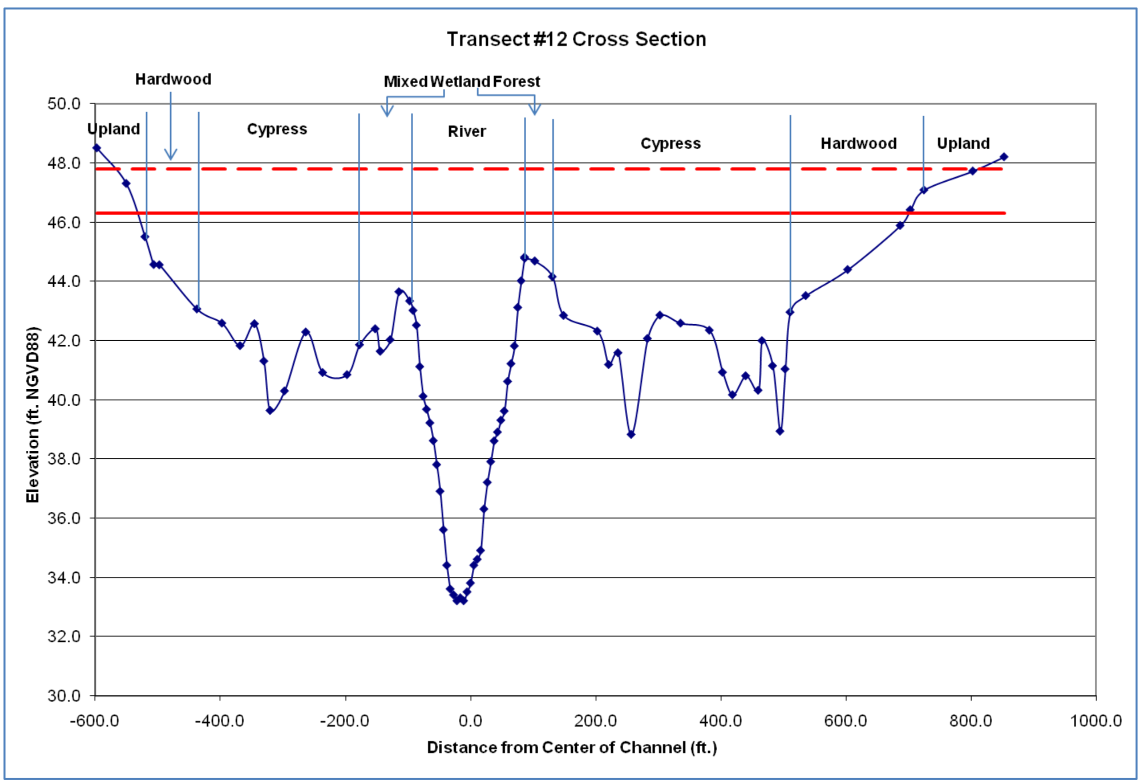


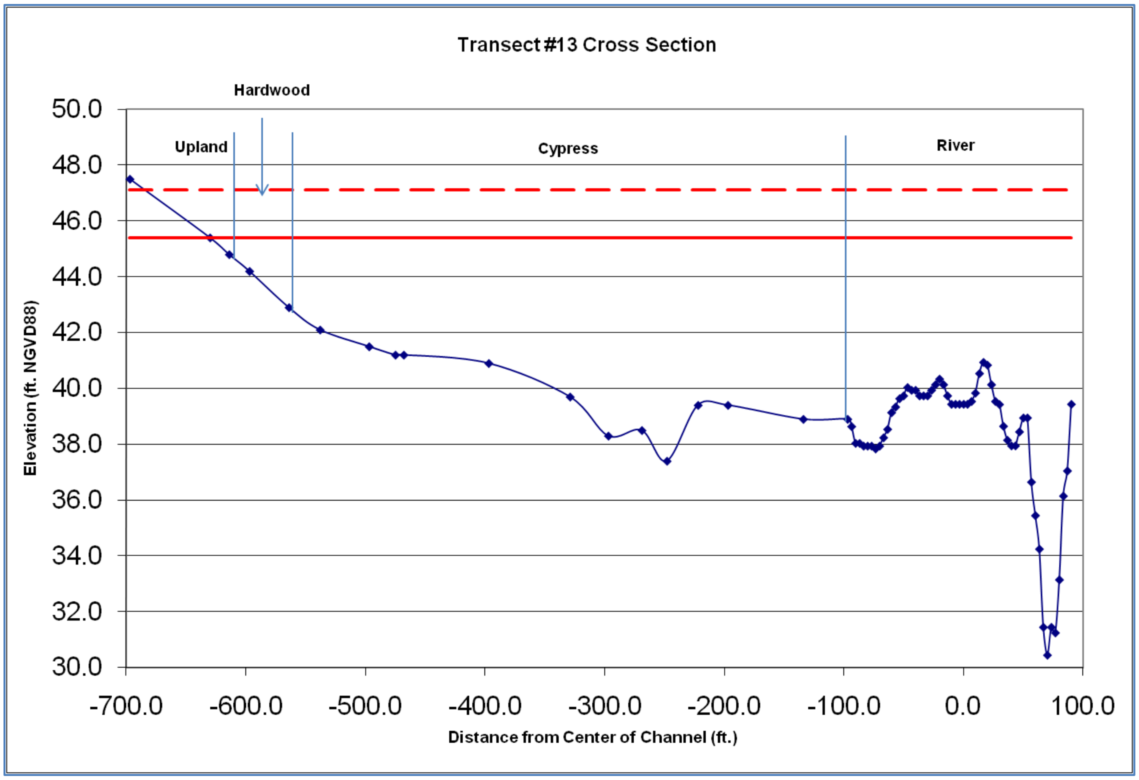
Transect #8 Cross Sections
River
Hardwood
Upland
Hardwood
Cypress
Cypress
Upland
70.0
65.0
60.0
55.0
50.0
45.0
Elevation (ft. NGVD88)
-1000.0
-800.0
-600.0
-400.0
-200.0
0.0
200.0
400.0
600.0
800.0
1000.0
Distance from Center of Channel (ft.)

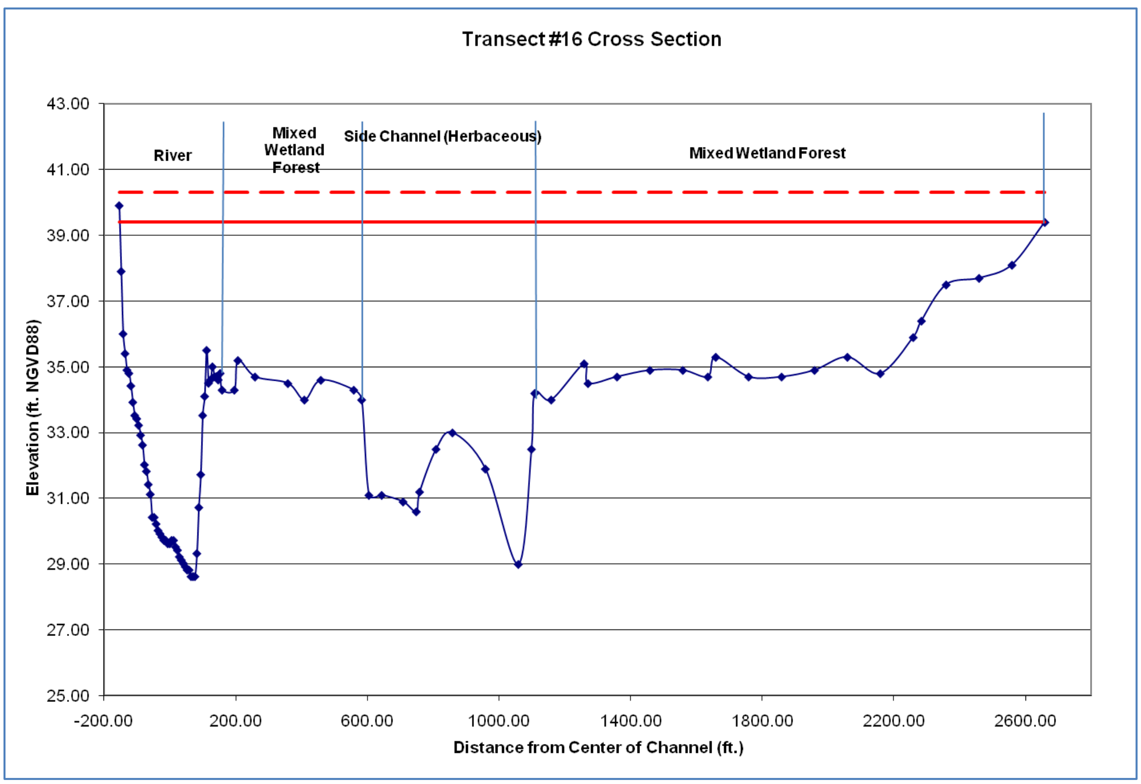

Transect #9 Cross Section
Mixed Wetland Forest
River
Mixed Wetland Forest
Cypress
Upland
Cypress
Willow
Cypress
Upland
Elevation (ft. NGVD88)
Distance from Center of Channel (ft.)

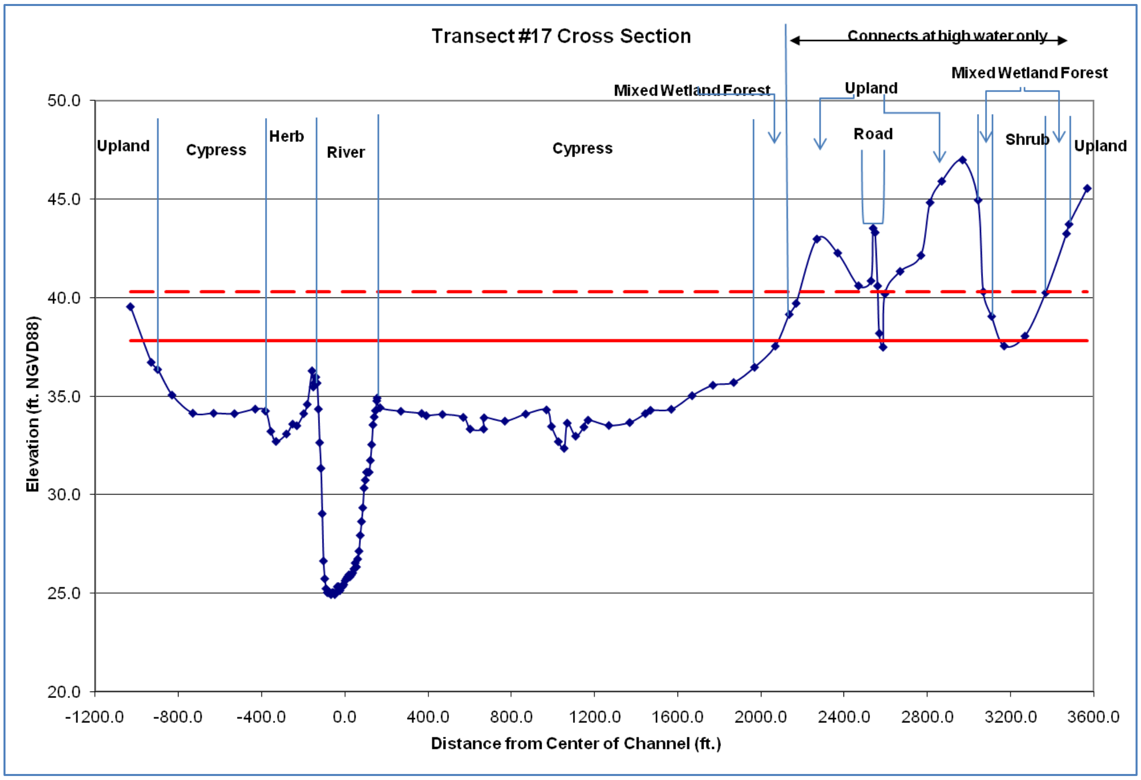

Transect #10 Cross Section
Hardwood
Cypress
Hardwood
River
Mixed Wetland Forest
Upland
Elevation (ft. NGVD88)
Distance from Center of Channel (ft.)

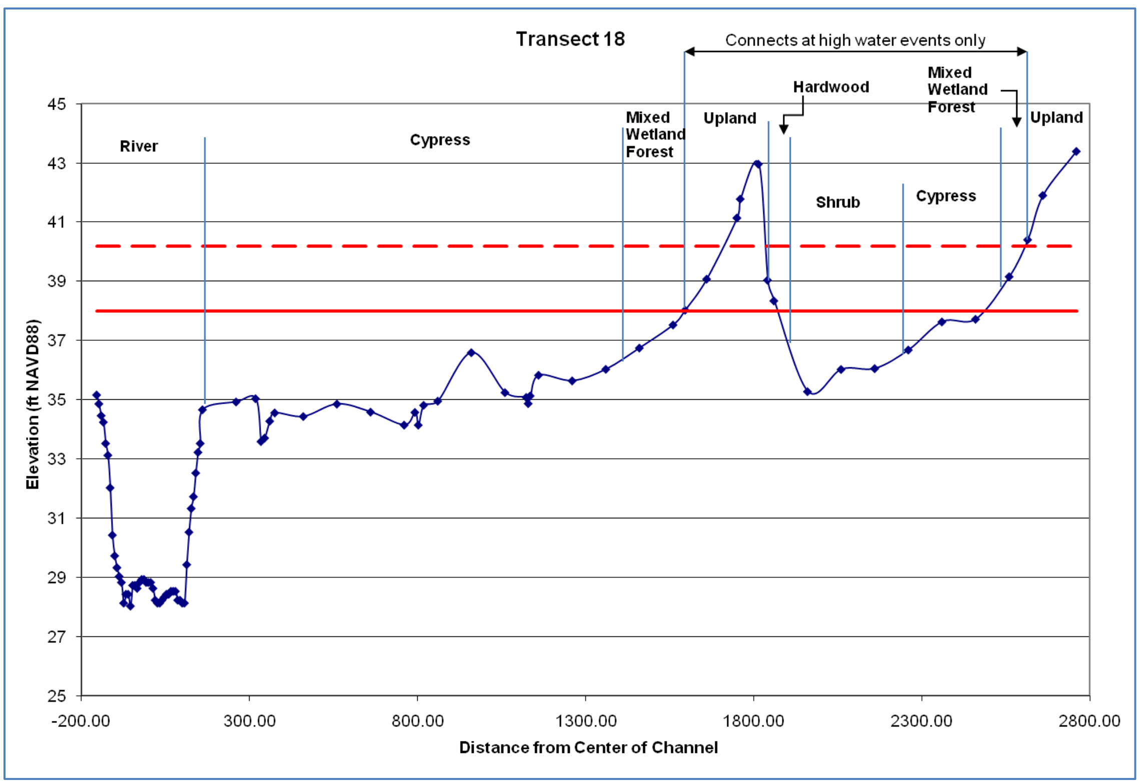

Transect #11 Cross Section
Hardwood
Upland
Mixed Wetland Forest
Cypress
River
Mixed Wetland Forest
Upland
Elevation (ft. NGVD88)
Distance from Center of Channel (ft.)
55.0
50.0
45.0
40.0
35.0
30.0
-700
-500
-300
-100
100
300
500
700
900
1100

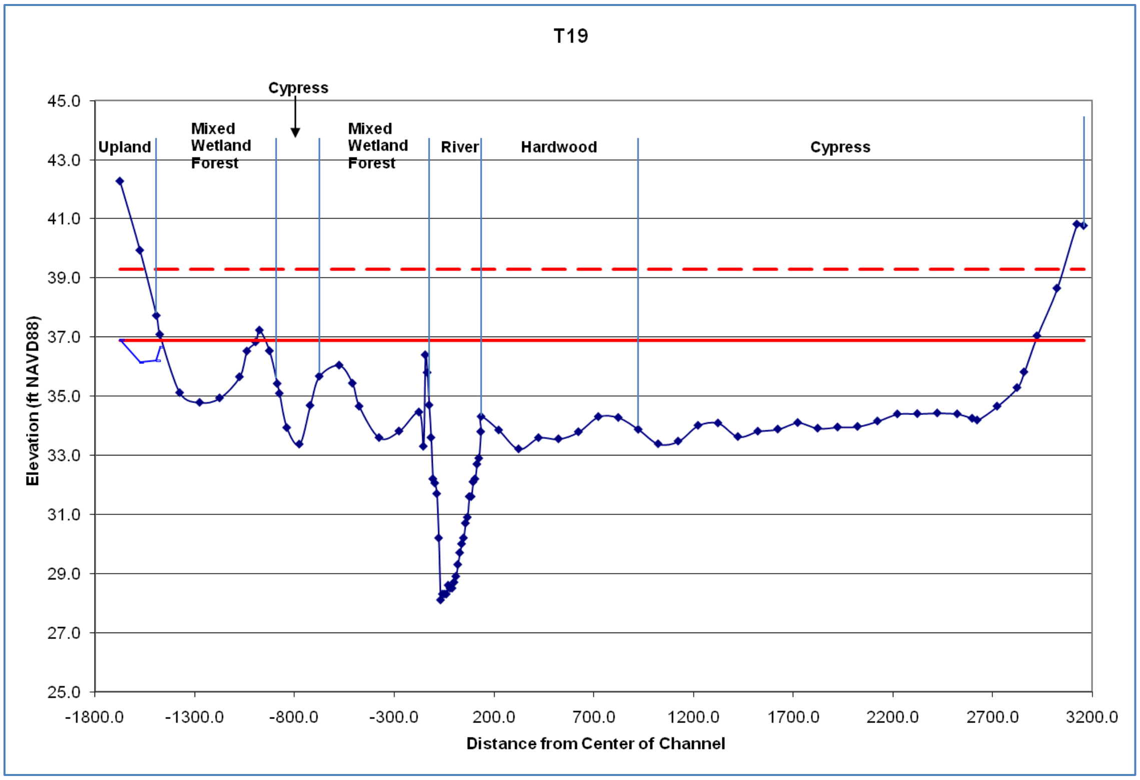

Transect #12 Cross Section
Hardwood
Mixed Wetland Forest
Upland
Cypress
River
Cypress
Hardwood
Upland
Elevation (ft. NGVD88)
Distance from Center of Channel (ft.)
50.0
48.0
46.0
44.0
42.0
40.0
38.0
36.0
34.0
32.0
30.0
-600.0
-400.0
-200.0
0.0
200.0
400.0
600.0
800.0
1000.0

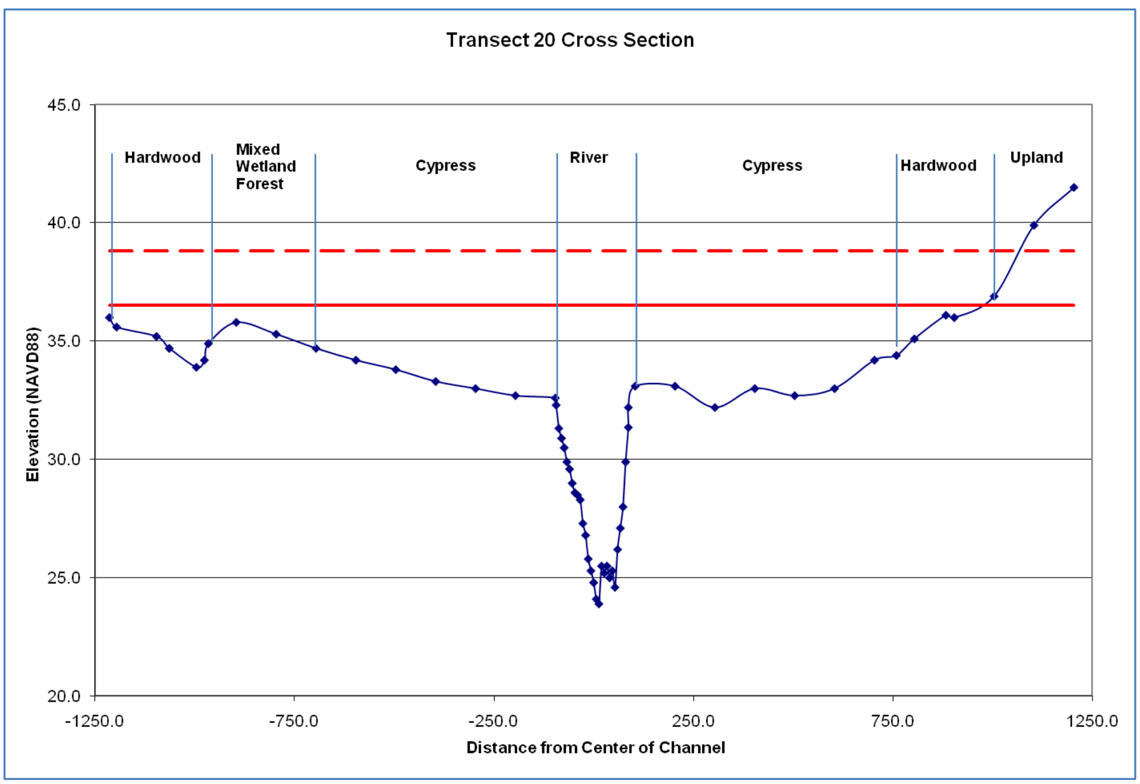

Transect #13 Cross Section
Hardwood
Upland
Cypress
River
Elevation (ft. NGVD88)
Distance from Center of Channel (ft.)
50.0
48.0
46.0
44.0
42.0
40.0
38.0
36.0
34.0
32.0
30.0
-700.0
-600.0
-500.0
-400.0
-300.0
-200.0
-100.0
0.0
100.0

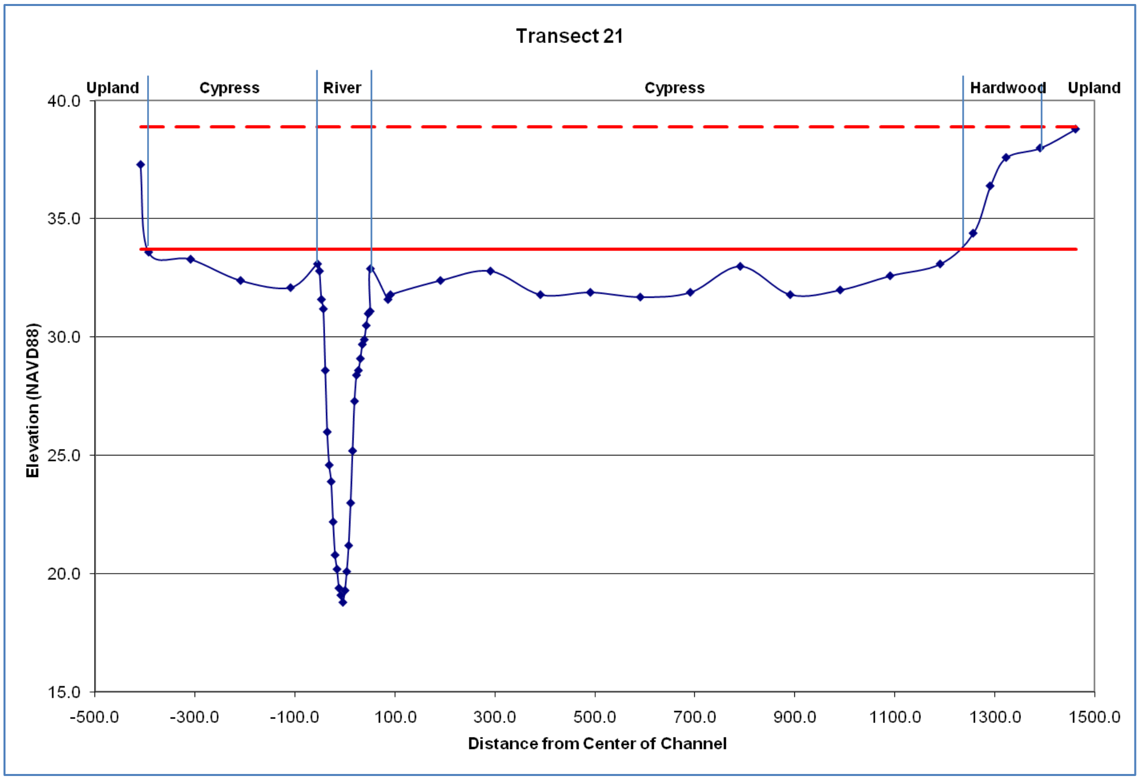

Transect #16 Cross Section
River
Mixed Wetland Forest
Side Channel (Herbaceous)
Mixed Wetland Forest
Elevation (ft. NGVD88)
Distance from Center of Channel (ft.)
43.00
41.00
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
-200.00
200.00
600.00
1000.00
1400.00
1800.00
2200.00
2600.00

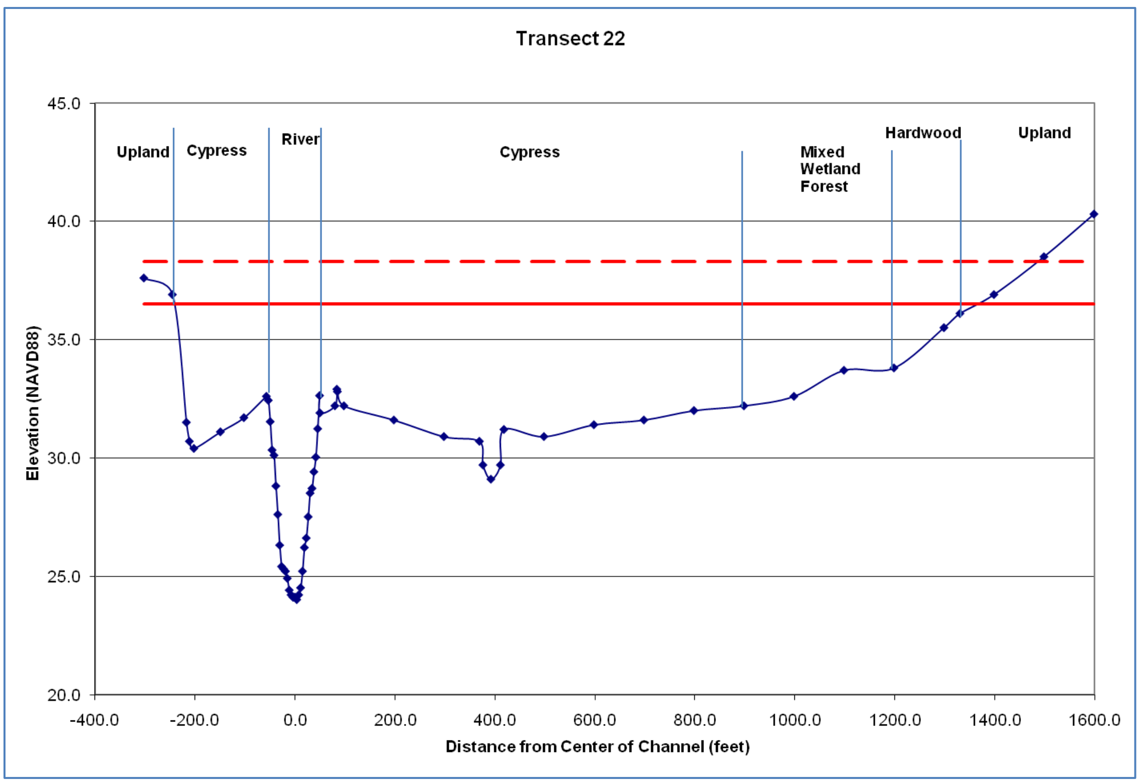

Transect #17 Cross Section
Connects at high water only
Mixed Wetland Forest
Upland
Mixed Wetland Forest
Upland
Cypress
Herb
River
Cypress
Road
Shrub
Upland
Elevation (ft. NGVD88)
Distance from Center of Channel (ft.)

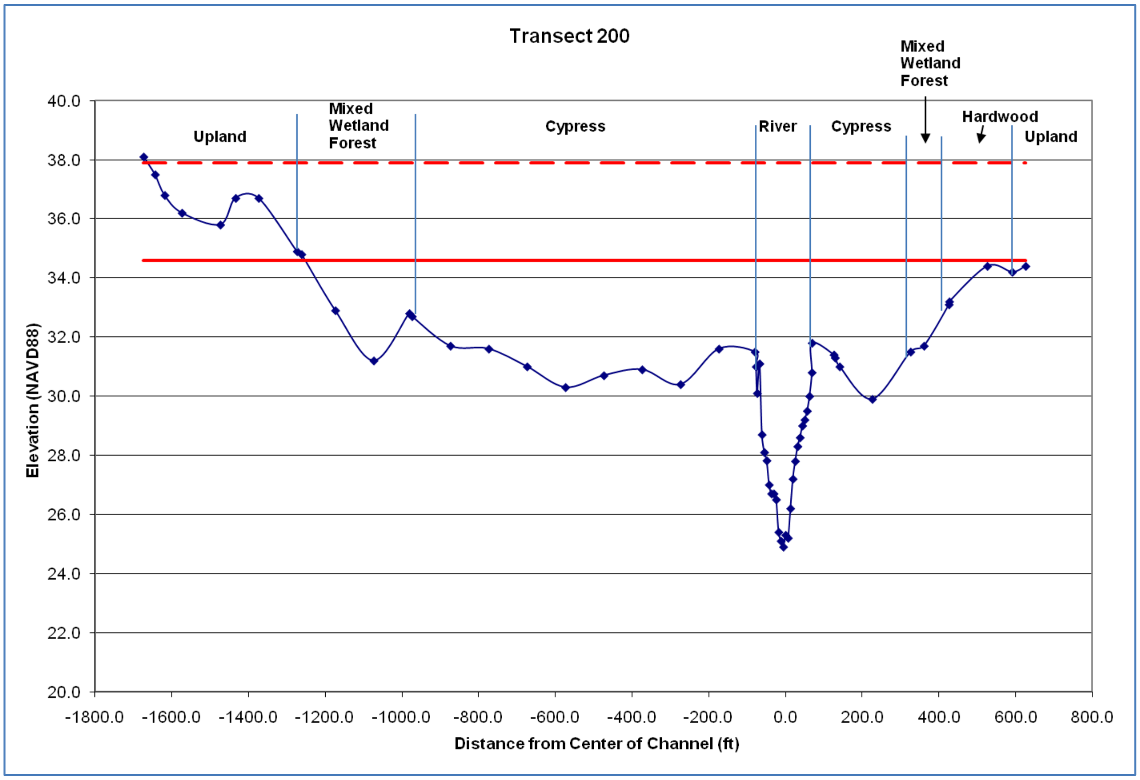

Transect 18
Connects at high water events only
Hardwood
Mixed Wetland Forest
Mixed Wetland Forest
Upland
Upland
River
Cypress
Shrub
Cypress
Elevation (ft NAVD88)
Distance from Center of Channel

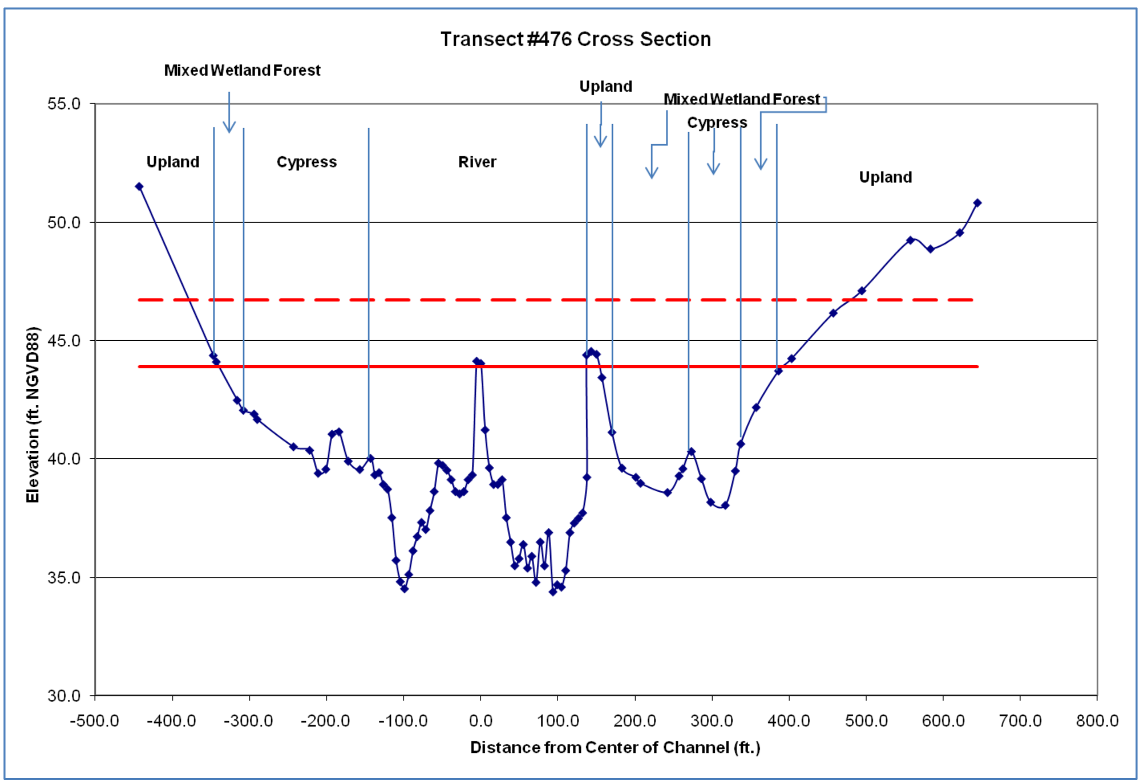

T19
Cypress
Upland
Mixed Wetland Forest
Mixed Wetland Forest
River
Hardwood
Cypress
Elevation (ft NAVD88)
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
-1800.0
-1300.0
-800.0
-300.0
200.0
700.0
1200.0
1700.0
2200.0
2700.0
3200.0
Distance from Center of Channel

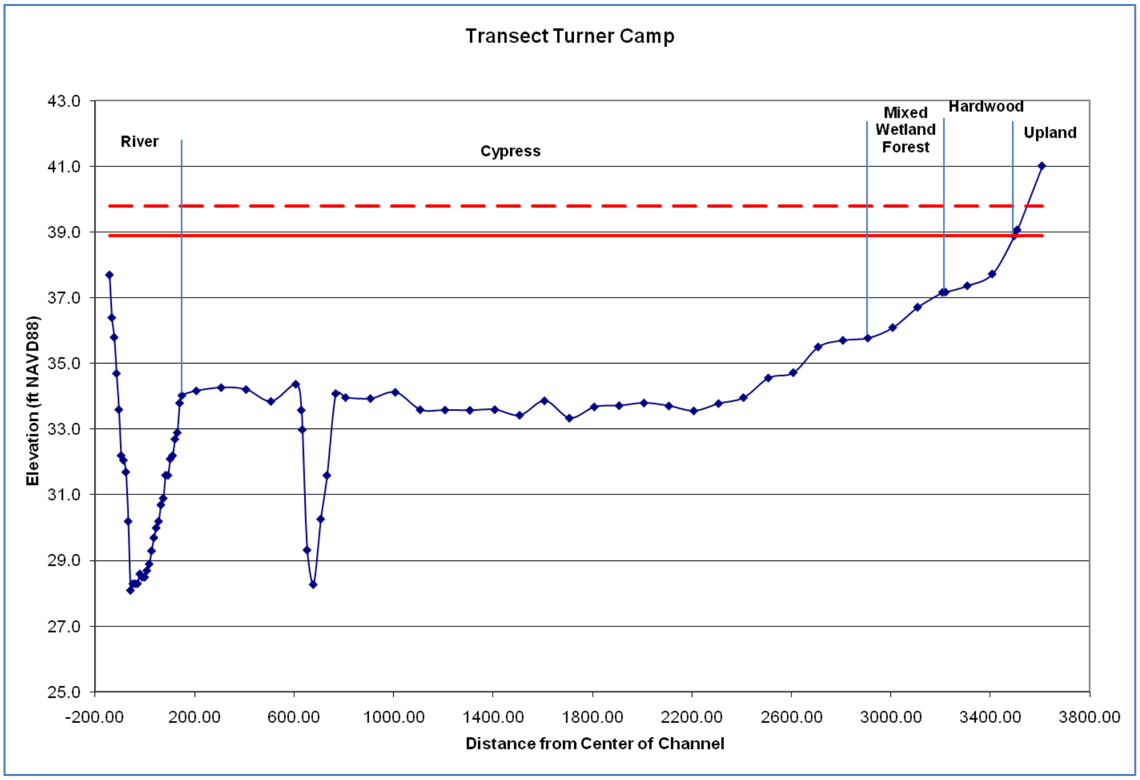

Transect 20 Cross Section
Hardwood
Mixed Wetland Forest
Cypress
River
Cypress
Hardwood
Upland
Elevation (NAVD88)
45.0
40.0
35.0
30.0
25.0
20.0
-1250.0
-750.0
-250.0
250.0
750.0
1250.0
Distance from Center of Channel

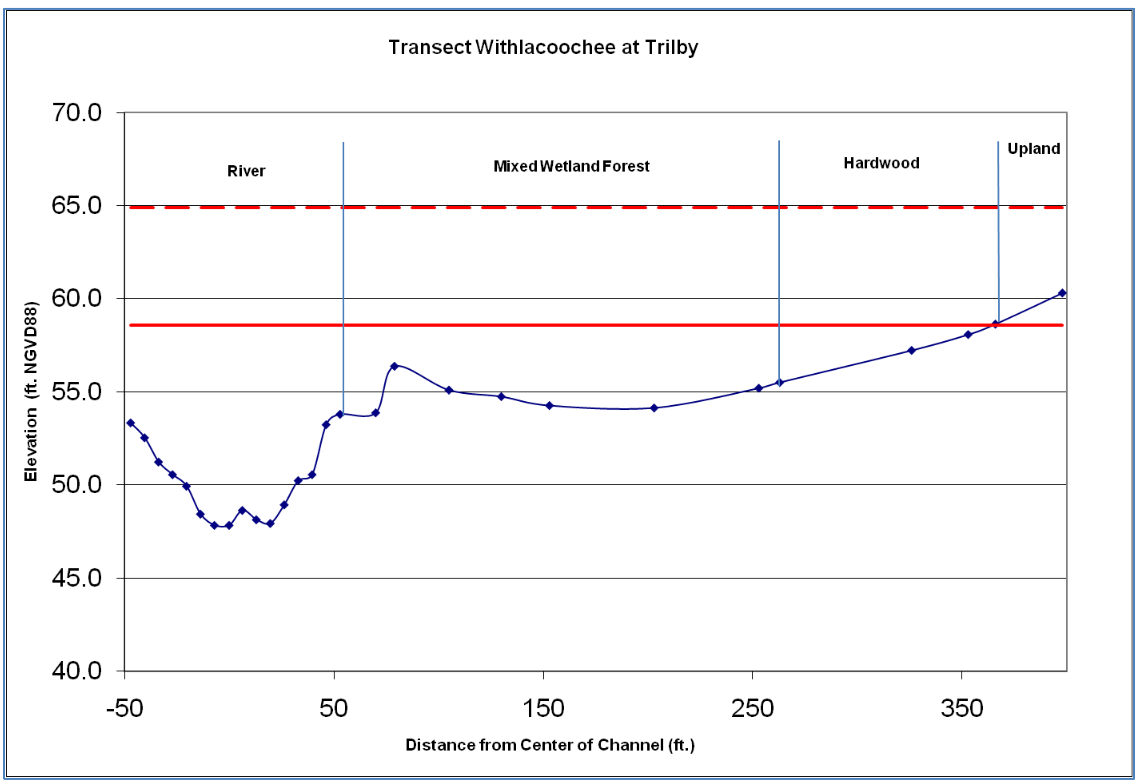

Transect 21
Upland
Cypress
River
Cypress
Hardwood
Upland
Elevation (NAVD88)
40.0
35.0
30.0
25.0
20.0
15.0
-500.0
-300.0
-100.0
100.0
300.0
500.0
700.0
900.0
1100.0
1300.0
1500.0
Distance from Center of Channel

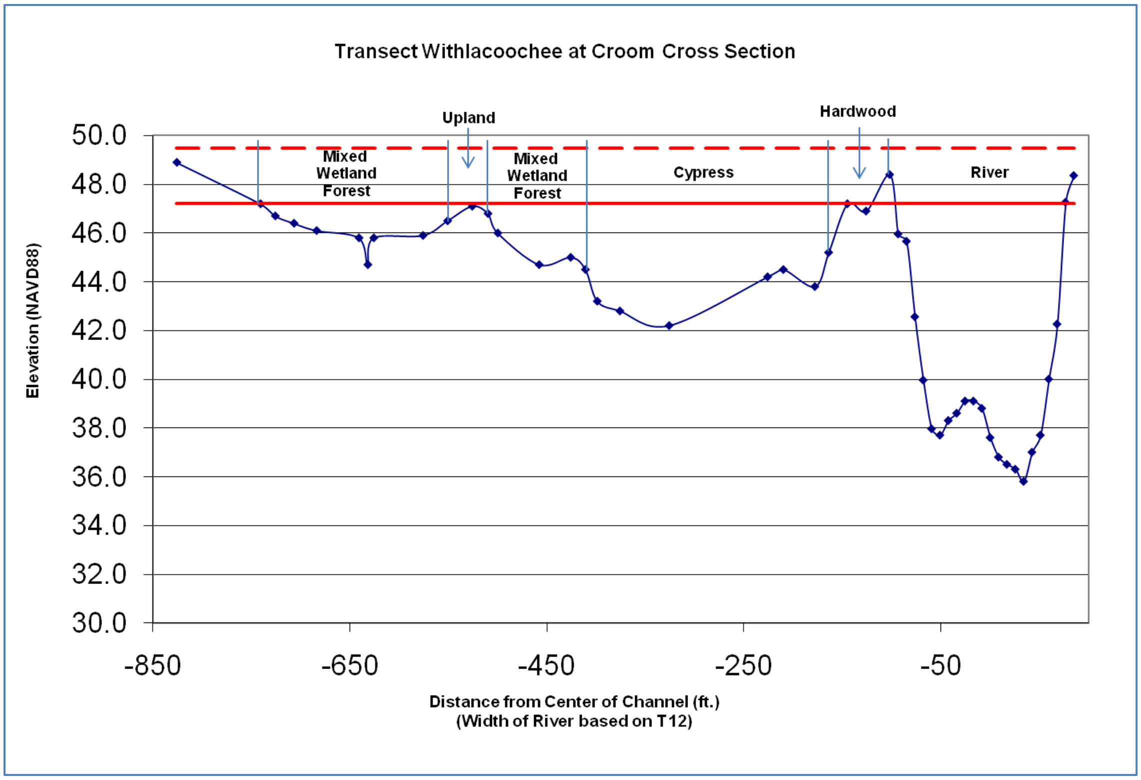

Transect 22
Upland
Cypress
River
Cypress
Mixed Wetland Forest
Hardwood
Upland
Elevation (NAVD88)
45.0
40.0
35.0
30.0
25.0
20.0
-400.0
-200.0
0.0
200.0
400.0
600.0
800.0
1000.0
1200.0
1400.0
1600.0
Distance from Center of Channel (feet)

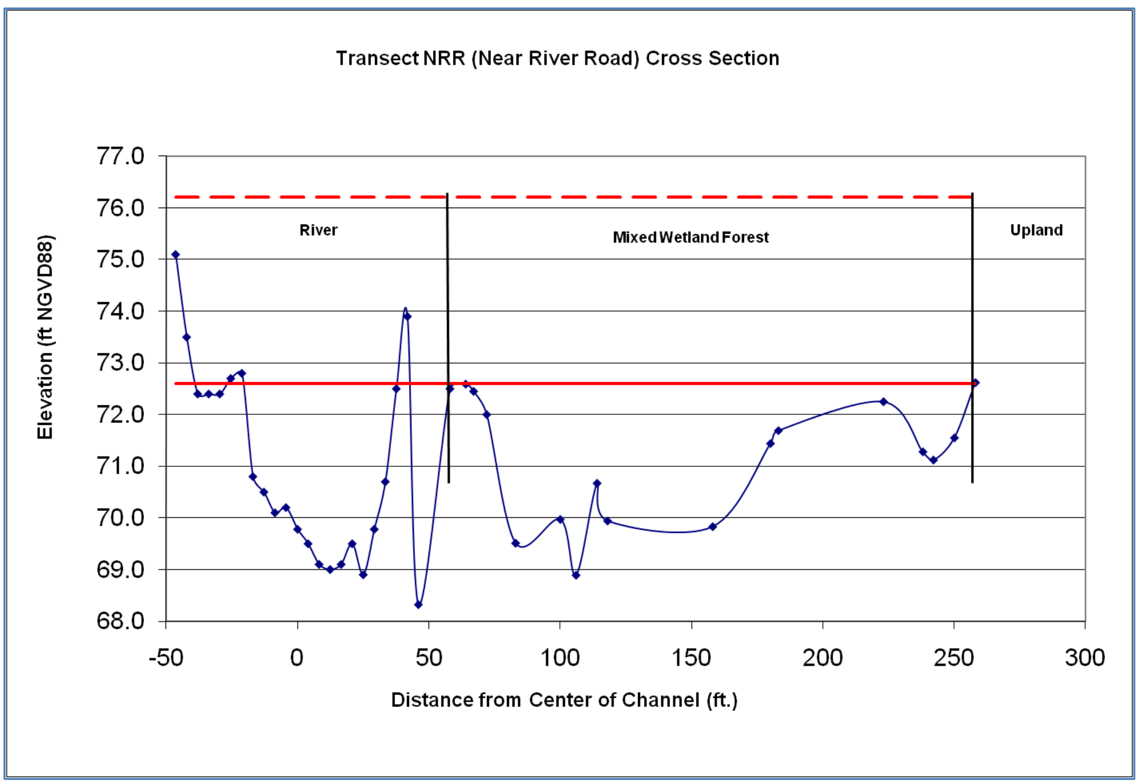

Transect 200
Upland
Mixed Wetland Forest
Cypress
River
Cypress
Mixed Wetland Forest
Hardwood
Upland
Elevation (NAVD88)
Distance from Center of Channel (ft)


Transect #476 Cross Section
Mixed Wetland Forest
Upland
Cypress
River
Upland
Mixed Wetland Forest
Cypress
Upland
Elevation (ft. NGVD88)
Distance from Center of Channel (ft.)


Transect Turner Camp
River
Cypress
Mixed
Wetland
Forest
Hardwood
Upland
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
Elevation (ft NAVD88)
-200.00
200.00
600.00
1000.00
1400.00
1800.00
2200.00
2600.00
3000.00
3400.00
3800.00
Distance from Center of Channel


Transect Withlacoochee at Trilby
River
Mixed Wetland Forest
Hardwood
Upland
70.0
65.0
60.0
55.0
50.0
45.0
40.0
Elevation (ft. NGVD88)
-50
50
150
250
350
Distance from Center of Channel (ft.)


Transect Withlacoochee at Croom Cross Section
Upland
Hardwood
Mixed Wetland Forest
Mixed Wetland Forest
Cypress
River
Elevation (NAVD88)
50.0
48.0
46.0
44.0
42.0
40.0
38.0
36.0
34.0
32.0
30.0
-850
-650
-450
-250
-50
Distance from Center of Channel (ft.)
(Width of River based on T12)


Transect NRR (Near River Road) Cross Section
River
Mixed Wetland Forest
Upland
Elevation (ft NGVD88)
77.0
76.0
75.0
74.0
73.0
72.0
71.0
70.0
69.0
68.0
-50
0
50
100
150
200
250
300
Distance from Center of Channel (ft.)

Appendix C - Photographs

Transect 1 Left Bank – Mixed Wetland Forest

Transect 2 Left Bank – Palmetto Edge

Transect 2 Right Bank – Flowing Side Channel

Transect 2 Right Bank – Flowing Side Channel

Transect 3 Left Bank – River Edge

Transect 3 Left Bank – Mixed Wetland Forest

Transect 3 Left Bank – River Edge

Transect 4 Left Bank – Palmetto Edge

Transect 4 Left Bank – Mixed Wetland Forest

Transect 4 Left Bank – Hardwood

Transect 5 Right Bank – River

Transect 6 Right Bank – Cypress

Transect 6 Right Bank – Mixed Wetland Forest

Transect 7 Left Bank – Shows Station Markers

Transect 7 Right Bank – River Bank

Transect 7 Right Bank – Mixed Wetland Forest

Transect 8 Right Bank – Cypress

Transect 8 Right Bank – Cypress

Transect 9 Right Bank – Cypress

Transect 9 Right Bank – Lichen Line

Transect 11 Left Bank – Transition to Cypress

Transect 11 Left Bank – Cypress

Transect 12 Left Bank – Cypress

Transect 12 Right Bank – Mixed Wetland Forest

Transect 12 Right Bank – Hardwood

Transect 12 Right Bank – Mixed Wetland Forest

Transect 12 Right Bank – Transect/PCQ Set-up

Transect 13 Left Bank – Lichen Line

Transect 476 Left Bank – Palmetto Edge

Transect 476 Left Bank – Cypress

Transect 476 Left Bank – Hardwood

Croom Left Bank – Mixed Wetland Forest

Transect 16 Right Bank – Lichen Line

Transect 16 Right Bank – Lichen Line

Transect 17 Right Bank – River

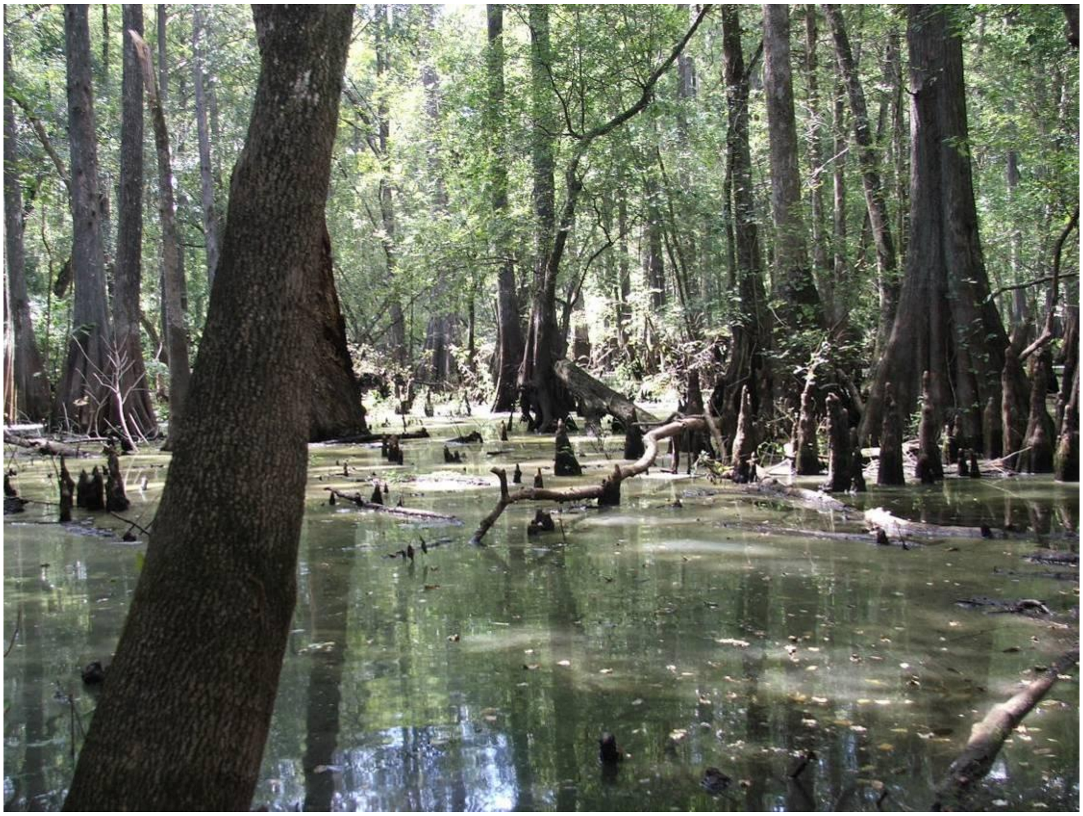

,

Transect 17 Right Bank

Transect 17 Right Bank

Transect 17 Right Bank – Cypress

Transect 18 Right Bank – Shrub



Transect 20-22 – Cypress

5	L1	69.10	17	Hardwood Forest Mixed	3.4	69.9	0.80	72.3	3.20	1480238	611969	0	0	50	1	0
5	R1	65.40	40	Cypress	2.2	70.1	4.70	72.3	6.90	1480389	612248	1	2	0	2	0
5	R10	67.40	490	Mixed Wetland Forest	2.8	70.1	2.70	72.3	4.90	1480604	612643	0	0	50	1	0
5	R11	67.20	540	Mixed Wetland Forest	2.8	70.1	2.90	72.3	5.10	1480628	612687	0	0	50	1	0
5	R12	67.90	590	Mixed Wetland Forest	3.2	70.1	2.20	72.3	4.40	1480652	612731	0	0	50	1	0
5	R13	68.60	693	Mixed Wetland Forest	3.2	70.1	1.50	72.3	3.70	1480701	612821	0	0	50	1	0
5	R14	69.40	751	Mixed Wetland Forest	3.3	70.1	0.70	72.3	2.90	1480729	612872	0	0	50	1	0
5	R2	65.90	90	Cypress	2.3	70.1	4.20	72.3	6.40	1480413	612292	1	2	0	2	0
5	R3	66.30	140	Cypress	2.3	70.1	3.80	72.3	6.00	1480437	612335	1	2	0	2	0
5	R4	65.80	190	Mixed Wetland Forest	2.4	70.1	4.30	72.3	6.50	1480461	612379	1	2	0	2	0
5	R5	65.60	240	Mixed Wetland Forest	2.3	70.1	4.50	72.3	6.70	1480485	612423	1	2	0	2	0
5	R6	65.90	290	Mixed Wetland Forest	2.4	70.1	4.20	72.3	6.40	1480509	612467	1	2	0	2	0
5	R7	66.70	340	Mixed Wetland Forest	2.1	70.1	3.40	72.3	5.60	1480532	612511	1	1	0	1	0
5	R8	67.50	390	Mixed Wetland Forest	3.1	70.1	2.60	72.3	4.80	1480556	612555	1	1	0	1	0
5	R9	67.40	440	Mixed Wetland Forest	3.2	70.1	2.70	72.3	4.90	1480580	612599	1	1	0	1	0
6	L1	64.50	33	Cypress	2.1	68.8	4.30	72	7.50	1485434	608973	1	2	0	2	0
6	L10	69.60	828	Mixed Wetland Forest	3.9	68.8	-0.80	72	2.40	1484956	608338	0	0	50	1	0
6	L11	68.60	928	Mixed Wetland Forest	3.4	68.8	0.20	72	3.40	1484896	608258	0	0	50	1	0
6	L12	68.60	1028	Mixed Wetland Forest	2.8	68.8	0.20	72	3.40	1484836	608178	0	0	50	1	0
6	L2	65.30	78	Cypress	2.3	68.8	3.50	72	6.70	1485407	608937	1	2	0	2	0
6	L4	68.40	228	Mixed Wetland Forest	3.3	68.8	0.40	72	3.60	1485316	608817	1	2	0	2	0
6	L5	68.60	328	Mixed Wetland Forest	3.7	68.8	0.20	72	3.40	1485256	608737	1	1	0	1	0
6	L6	68.30	428	Mixed Wetland Forest	3.5	68.8	0.50	72	3.70	1485196	608657	0	0	30	1	0
6	L7	67.90	528	Mixed Wetland Forest	3.2	68.8	0.90	72	4.10	1485136	608577	1	1	0	1	0
6	L8	68.60	628	Mixed Wetland Forest	3.6	68.8	0.20	72	3.40	1485076	608498	1	1	0	1	0
6	L9	69.40	728	Mixed Wetland Forest	3.9	68.8	-0.60	72	2.60	1485016	608418	1	1	0	1	0
6	R10	68.30	899	Mixed Wetland Forest	3.4	68.1	-0.20	72	3.70	1486067	609817	1	1	0	1	0
6	R11	66.90	999	Mixed Wetland Forest	2.8	68.1	1.20	72	5.10	1486127	609897	1	1	0	1	0
6	R12	67.40	1049	Mixed Wetland Forest	3.5	68.1	0.70	72	4.60	1486157	609937	0	0	30	1	0
6	R2	68.60	249	Upland	3.9	68.1	-0.50	72	3.40	1485677	609297	0	0	50	1	0
6	R3	68.40	295	Upland	3.7	68.1	-0.30	72	3.60	1485704	609334	0	0	50	1	0
6	R4	67.30	349	Cypress	2.8	68.1	0.80	72	4.70	1485737	609377	1	1	0	1	0
6	R5	66.20	449	Cypress	1.6	68.1	1.90	72	5.80	1485797	609457	1	2	0	2	0
6	R6	66.70	499	Cypress	2.3	68.1	1.40	72	5.30	1485827	609497	1	2	0	2	0
6	R7	67.20	599	Cypress	2.4	68.1	0.90	72	4.80	1485887	609577	1	1	0	1	0
6	R8	67.30	699	Mixed Wetland Forest	2.5	68.1	0.80	72	4.70	1485947	609657	1	1	15	1	0
6	R9	68.00	799	Mixed Wetland Forest	3.0	68.1	0.10	72	4.00	1486007	609737	1	1	15	1	0
7	L1	62.70	79	Hardwood Forest Mixed		63.8	1.10	67.5	4.80	1501751	612624	1	1	15	1	0
7	L2	63.00	135	Mixed Wetland Forest		63.8	0.80	67.5	4.50	1501772	612572	0	0	20	1	0
7	R1	63.50	1492	Hardwood Forest Mixed	3.5	64.7	1.20	67.5	4.00	1501128	614146	0	0	38	1	0
7	R2	63.10	1392	Hardwood Forest Mixed	3.3	64.7	1.60	67.5	4.40	1501166	614053	0	0	20	1	0
7	R3	62.60	1292	Hardwood Forest Mixed	3.1	64.7	2.10	67.5	4.90	1501204	613960	1	1	10	1	0

7	R4	62.10	1192	Hardwood Forest Mixed	2.8	64.7	2.60	67.5	5.40	1501242	613868	1	2	0	2	0
7	R5	61.80	1092	Mixed Wetland Forest	3.3	64.7	2.90	67.5	5.70	1501280	613775	1	1	0	0	1
7	R6	61.50	992	Mixed Wetland Forest	2.4	64.7	3.20	67.5	6.00	1501318	613683	1	1	0	0	1
7	R7	61.50	892	Mixed Wetland Forest	2.7	64.7	3.20	67.5	6.00	1501356	613590	1	1	0	0	1
7	R8	61.20	792	Mixed Wetland Forest	2.4	64.7	3.50	67.5	6.30	1501394	613498	1	1	0	0	1
7	R9	61.50	692	Mixed Wetland Forest	2.9	64.7	3.20	67.5	6.00	1501431	613405	1	1	0	0	1
7	R10	61.40	592	Mixed Wetland Forest	3.0	64.7	3.30	67.5	6.10	1501469	613313	1	1	0	0	1
7	R11	61.10	492	Mixed Wetland Forest	2.7	64.7	3.60	67.5	6.40	1501507	613220	1	1	0	0	1
7	R12	60.80	392	Mixed Wetland Forest	2.5	64.7	3.90	67.5	6.70	1501545	613128	1	1	0	0	1
7	R13	60.80	292	Mixed Wetland Forest	2.3	64.7	3.90	67.5	6.70	1501583	613035	1	1	0	0	1
7	R14	60.80	192	Mixed Wetland Forest	2.6	64.7	3.90	67.5	6.70	1501621	612942	1	1	0	0	1
7	R15	60.70	92	Mixed Wetland Forest	3.1	64.7	4.00	67.5	6.80	1501659	612850	1	1	0	0	1
8	L1	63.50	747	Upland	3.6	64.1	0.60	67.2	3.70	1504508	610012	0	0	25	1	0
8	L2	63.10	648	Hardwood Forest Mixed	2.7	64.1	1.00	67.2	4.10	1504595	610059	0	0	22	1	0
8	L3	61.80	600	Hardwood Forest Mixed	2.7	64.1	2.30	67.2	5.40	1504638	610082	0	0	20	1	0
8	L4	61.10	500	Hardwood Forest Mixed	3.5	64.1	3.00	67.2	6.10	1504726	610129	0	0	20	1	0
8	L5	61.10	400	Hardwood Forest Mixed	3.1	64.1	3.00	67.2	6.10	1504814	610177	0	0	20	1	0
8	L6	60.80	341	Hardwood Forest Mixed	3.6	64.1	3.30	67.2	6.40	1504865	610205	1	1	5	1	0
8	L7	59.30	200	Cypress	2.0	64.1	4.80	67.2	7.90	1504990	610272	1	1	0	1	0
8	L8	58.80	156	Cypress	2.2	64.1	5.30	67.2	8.40	1505028	610293	1	1	0	0	1
8	L9	57.70	60	Cypress	2.3	64.1	6.40	67.2	9.50	1505113	610338	1	1	0	0	1
8	R1	63.10	717	Upland	3.3	64.4	1.30	67.2	4.10	1505870	610747	0	0	25	1	0
8	R2	56.60	617	Cypress	1.5	64.4	7.80	67.2	10.60	1505782	610699	1	2	0	2	0
8	R3	55.70	517	Cypress	1.6	64.4	8.70	67.2	11.50	1505694	610652	1	2	0	2	0
8	R4	55.10	417	Cypress	1.5	64.4	9.30	67.2	12.10	1505606	610604	1	2	0	2	0
8	R5	55.20	317	Cypress	1.9	64.4	9.20	67.2	12.00	1505518	610557	1	2	0	2	0
8	R6	55.50	217	Cypress	2.0	64.4	8.90	67.2	11.70	1505430	610509	1	2	0	2	0
8	R7	58.00	117	Cypress	2.3	64.4	6.40	67.2	9.20	1505342	610462	1	1	0	1	0
9	L1	44.60	28	Mixed Wetland Forest	2.8	47.6	3.00	49.4	4.80	1549874	583436	1	1	0	1	0
9	R1	43.50	1136	Cypress	1.9	46.3	2.80	49.5	6.00	1551002	584265	1	1	0	1	0
9	R2	40.30	1064	Willow	1.3	46.3	6.00	49.5	9.20	1550944	584222	1	2	0	2	0
9	R3	40.50	964	Willow	1.3	46.3	5.80	49.5	9.00	1550863	584163	1	2	0	2	0
9	R4	43.80	864	Cypress	2.8	46.3	2.50	49.5	5.70	1550783	584104	1	1	0	0	1
9	R5	46.90	764	Upland	3.5	46.3	-0.60	49.5	2.60	1550702	584045	0	0	20	1	0
9	R6	51.80	664	Upland	4.3	46.3	-5.50	49.5	-2.30	1550622	583986	0	0	25	1	0
9	R7	52.90	564	Upland	4.1	46.3	-6.60	49.5	-3.40	1550541	583926	0	0	30	1	0
9	R8	42.30	464	Cypress	2.0	46.3	4.00	49.5	7.20	1550460	583867	1	2	0	2	0
9	R9	42.70	364	Cypress	2.0	46.3	3.60	49.5	6.80	1550380	583808	1	1	10	1	0
9	R10	45.40	164	Mixed Wetland Forest	2.5	46.3	0.90	49.5	4.10	1550219	583690	1	1	0	0	1
9	R11	45.40	64	Mixed Wetland Forest	2.6	46.3	0.90	49.5	4.10	1550138	583630	1	1	0	0	1
10	L1	45.90	791	Hardwood Forest Mixed	3.7	46.7	0.80	49	3.10	1550138	581974	1	1	10	1	0

10	L2	43.20	691	Cypress	2.3	46.7	3.50	49	5.80	1550229	582017	1	1	0	0	1
10	L3	40.50	591	Cypress	1.6	46.7	6.20	49	8.50	1550320	582059	1	2	0	2	0
10	L4	44.00	491	Cypress	3.0	46.7	2.70	49	5.00	1550410	582101	1	1	0	0	1
10	L5	45.40	391	Hardwood Forest Mixed	3.7	46.7	1.30	49	3.60	1550501	582144	1	1	0	0	1
10	L6	45.30	268	Hardwood Forest Mixed	2.9	46.7	1.40	49	3.70	1550612	582196	1	1	0	0	1
10	L7	45.20	191	Hardwood Forest Mixed	3.4	46.7	1.50	49	3.80	1550682	582229	1	1	0	0	1
10	L8	44.70	91	Hardwood Forest Mixed	3.3	46.7	2.00	49	4.30	1550772	582271	1	1	0	0	1
10	R1	40.10	690	Mixed Wetland Forest	2.1	46	5.90	49	8.90	1551587	582653	1	2	0	2	0
10	R2	42.60	590	Mixed Wetland Forest	2.4	46	3.40	49	6.40	1551497	582611	1	1	10	1	0
10	R3	41.00	490	Mixed Wetland Forest	1.9	46	5.00	49	8.00	1551406	582568	1	1	0	1	0
10	R4	41.60	390	Mixed Wetland Forest	2.6	46	4.40	49	7.40	1551315	582526	1	1	0	2	0
10	R5	44.60	290	Mixed Wetland Forest	3.0	46	1.40	49	4.40	1551225	582484	1	1	0	0	1
10	R6	43.80	190	Mixed Wetland Forest	2.1	46	2.20	49	5.20	1551134	582441	1	1	0	0	1
10	R7	43.80	90	Mixed Wetland Forest	2.3	46	2.20	49	5.20	1551044	582399	1	1	0	0	1
11	L1	41.50	400	Mixed Wetland Forest	1.9	45.7	4.20	48.3	6.80	1553759	580678	1	1	0	1	0
11	L2	40.70	300	Mixed Wetland Forest	1.8	45.7	5.00	48.3	7.60	1553736	580776	1	1	0	0	1
11	L3	39.70	200	Cypress	1.4	45.7	6.00	48.3	8.60	1553714	580873	1	1	0	0	1
11	L4	40.90	55	Mixed Wetland Forest	2.2	45.7	4.80	48.3	7.40	1553682	581015	1	1	0	0	1
11	R1	46.00	862	Hardwood Forest Mixed	3.3	46.8	0.80	48.3	2.30	1553445	582060	0	0	40	1	0
11	R2	40.70	745	Mixed Wetland Forest	2.4	46.8	6.10	48.3	7.60	1553471	581946	1	2	0	0	1
11	R3	40.00	645	Mixed Wetland Forest	1.9	46.8	6.80	48.3	8.30	1553493	581849	1	2	0	2	0
11	R4	40.30	545	Mixed Wetland Forest	2.1	46.8	6.50	48.3	8.00	1553515	581751	1	2	0	2	0
11	R5	42.50	445	Mixed Wetland Forest	1.9	46.8	4.30	48.3	5.80	1553537	581654	1	2	0	2	0
11	R6	42.20	345	Cypress	1.7	46.8	4.60	48.3	6.10	1553559	581556	1	2	0	2	0
11	R7	42.00	245	Cypress	1.4	46.8	4.80	48.3	6.30	1553582	581459	1	2	0	2	0
11	R8	40.50	145	Mixed Wetland Forest	1.9	46.8	6.30	48.3	7.80	1553604	581361	1	2	0	2	0
11	R9	41.30	45	Cypress	1.7	46.8	5.50	48.3	7.00	1553626	581264	1	2	0	2	0
11	R10	41.50	0	Mixed Wetland Forest	1.8	46.8	5.30	48.3	6.80	1553636	581220	1	2	0	2	0
12	L1	44.60	400	Hardwood Forest Mixed	3.1	45.5	0.90	47.8	3.20	1557616	577636	0	0	20	1	0
12	L2	42.60	300	Cypress	1.9	45.5	2.90	47.8	5.20	1557706	577680	1	1	0	0	1
12	L3	40.30	200	Cypress	1.6	45.5	5.20	47.8	7.50	1557796	577723	1	2	0	2	0
12	L4	40.80	100	Cypress	1.7	45.5	4.70	47.8	7.00	1557886	577766	1	2	0	2	0
12	L5	42.00	31	Mixed Wetland Forest	2.0	45.5	3.50	47.8	5.80	1557948	577796	1	1	0	0	1
12	R1	46.40	616	Hardwood Forest Mixed	3.6	47.1	0.70	47.8	1.40	1558697	578156	1	1	10	1	0
12	R2	44.40	516	Hardwood Forest Mixed	3.4	47.1	2.70	47.8	3.40	1558607	578113	1	1	25	1	0
12	R3	40.90	316	Cypress	1.8	47.1	6.20	47.8	6.90	1558427	578026	1	1	0	0	1
12	R4	42.90	216	Cypress	1.9	47.1	4.20	47.8	4.90	1558337	577983	1	1	0	0	1
12	R5	42.30	116	Cypress	1.6	47.1	4.80	47.8	5.50	1558247	577939	1	1	0	0	1
12	R6	44.70	16	Mixed Wetland Forest	3.3	47.1	2.40	47.8	3.10	1558157	577896	1	1	12	1	0
13	L1	44.20	500	Hardwood Forest Mixed	3.4	45.4	1.20	47.1	2.90	1562289	573730	0	0	40	1	0

13	L2	41.50	400	Cypress	2.7	45.4	3.90	47.1	5.60	1562358	573802	1	1	0	0	1
13	L3	40.90	300	Cypress	2.4	45.4	4.50	47.1	6.20	1562427	573874	1	2	0	2	0
13	L4	38.30	200	Cypress	1.1	45.4	7.10	47.1	8.80	1562496	573947	1	2	0	2	0
13	L5	39.40	100	Cypress	1.5	45.4	6.00	47.1	7.70	1562565	574019	1	2	0	2	0
16	R1	34.70	100	Mixed Wetland Forest	2.0	39.4	4.70	40.3	5.60	1645199	581575	1	2	0	2	0
16	R2	34.60	300	Mixed Wetland Forest	1.6	39.4	4.80	40.3	5.70	1645345	581712	1	2	0	2	0
16	R3	32.50	650	Herbaceous	1.0	39.4	6.90	40.3	7.80	1645599	581952	1	1	0	1	0
16	R4	33.00	700	Herbaceous	1.6	39.4	6.40	40.3	7.30	1645635	581987	1	1	0	1	0
16	R5	31.90	800	Herbaceous	2.0	39.4	7.50	40.3	8.40	1645708	582055	1	1	0	1	0
16	R6	38.10	2400	Mixed Wetland Forest	2.3	39.4	1.30	40.3	2.20	1646871	583154	1	1	0	1	1
16	R8	37.50	2200	Mixed Wetland Forest	3.0	39.4	1.90	40.3	2.80	1646726	583017	1	1	0	1	0
16	R9	35.90	2100	Mixed Wetland Forest	2.4	39.4	3.50	40.3	4.40	1646653	582948	1	2	0	2	1
16	R10	34.80	2000	Mixed Wetland Forest	1.3	39.4	4.60	40.3	5.50	1646580	582880	1	2	0	2	0
16	R11	35.30	1900	Mixed Wetland Forest	2.0	39.4	4.10	40.3	5.00	1646508	582811	1	2	0	2	0
16	R12	34.90	1800	Mixed Wetland Forest	1.6	39.4	4.50	40.3	5.40	1646435	582742	1	2	0	2	1
16	R13	34.70	1700	Mixed Wetland Forest	1.6	39.4	4.70	40.3	5.60	1646362	582674	1	2	0	2	1
16	R14	34.70	1600	Mixed Wetland Forest	1.6	39.4	4.70	40.3	5.60	1646290	582605	1	2	0	2	1
16	R16	34.90	1400	Mixed Wetland Forest	2.2	39.4	4.50	40.3	5.40	1646144	582468	1	2	0	2	1
16	R17	34.90	1300	Mixed Wetland Forest	1.7	39.4	4.50	40.3	5.40	1646072	582399	1	2	0	2	1
16	R18	34.70	1200	Mixed Wetland Forest	2.1	39.4	4.70	40.3	5.60	1645999	582330	1	2	0	2	1
16	R20	34.00	1000	Mixed Wetland Forest	1.0	39.4	5.40	40.3	6.30	1645853	582193	1	2	0	2	1
17	L1	36.70	773	Herbaceous	3.2	36.4	-0.30	40.3	3.60	1650926	577793	1	1	7	1	0
17	L2	35.10	673	Cypress	1.4	36.4	1.30	40.3	5.20	1650932	577893	1	2	0	2	0
17	L3	34.10	473	Cypress	1.0	36.4	2.30	40.3	6.20	1650943	578093	1	2	0	2	0
17	L4	34.30	273	Cypress	1.0	36.4	2.10	40.3	6.00	1650954	578293	1	2	0	2	0
17	L5	32.70	173	Herbaceous	1.1	36.4	3.70	40.3	7.60	1650960	578393	1	1	0	1	0
17	L6	33.50	73	Herbaceous	1.3	36.4	2.90	40.3	6.80	1650965	578492	1	2	0	2	0
17	R6	37.50	1914	Mixed Wetland Forest	2.4	39.1	1.60	40.3	2.80	1651095	580789	1	1	0	1	1
17	R7	35.70	1714	Cypress	1.5	39.1	3.40	40.3	4.60	1651083	580589	1	2	0	2	1
17	R8	35.00	1514	Cypress	1.3	39.1	4.10	40.3	5.30	1651072	580389	1	2	0	2	1
17	R9	34.30	1314	Cypress	2.0	39.1	4.80	40.3	6.00	1651061	580190	1	1	0	2	0
17	R10	33.70	1214	Cypress	1.6	39.1	5.40	40.3	6.60	1651055	580090	1	1	0	1	0
17	R11	33.80	1014	Cypress	1.8	39.1	5.30	40.3	6.50	1651044	579890	1	2	0	2	0
17	R12	33.60	914	Cypress	1.8	39.1	5.50	40.3	6.70	1651038	579790	1	1	0	1	0
17	R13	34.30	814	Cypress	1.5	39.1	4.80	40.3	6.00	1651033	579690	1	2	0	2	0
17	R14	33.70	614	Cypress	1.0	39.1	5.40	40.3	6.60	1651022	579491	1	2	0	2	0
17	R15	33.90	414	Cypress	1.7	39.1	5.20	40.3	6.40	1651010	579291	1	2	0	2	0
17	R16	34.10	214	Cypress	1.8	39.1	5.00	40.3	6.20	1650999	579091	1	2	0	2	0
17	R17	40.20	114	Cypress	1.5	39.1	-1.10	40.3	0.10	1650994	578992	1	2	0	2	0
18	R10	37.50	1400	Mixed Wetland Forest	2.2	38	0.50	40.2	2.70	1655537	575504	1	1	0	0	1

18	R11	36.70	1300	Mixed Wetland Forest	2.8	38	1.30	40.2	3.50	1655449	575458	1	2	0	2	1
18	R12	35.60	1100	Cypress	2.2	38	2.40	40.2	4.60	1655272	575365	1	2	0	2	1
18	R13	35.20	900	Cypress	2.2	38	2.80	40.2	5.00	1655095	575272	1	2	0	2	1
18	R14	36.60	800	Cypress	2.0	38	1.40	40.2	3.60	1655006	575225	1	2	0	2	0
18	R15	35.00	700	Cypress	2.2	38	3.00	40.2	5.20	1654918	575179	1	2	0	2	0
18	R16	34.60	500	Cypress	1.6	38	3.40	40.2	5.60	1654741	575086	1	2	0	2	0
18	R17	34.40	300	Cypress	1.9	38	3.60	40.2	5.80	1654563	574993	1	2	0	2	0
18	R18	34.90	100	Cypress	1.6	38	3.10	40.2	5.30	1654386	574900	1	2	0	2	0
19	L1	37.10	1322	Mixed Wetland Forest	2.9	37.7	0.60	36.9	-0.20	1655202	570553	0	0	20	1	0
19	L2	35.10	1222	Mixed Wetland Forest	2.0	37.7	2.60	36.9	1.80	1655288	570603	1	2	0	2	0
19	L3	34.90	1022	Mixed Wetland Forest	1.7	37.7	2.80	36.9	2.00	1655461	570703	1	2	0	2	0
19	L4	37.20	822	Mixed Wetland Forest	2.6	37.7	0.50	36.9	-0.30	1655634	570803	1	1	10	1	0
19	L5	35.10	722	Cypress	1.2	37.7	2.60	36.9	1.80	1655721	570854	1	2	0	2	0
19	L6	33.40	622	Cypress	1.4	37.7	4.30	36.9	3.50	1655807	570904	1	2	0	2	0
19	L7	35.70	522	Mixed Wetland Forest	2.2	37.7	2.00	36.9	1.20	1655894	570954	1	2	0	2	0
19	L8	36.00	422	Mixed Wetland Forest	2.4	37.7	1.70	36.9	0.90	1655980	571004	1	2	0	2	0
19	L9	33.60	222	Mixed Wetland Forest	1.8	37.7	4.10	36.9	3.30	1656153	571104	1	2	0	2	0
19	L10	34.50	22	Mixed Wetland Forest	1.7	37.7	3.20	36.9	2.40	1656326	571205	1	2	0	2	0
19	R1	33.20	0	Hardwood Forest Mixed	3.5	40.8	7.60	36.9	3.70	1656759	571455	1	1	17	0	1
19	R2	33.80	300	Hardwood Forest Mixed	3.4	40.8	7.00	36.9	3.10	1657018	571606	1	1	0	1	0
19	R3	34.30	500	Hardwood Forest Mixed	3.2	40.8	6.50	36.9	2.60	1657191	571706	1	1	0	1	0
19	R4	33.50	800	Cypress	2.0	40.8	7.30	36.9	3.40	1657451	571857	1	2	0	2	0
19	R5	34.10	1000	Cypress	1.4	40.8	6.70	36.9	2.80	1657624	571957	1	2	0	2	0
19	R6	33.90	1300	Cypress	1.3	40.8	6.90	36.9	3.00	1657883	572108	1	2	0	2	0
19	R7	33.90	1500	Cypress	1.6	40.8	6.90	36.9	3.00	1658056	572208	1	2	0	2	0
19	R8	34.20	1800	Cypress	1.1	40.8	6.60	36.9	2.70	1658316	572358	1	2	0	2	0
19	R9	34.40	2000	Cypress	1.4	40.8	6.40	36.9	2.50	1658489	572459	1	2	0	2	0
19	R10	34.20	2300	Cypress	1.6	40.8	6.60	36.9	2.70	1658748	572609	1	2	0	2	0
19	R11	35.30	2500	Cypress	1.5	40.8	5.50	36.9	1.60	1658921	572710	1	2	0	2	0
19	R12	37.00	2600	Cypress	1.7	40.8	3.80	36.9	-0.10	1659008	572760	1	2	0	2	0
19	R13	38.70	2700	Cypress	1.8	40.8	2.10	36.9	-1.80	1659094	572810	1	2	0	2	0
19	R14	40.80	2800	Cypress	1.8	40.8	0.00	36.9	-3.90	1659181	572860	1	2	0	2	0
20	L1	35.60	1102	Mixed Wetland Forest	2.3	36	0.40	38.8	3.20	1684305	555022	1	1	8	1	1
20	L2	35.20	1002	Mixed Wetland Forest	2.6	36	0.80	38.8	3.60	1684329	555119	1	1	0	1	0
20	L3	33.90	902	Mixed Wetland Forest	1.8	36	2.10	38.8	4.90	1684353	555216	1	2	0	2	0
20	L4	35.80	802	Hardwood Forest Mixed	2.7	36	0.20	38.8	3.00	1684377	555313	1	1	8	1	0
20	L5	35.30	702	Hardwood Forest Mixed	2.9	36	0.70	38.8	3.50	1684400	555410	1	1	8	1	0
20	L7	34.20	502	Mixed Wetland Forest	2.8	36	1.80	38.8	4.60	1684448	555605	1	1	0	1	0
20	L8	33.30	302	Cypress	1.8	36	2.70	38.8	5.50	1684496	555799	1	2	0	2	0
20	L9	32.70	102	Cypress	1.5	36	3.30	38.8	6.10	1684543	555993	1	2	0	2	0
20	R1	33.10	17	Cypress	2.3	36.9	3.80	38.8	5.70	1684615	556284	1	2	0	2	0

20	R2	32.20	217	Cypress	1.0	36.9	4.70	38.8	6.60	1684662	556479	1	2	0	2	0
20	R3	32.70	417	Cypress	1.8	36.9	4.20	38.8	6.10	1684710	556673	1	2	0	2	0
20	R4	34.20	617	Cypress	2.1	36.9	2.70	38.8	4.60	1684758	556867	1	1	0	1	0
20	R5	35.10	717	Mixed Wetland Forest	3.0	36.9	1.80	38.8	3.70	1684781	556964	1	1	0	1	0
20	R6	36.00	817	Mixed Wetland Forest	3.3	36.9	0.90	38.8	2.80	1684805	557061	1	1	0	1	1
20	R7	36.90	917	Upland	3.4	36.9	0.00	38.8	1.90	1684829	557159	1	1	12	1	0
21	L1	33.30	254	Cypress	1.7	33.6	0.30	38.9	5.60	1685998	554885	1	2	0	2	0
21	L2	32.40	154	Cypress	1.5	33.6	1.20	38.9	6.50	1686000	554985	1	2	0	2	0
21	L3	32.10	54	Cypress	1.5	33.6	1.50	38.9	6.80	1686002	555085	1	2	0	2	0
21	R1	32.40	105	Cypress	1.5	36.4	4.00	38.9	6.50	1686008	555385	1	2	0	2	0
21	R2	31.80	305	Cypress	1.3	36.4	4.60	38.9	7.10	1686012	555585	1	2	0	2	0
21	R3	31.70	505	Cypress	1.4	36.4	4.70	38.9	7.20	1686016	555785	1	2	0	2	0
21	R4	33.00	705	Cypress	1.0	36.4	3.40	38.9	5.90	1686020	555985	1	2	0	2	0
21	R5	32.00	905	Cypress	1.0	36.4	4.40	38.9	6.90	1686024	556185	1	2	0	2	0
21	R6	33.10	1105	Cypress	1.0	36.4	3.30	38.9	5.80	1686028	556385	1	2	0	2	0
22	L1	30.40	145	Cypress	1.8	36.9	6.50	38.3	7.90	1690233	548727	1	2	0	2	0
22	L2	31.10	92	Cypress	2.0	36.9	5.80	38.3	7.20	1690283	548744	1	2	0	2	0
22	L3	31.70	45	Cypress	1.6	36.9	5.20	38.3	6.60	1690328	548759	1	2	0	2	0
22	R1	32.20	14	Cypress	2.1	36.1	3.90	38.3	6.10	1690517	548822	1	2	0	2	0
22	R2	30.90	214	Cypress	1.8	36.1	5.20	38.3	7.40	1690707	548885	1	2	0	2	0
22	R3	30.90	414	Cypress	1.7	36.1	5.20	38.3	7.40	1690897	548948	1	2	0	2	0
22	R4	31.60	614	Cypress	2.0	36.1	4.50	38.3	6.70	1691087	549011	1	2	0	2	0
22	R6	33.70	1014	Mixed Wetland Forest	3.2	36.1	2.40	38.3	4.60	1691466	549137	1	1	0	1	0
22	R7	33.80	1114	Hardwood Forest Mixed	3.8	36.1	2.30	38.3	4.50	1691561	549169	1	1	0	1	0
22	R8	35.50	1214	Upland	3.9	36.1	0.60	38.3	2.80	1691656	549200	1	1	15	1	0
Croom	L1	46.70	624	Mixed Wetland Forest	3.2	47.2	0.50	49.5	2.80	1548181	584373	1	1	10	1	0
Croom	L2	45.80	524	Mixed Wetland Forest	2.0	47.2	1.40	49.5	3.70	1548250	584446	1	1	5	1	0
Croom	L3	47.10	424	Upland	2.9	47.2	0.10	49.5	2.40	1548318	584519	0	0	20	1	0
Croom	L4	45.00	324	Mixed Wetland Forest	2.0	47.2	2.20	49.5	4.50	1548387	584592	1	1	0	1	0
Croom	L5	42.20	224	Cypress	1.5	47.2	5.00	49.5	7.30	1548455	584665	1	1	0	1	0
Croom	L6	44.20	124	Cypress	2.4	47.2	3.00	49.5	5.30	1548523	584738	1	1	0	0	1
Croom	L7	46.90	24	Hardwood Forest Mixed	3.3	47.2	0.30	49.5	2.60	1548592	584811	0	0	17	1	0
Trilby	R1	58.10	300	Hardwood Forest Mixed	3.3	58.6	0.50	64.9	6.80	1506624	600815	1	1	0	0	1
Trilby	R2	54.30	200	Mixed Wetland Forest	2.0	58.6	4.30	64.9	10.60	1506568	600732	1	1	0	0	1
Trilby	R3	54.30	100	Cypress	1.9	58.6	4.30	64.9	10.60	1506512	600650	1	1	0	0	1
Trilby	R4	55.10	52	Cypress	1.7	58.6	3.50	64.9	9.80	1506485	600610	1	1	0	0	1
RR	R1	72.00	26	Mixed Wetland Forest	1.8	72.6	0.60	76.15	4.15	1460695	615678	0	0	40	1	0
RR	R2	71.70	137	Mixed Wetland Forest	2.8	72.6	0.90	76.15	4.45	1460730	615783	1	1	5	1	0
RR	R3	71.30	192	Mixed Wetland Forest	3.1	72.6	1.30	76.15	4.85	1460747	615836	0	0	15	1	0
476	L1	42.50	173	Mixed Wetland Forest	3.2	44.1	1.60	46.7	4.20	1563674	572490	1	1	0	1	0
476	L2	40.50	100	Hardwood Forest Mixed	3.0	44.1	3.60	46.7	6.20	1563719	572548	1	1	0	1	0

476	L3	39.90	29	Mixed Wetland Forest	2.8	44.1	4.20	46.7	6.80	1563763	572603	1	1	0	1	0
476	R1	48.90	446	Hardwood Forest Mixed	3.2	49.6	0.70	46.7	-2.20	1564124	573261	0	0	20	1	0
476	R2	47.10	357	Hardwood Forest Mixed	3.4	49.6	2.50	46.7	-0.40	1564078	573184	0	0	10.16	1	1
476	R3	44.20	266	Hardwood Forest Mixed	3.3	49.6	5.40	46.7	2.50	1564031	573107	0	0	15	1	0
476	R4	44.20	220	Mixed Wetland Forest	2.2	49.6	5.40	46.7	2.50	1564007	573067	0	0	10	1	0
476	R5	39.20	149	Cypress	1.7	49.6	10.40	46.7	7.50	1563970	573007	1	2	0	2	0
476	R6	44.50	6	Mixed Wetland Forest	3.0	49.6	5.10	46.7	2.20	1563896	572884	1	1	14	1	0
200	L3	32.90	1100	Mixed Wetland Forest	3.0	34.9	2.00	37.9	5.00	1690586	545916	1	2	0	2	0
200	L4	32.70	900	Mixed Wetland Forest	2.6	34.9	2.20	37.9	5.20	1690785	545899	1	2	0	2	0
200	L5	31.00	600	Cypress	2.1	34.9	3.90	37.9	6.90	1691084	545874	1	1	0	1	0
200	L6	30.70	400	Cypress	1.7	34.9	4.20	37.9	7.20	1691284	545858	1	2	0	2	0
200	L7	30.40	200	Cypress	2.2	34.9	4.50	37.9	7.50	1691483	545841	1	2	0	2	0
200	R1	31.40	57	Cypress	2.0	34.2	2.80	37.9	6.50	1691881	545808	1	1	0	1	0
200	R2	29.90	157	Cypress	1.0	34.2	4.30	37.9	8.00	1691981	545800	1	2	0	2	0
200	R3	31.50	257	Mixed Wetland Forest	2.6	34.2	2.70	37.9	6.40	1692081	545791	1	1	0	1	0
200	R4	33.10	357	Hardwood Forest Mixed	3.2	34.2	1.10	37.9	4.80	1692180	545783	1	1	10	1	0
200	R5	34.40	457	Hardwood Forest Mixed	3.4	34.2	-0.20	37.9	3.50	1692280	545775	0	0	12	1	0
TFC	R1	34.20	58	Cypress	1.7	38.9	4.70	39.8	5.60	1662498	567956	1	2	0	2	0
TFC	R2	34.30	158	Cypress	1.6	38.9	4.60	39.8	5.50	1662502	568055	1	2	0	2	0
TFC	R3	34.20	258	Cypress	1.6	38.9	4.70	39.8	5.60	1662507	568155	1	2	0	2	0
TFC	R4	34.40	458	Cypress	1.6	38.9	4.50	39.8	5.40	1662516	568355	1	2	0	2	0
TFC	R5	34.00	658	Cypress	1.3	38.9	4.90	39.8	5.80	1662525	568555	1	2	0	2	0
TFC	R6	33.60	958	Cypress	1.0	38.9	5.30	39.8	6.20	1662538	568855	1	2	0	2	0
TFC	R7	33.60	1158	Cypress	1.5	38.9	5.30	39.8	6.20	1662547	569054	1	2	0	2	0
TFC	R8	33.40	1358	Cypress	1.6	38.9	5.50	39.8	6.40	1662556	569254	1	2	0	2	0
TFC	R9	33.30	1558	Cypress	1.0	38.9	5.60	39.8	6.50	1662565	569454	1	2	0	2	0
TFC	R10	33.70	1758	Cypress	1.3	38.9	5.20	39.8	6.10	1662575	569654	1	2	0	2	0
TFC	R11	33.70	1958	Cypress	1.1	38.9	5.20	39.8	6.10	1662584	569854	1	2	0	2	0
TFC	R12	33.80	2158	Cypress	1.1	38.9	5.10	39.8	6.00	1662593	570053	1	2	0	2	0
TFC	R13	34.60	2358	Cypress	1.2	38.9	4.30	39.8	5.20	1662602	570253	1	2	0	2	0
TFC	R14	35.50	2558	Cypress	1.3	38.9	3.40	39.8	4.30	1662611	570453	1	2	0	2	0
TFC	R15	35.80	2758	Cypress	2.6	38.9	3.10	39.8	4.00	1662620	570653	1	1	0	1	0
TFC	R16	36.70	2958	Mixed Wetland Forest	3.0	38.9	2.20	39.8	3.10	1662633	570952	1	2	0	2	0
TFC	R17	37.20	3058	Hardwood Forest Mixed	3.7	38.9	1.70	39.8	2.60	1662629	570853	1	1	0	1	0
TFC	R18	37.40	3158	Hardwood Forest Mixed	3.0	38.9	1.50	39.8	2.40	1662638	571052	1	1	0	1	1
TFC	R19	37.70	3258	Upland	3.9	38.9	1.20	39.8	2.10	1662642	571152	1	1	0	1	0
TFC	R20	39.10	3358	upland	3.8	38.9	-0.20	39.8	0.70	1662647	571252	1	1	0	1	1

Appendix E – Plant List

Species	Count	Indicator Status (NWI)	Indicator Status (NWI)	Cyp	Hardwood Swamp	Mixed Wetland Forest	Shrub Wetland	Willow	Herb	Upland
Ferns										
Osmunda regalis	4	OBL	OBL	3	0	1	0	0	0	0
Thelypteris spp.	2	FACW	FACW	0	0	1	1	0	0	0
Woodwardia virginica	2	FACW	OBL	0	0	1	0	0	0	1
Unknown fern	1			0	0	1	0	0	0	0
Polypodium polypodioides var, michauxiana	1	n/a	n/a	0	1	0	0	0	0	0
Woodwardia areolata	1	OBL	OBL	1	0	0	0	0	0	0
Individual SubTotal (6 species)	**11**			**4**	**1**	**4**	**1**	**0**	**0**	**1**
Herbs										
Centella asiatica	122	FACW	FACW	37	15	68	1	0	1	0
Hydrocotyle umbellata	84	FACW	FACW	28	5	47	2	1	1	0
Dichanthelium commutatum	78	FAC	FAC	9	18	42	0	0	1	8
Galium tinctorium	59	FACW	FACW	13	2	42	0	0	0	2
Carex gigantea	56	OBL	OBL	19	6	31	0	0	0	0
Boehmeria cylindrica	44	OBL	OBL	0	5	19	1	0	1	1
Axonopus affinis	43	FAC	FAC	0	7	29	0	0	0	1
Dichondra carolinensis	40	FAC	FAC	3	15	21	0	0	0	1
Carex albolutescens	34	FACW	FACW	10	8	15	0	1	0	0
Ptilimnium	33	FACW	OBL	10	2	21	0	0	0	0

capillaceum										
Hypoxis curtissii	30	FACW	FACW	5	2	22	0	0	0	1
Alternanthera philoxeroides	26	OBL	OBL	14	1	7	0	0	3	1
Panicum dichotomiflorum	20	FACW	FACW	3	4	12	0	0	0	1
Polygonum hydropiperoides	19	OBL	OBL	8	2	7	0	0	2	0
Carex longii	17	FACW	FACW	5	2	10	0	0	0	0
Eryngium baldwinii	17	FAC	FAC	0	3	14	0	0	0	0
Erechtites hieracifolia	16	FAC	FAC	4	2	9	0	0	0	1
Dichanthelium dichotomum	15	FAC	FAC	1	2	13	0	0	0	0
Cirsium nuttallii	13	FACW	FACW	6	1	6	0	0	0	0
Diodia virginiana	13	FACW	FACW	3	4	6	0	0	0	0
Ambrosia artemisiifolia	12	FACU	FACU	3	4	5	0	0	0	0
Commelina diffusa	12	FACW	FACW	3	1	8	0	0	0	0
Panicum hemitomon	12	OBL	OBL	2	1	6	0	0	3	0
Hyptis alata	11	FACW	FACW	3	3	5	0	0	0	0
Panicum rigidulum	11	FACW	FACW	3	0	8	0	0	0	0
Rhynchospora mixta	10	OBL	OBL	0	4	8	0	0	0	0
Mitchella repens	9			0	3	3	0	0	0	3
Cyperus surinamensis	9	FACW	FACW	1	1	7	0	0	0	0
Axonopus furcatus	8	FAC	OBL	1	3	3	0	0	1	0
Paspalum setaceum	8	FAC	FAC	2	0	5	0	0	0	1
Azolla caroliniana	7	n/a	OBL	2	0	0	2	0	3	0
Eleocharis baldwinii	7	OBL	FACW+	4	0	3	0	0	0	0
Galactia elliottii	7	n/a	FACU	0	0	6	0	0	0	1

Ludwigia repens	7	OBL	OBL	2	2	3	0	0	0	0
Phytolacca americana	7	n/a	FACU	2	0	5	0	0	0	0
Rubus argutus	7	FAC	FACU+	1	3	3	0	0	0	0
Urena lobata	7	EPPC(II)	FACU	1	1	4	0	0	0	1
Eupatorium capillifolium	6	FAC	FACU	2	0	4	0	0	0	0
Rhexia mariana	6	FACW	FACW+	0	2	4	0	0	0	0
Lemna minor	5	n/a	n/a	2	0	1	0	0	2	0
Melothria pendula	5	n/a	FACW-	0	1	3	0	0	0	1
Oxalis corniculata	5	n/a	FACU	1	2	2	0	0	0	0
Phyla nodiflora	5	FAC	FACW	1	1	3	0	0	0	0
Saururus cernuus	5	OBL	OBL	3	0	1	1	0	0	0
Bidens mitis	4	OBL	OBL	1	1	2	0	0	0	0
Nymphoides aquatica	4	OBL	OBL	1	0	0	0	0	3	0
Unknown grass (Para grass?)	4			1	0	3	0	0	0	0
Scleria oligantha	4	FACW	FACU	0	1	2	0	0	0	1
Sisyrinchium atlanticum	4	FACW	FAC	0	2	2	0	0	0	0
Solidago sp.	4	n/a	n/a	0	1	3	0	0	0	0
Drymaria cordata	3	FAC	FAC	0	0	2	0	0	0	1
Lemna obscura	3	n/a	OBL	2	0	1	0	0	0	0
Oldenlandia uniflora	3	FACW	FACW-	0	1	2	0	0	0	0
Paspalum repens	3	OBL	OBL	1	0	2	0	0	0	0
Ruellia sp.	3	n/a	n/a	1	1	1	0	0	0	0
Salvinia minima	3	n/a	OBL	2	0	1	0	0	0	0
Unknown grass	3			1	2	0	0	0	0	0
Viola lanceolata	3	OBL	OBL	0	0	3	0	0	0	0
Viola sp.	3	FACW+	FACW+	1	0	1	0	0	0	1
Carex lupulina	2	OBL	OBL	0	1	1	0	0	0	0
Carya aquatica	2	OBL	OBL	1	0	1	0	0	0	0
Cyperus difformis	2	OBL	OBL	0	0	1	0	0	0	1
Cyperus haspan	2	OBL	OBL	0	0	2	0	0	0	0
Cyperus virens	2	FACW	FACW	1	0	1	0	0	0	0

Eichhornia crassipes	2	EPPC(I)	OBL	1	0	1	0	0	0	0
Eriocaulon compressum	2	OBL	OBL	0	1	1	0	0	0	0
Geranium carolinianum	2	n/a	n/a	1	1	0	0	0	0	0
Panicum gymnocarpon	2	OBL	OBL	1	0	1	0	0	0	0
Parietaria floridana	2	FAC	FAC-	2	0	0	0	0	0	0
Paspalum spp.	2			0	0	1	0	0	1	0
Polygala chapmanii	2	FACW	OBL	1	0	1	0	0	0	0
Scirpus spp.	2	OBL	OBL	0	0	1	0	0	1	0
Andropogon glomeratus	1	FACW	FACW	0	1	0	0	0	0	0
Andropogon virginicus	1	FAC	FAC -	0	0	1	0	0	0	0
Asclepias incarnata	1	OBL	OBL	1	0	0	0	0	0	0
Unknown grass Bag #2	1			0	1	0	0	0	0	0
Unknown Carex (Chasmanthium?) Bag #4	1			0	0	1	0	0	0	0
Unknown Panicum Bag #4	1			0	0	1	0	0	0	0
Campanula floridana	1	OBL	OBL	0	0	1	0	0	0	0
Carex verrucosa	1	FACW	OBL	0	1	0	0	0	0	0
Chasmanthium nitidum	1	FACW	FACW+	0	1	0	0	0	0	0
Cinnamomum camphora	1	EPPC(I)	FACU-	1	0	0	0	0	0	0
Conoclinium coelestinum	1	FAC	FAC	0	1	0	0	0	0	0
Crinum americanum	1	OBL	OBL	0	0	1	0	0	0	0
Cynanchum scoparium	1	n/a	n/a	0	0	1	0	0	0	0

Cyperus spp.	1	FACW	FACW	0	0	1	0	0	0	0
Dichanthelium portoricense	1	n/a	FACU	0	0	1	0	0	0	0
Erigeron annuus	1	n/a	FACU	1	0	0	0	0	0	0
Eragrostis spectabilis	1	FAC	FACU	0	0	0	0	0	0	0
Eupatorium leptophyllum	1	OBL	FAC+	1	0	0	0	0	0	0
Gnaf Count	1			0	0	0	0	0	0	0
Hypericum fasciculatum	1	OBL	FACW+	0	1	0	0	0	0	0
Hypericum spp.	1	FACW	FACW	0	0	0	0	0	1	0
Iris hexagona	1	OBL	OBL	0	0	1	0	0	0	0
Iris virginica	1	OBL	OBL	0	0	1	0	0	0	0
Iva microcephala	1	FACW	FACW	0	0	1	0	0	0	0
Leersia hexandra	1	OBL	OBL	1	0	0	0	0	0	0
Limnobium spongia	1	OBL	OBL	1	0	0	0	0	0	0
Lindernia grandiflora	1	FACW	OBL	0	0	0	0	0	0	1
Lycopus rubellus	1	OBL	OBL	1	0	0	0	0	0	0
Panicum verrucosum	1	FACW	FACW	0	1	0	0	0	0	0
Passiflora incarnata	1	n/a	n/a	0	0	1	0	0	0	0
Phyllanthus abnormis	1	n/a	n/a	0	0	0	0	0	0	1
Unknown (Phyto rig)	1			0	0	1	0	0	0	0
Polygonum setaceum	1	OBL	FACW	0	1	0	0	0	0	0
Rhyncospora spp.	1	FACW	FACW	0	0	1	0	0	0	0
Unknown (Rich spp.)	1			0	0	1	0	0	0	0
Rubus trivialis	1	FAC	FAC	0	1	0	0	0	0	0
Saccharum giganteum	1	OBL	FACW	0	0	1	0	0	0	0
Sagittaria sp.	1	OBL	OBL	0	0	0	0	0	1	0

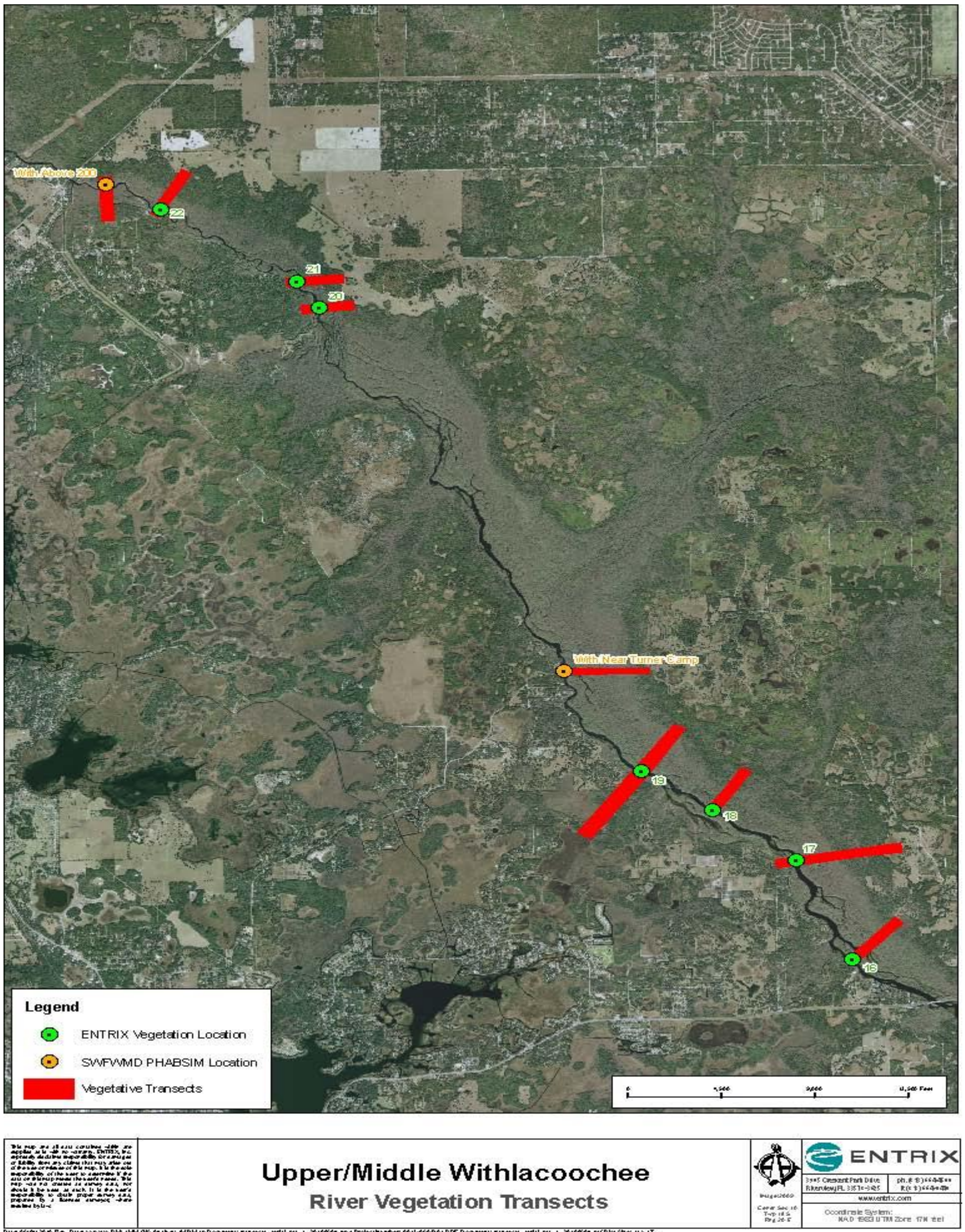
Scleria lacustris	1	FACW (EPPC(II))	n/a	0	1	0	0	0	0	0
Setaria parviflora	1	FAC	FAC	0	0	1	0	0	0	0
Teucrium canadense	1	FACW	FACW	0	0	0	0	0	1	0
Tillandsia spp.	1			0	0	1	0	0	0	0
Trichostema dichotomum	1	n/a	n/a	0	0	1	0	0	0	0
Typha latifolia	1	OBL	OBL	0	0	0	0	0	1	0
Unknown large grass	1			1	0	0	0	0	0	0
Unknown Plant #22	1			1	0	0	0	0	0	0
Unknown water grass	1			1	0	0	0	0	0	0
Vicia acutifolia	1	FACW	FACW+	0	0	1	0	0	0	0
Viola primulifolia	1	FACW	FACW	0	0	1	0	0	0	0
Individual Sub Total (121 species)	**1093**			**246**	**160**	**599**	**7**	**2**	**27**	**30**
Shrubs										
Cephalanthus occidentalis	331	OBL	OBL	146	12	131	8	8	21	5
Hypericum hypericoides	159	FAC	FAC	10	20	114	0	0	0	15
Viburnum obovatum	87	FACW	FACW	7	11	59	0	0	0	10
Serenoa repens	28	UPL	UPL	0	14	11	0	0	0	3
Sideroxylon reclinatum	17	FAC	FAC	1	9	7	0	0	0	0
Baccharis halimifolia	14	FAC	FAC	6	5	3	0	0	0	0
Sabal minor	13	FACW	FACW	0	0	13	0	0	0	0
Cornus foemina	9	FACW	FACW	0	3	6	0	0	0	0
Myrica cerifera	9	FAC	FAC	1	0	7	0	0	0	1
Hibiscus grandiflorus	5	OBL	OBL	0	0	0	0	0	5	0
Callicarpa americana	3	n/a	FACU-	0	0	3	0	0	0	0

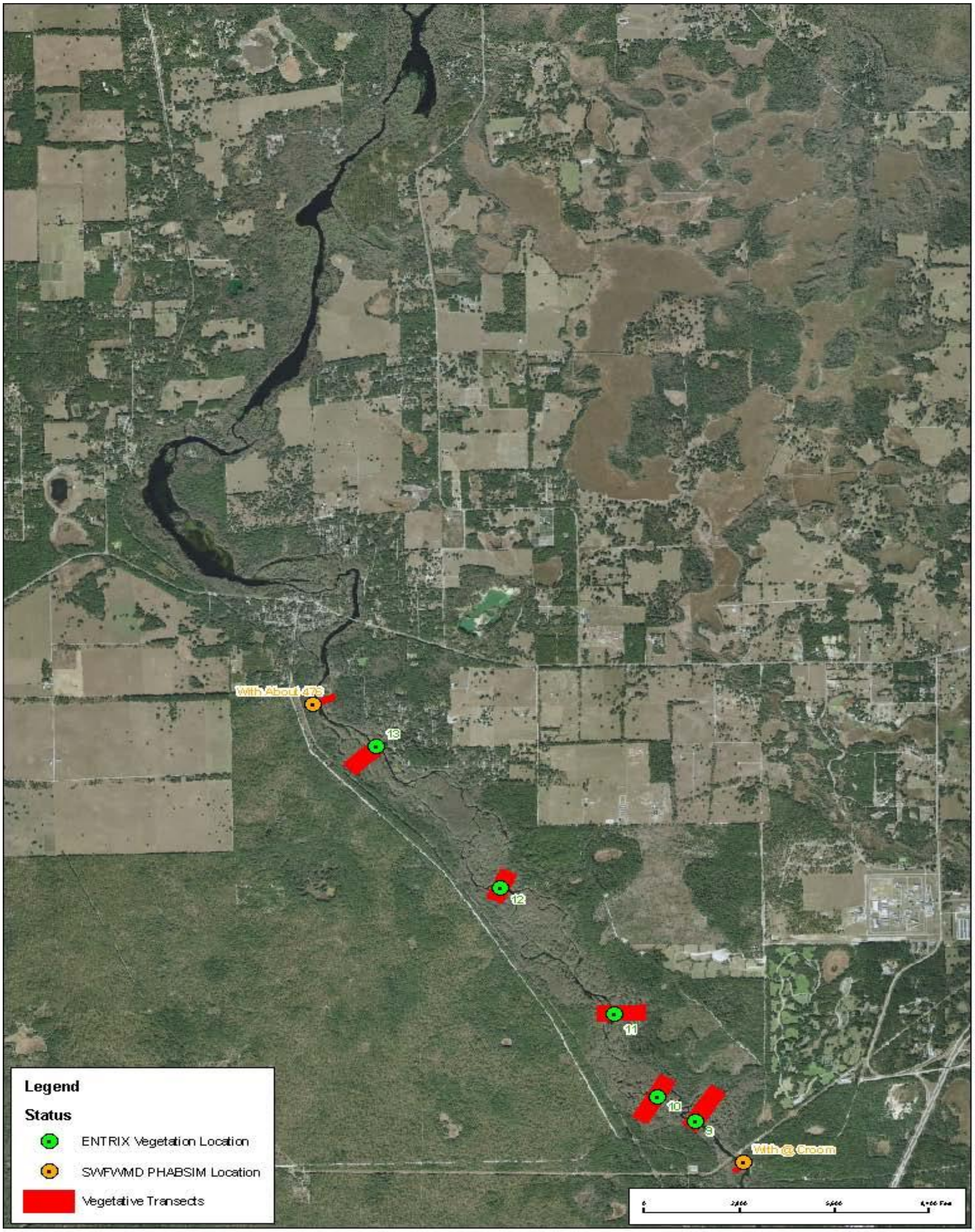
Psychotria sulzneri/P. nervosa	2	FAC	n/a	0	2	0	0	0	0	0
Ilex glabra	1	n/a	FACW	0	0	0	0	0	0	1
Individual SubTotal (13 species)	**678**			**171**	**76**	**354**	**8**	**8**	**26**	**34**
Trees										
Taxodium distichum	384	OBL	OBL	204	5	168	1	0	0	5
Acer rubrum	287	FACW	FACW	146	18	112	2	2	5	2
Quercus laurifolia	263	FACW	FACW	29	44	172	2	0	3	13
Fraxinus caroliniana	249	OBL	OBL	140	14	91	0	1	2	1
Liquidambar styraciflua	239	FACW	FACW	42	46	129	2	0	1	19
Ulmus americana	213	FACW	FACW	77	26	105	0	1	3	1
Carpinus caroliniana	100	FACW	FACW	2	44	47	1	0	1	5
Sabal palmetto	83	FAC	FAC	2	40	28	0	0	2	11
Diospyros virginiana	41	FAC	FAC	9	9	17	0	0	0	6
Nyssa sylvatica var. biflora	35	OBL	OBL	30	2	3	0	0	0	0
Quercus nigra	32	FACW	FACW	0	7	9	0	0	0	17
Gleditsia aquatica	31	OBL	OBL	5	0	27	0	0	0	0
Quercus virginiana	18	FACU	FACU	1	5	3	0	0	0	9
Salix caroliniana	14	OBL	OBL	1	0	2	0	6	5	0
Vaccinium arboreum	13	FACU	FACU	0	1	6	0	0	0	6
Pinus elliottii	13	FACW	FACW	0	3	5	0	0	0	5
Celtis laevigata	11	FACW	FACW	1	4	6	0	0	0	0
Carya aquatica	8	n/a	FAC	0	8	0	0	0	0	0
Fraxinus pennsylvanica	7	OBL	FACW	3	0	3	0	0	0	1

Persea borbonia/P. palustris	6	n/a	FACW	0	0	0	0	0	0	6
Magnolia grandiflora	4	n/a	FAC+	0	0	0	0	0	0	4
Ilex opaca	3	FAC	FAC-	0	3	0	0	0	0	0
Acer saccharinum	3	OBL	FACW	2	1	0	0	0	0	0
Platanus occidentalis	2	FACW	FACW-	1	0	1	0	0	0	0
Sapium sebiferum	2	FAC (EPPC(I))	FAC	1	0	0	0	0	1	0
Pinus serotina	1	FACW	FACW+	0	1	0	0	0	0	0
Prunus serotina	1	n/a	FACU	0	0	1	0	0	0	0
Ilex cassine	1	OBL	FACW	0	1	0	0	0	0	0
Ilex vomitoria	1	FAC	FAC	0	0	1	0	0	0	0
Individual SubTotal (29 species)	**2065**			**696**	**282**	**936**	**8**	**10**	**23**	**111**
Vines										
Lygodium japonicum	1	EPPC(I)	FAC	0	0	1	0	0	0	0
Smilax hispida	2	n/a	FAC+	0	0	2	0	0	0	0
Smilax laurifolia	2		FACW+	0	1	0	0	0	0	1
Gelsemium sempervirens	5	n/a	FAC	0	2	0	0	0	0	3
Parthenocissus quinquefolia	5	n/a	FAC	0	3	1	0	0	0	1
Mikania scandens	7	n/a	FACW+	4	1	1	0	0	1	0
Paederia foetida	7	EPPC(I)	FACU	1	0	6	0	0	0	0
Vitis rotundifolia	14	FAC	FAC	1	4	3	0	0	0	6
Campsis radicans	15	FAC	FAC	0	2	10	0	0	0	3
Ampelopsis arborea	25	FAC	FAC	3	8	13	0	0	0	1
Toxicodendron radicans	58	FAC	FAC	16	11	28	1	0	0	2

Smilax bona-nox	80	FAC	FAC	4	24	43	0	0	0	9
Individual SubTotal (12 species)	**221**			**29**	**56**	**108**	**1**	**0**	**1**	**26**
Sub Total	**4068**			**1146**	**575**	**2001**	**25**	**20**	**77**	**202**

Appendix F – Maps





Upper/Middle Withlacoochee

River Vegetation Transects

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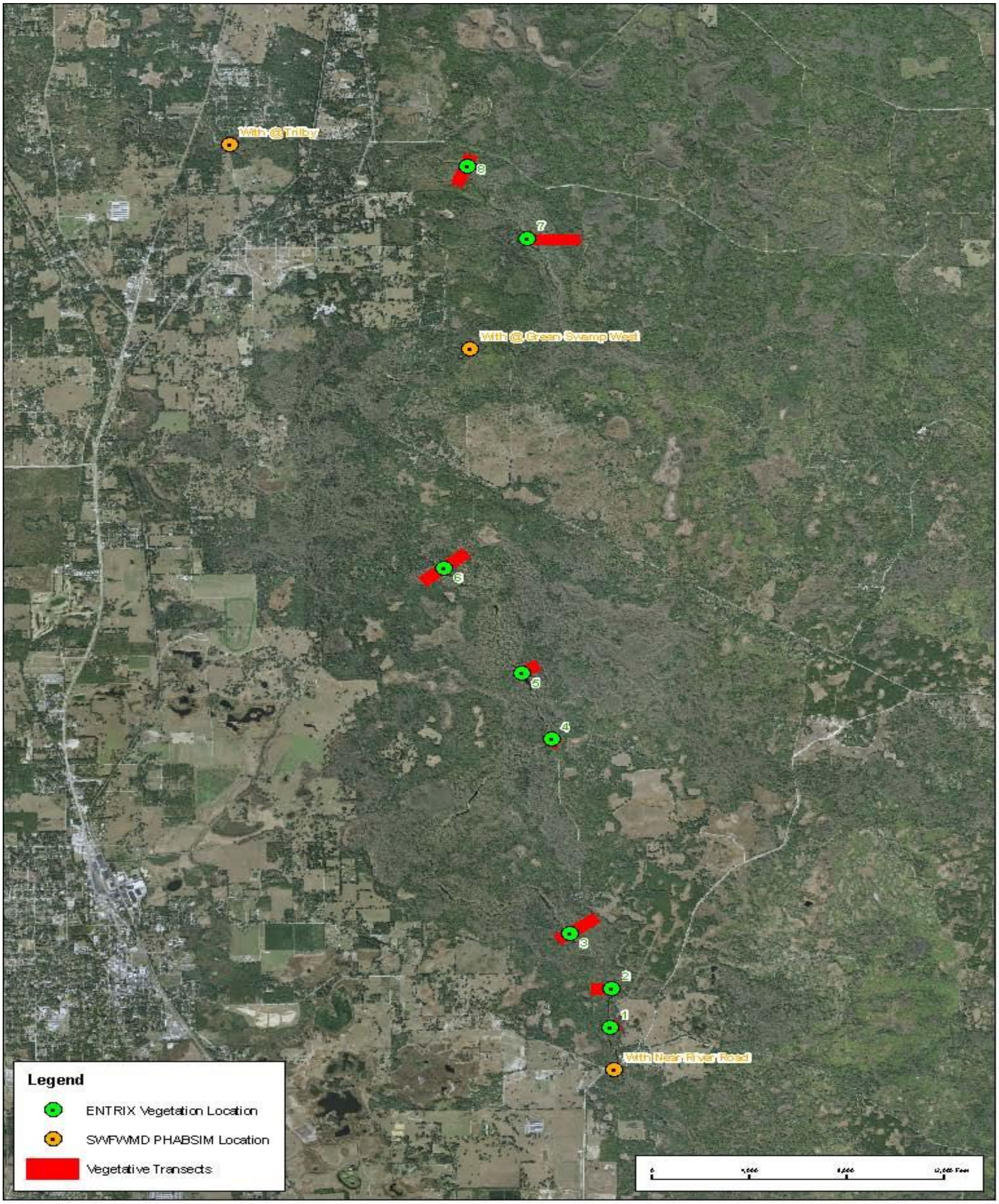
Coordinate System:



Upper/Middle Withlacoochee

River Vegetation Transects

ENTRIX

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Coordinate System:

HEC-RAS Appendix – HEC-RAS Modeling of Withlacoochee River

FINAL REPORT

Prepared for:

Southwest Florida Water Management District

2379 Broad Street (U.S. 41 South)

Brooksville, FL 34604-6899

Prepared by:

Engineering & Applied Science, Inc.

13087 Telecom Parkway North

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December 15, 2009

HEC-RAS Modeling of Withlacoochee River

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ACKNOWLEDGEMENTS

Engineering & Applied Science, Inc. (EAS) performed this project with funding from the Southwest Florida Water Management District (SWFWMD) under Purchase Order No. 08POSOW1795, dated September 3, 2008. At EAS, Srinivas G. Rao, PhD, P.E., served as the project manager and Jiangtao Sun, P.E., served as the project engineer. Timely guidance, data procurement, review of technical memorandums and draft/final report by Dr. Marty Kelly, Dr. Adam Munson, and Jason Hood are greatly appreciated.

Also, EAS would like to thank all of the manager and staff from the numerous Federal, State, and local agencies who generously offered their assistance in providing the wide range of data and information presented in this report. Without their assistance the data collection and review effort would not have been possible. In particular, we would like to acknowledge and thank the following individuals by organizations: Gene Altman, Mike Bartlett, Danny Brooks, Margit Crowell, Mark Fulkerson, Doug Leeper, Jonathan Morales, and Lisann Morris of Southwest Florida Water Management District; Hal Gibson, Karen Mohler of CSX; and Rebecca Skyles of Florida Department of Transportation. Finally, we would like to thank the timely technical review comments from Dr. Ahmed Said on the draft report.

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1.0 INTRODUCTION

Engineering & Applied Science, Inc. (EAS) was authorized by the Southwest Florida Water Management District (SWFWMD or the District) to conduct the HEC-RAS modeling for establishing Minimal Flows and Levels for the middle Withlacoochee River (With River) system.

The Withlacoochee River watershed, which is located in the Central/Northwest part of the District, covers approximately 2,100 square miles (Figure 1.1). The 157 mile long Withlacoochee River originates in the Green Swamp in Polk County and extends northward, discharging into the Gulf of Mexico near Yankeetown, FL. The Withlacoochee River is one of two rivers in the State that flows north. It traverses eight counties (Polk, Lake, Sumter, Pasco, Hernando, Citrus, Marion, and Levy counties). The Withlacoochee River watershed is largely undeveloped, and the dominant land uses and coverages are wetlands, upland forest, rangeland, agriculture, mining and urban (built-up).

The 77 mile long project area is located in the middle portion of the Withlacoochee River. The upstream end of the project area is located at the United States Geological Survey (USGS) 02311500 Withlacoochee River near Dade City, about 4 miles east of Dade City, FL and 110 miles upstream from the river mouth at the Gulf of Mexico near Yankeetown, FL. The downstream end of the project area is located at USGS 02313000 Withlacoochee River near Holder, on downstream side of bridge on S.R. 200, and about 38 miles upstream from the river mouth.

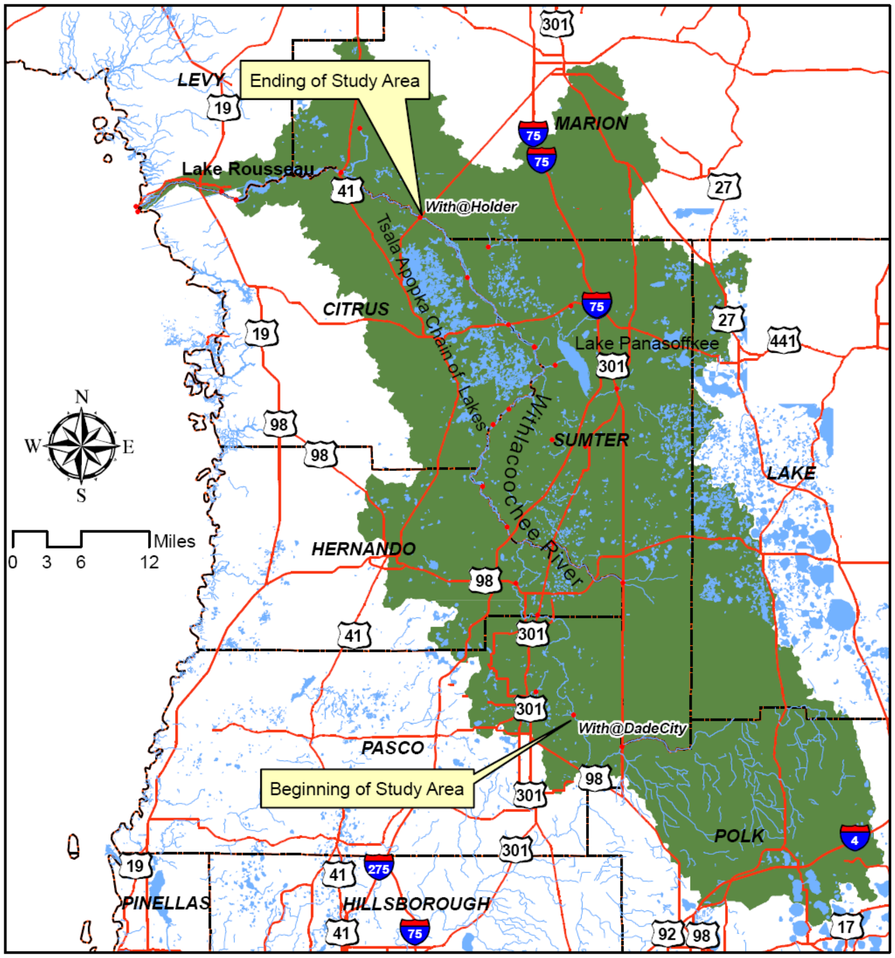


Figure 1.1 Withlacoochee River Watershed Map

2.0 MODEL DEVELOPMENT

2.1 Cross-Sections

The major topographic data source is the Digital Elevation Model (DEM) in a 5 ft x 5 ft grid, which was provided to EAS by SWFWMD (Mr. Mark Fulkerson); however, the DEM derived from the LiDAR data is only accurate in the floodplain above the water surface. To obtain the bathymetric data that is not included in the LiDAR survey, a hydrographic survey was performed by SWFWMD and provided in ESRI shape file format (point shape file). The bathymetric points from the hydrographic survey were used to generate an ESRI Triangulated irregular Network (TIN) file, which was converted to DEM within the main channel. By combining the DEM for the main channel and the original DEM for the floodplain, the updated DEM was ready for digitizing the cross-sections for the HEC-RAS modeling.

Using HEC-GeoRAS 4.1.1, an ArcGIS extension for HEC-RAS, 1,065 cross-sections were generated based on the DEM data, and the cross-section cut lines are shown in Figure 2.1 thru Figure 2.3. The cross-section data was imported into HEC-RAS 4.0, and was simplified by eliminating the redundant station-stage points using the tools in HEC-RAS.

There is a data variance during the conversion from a TIN to a DEM. The DEM can not conserve the same values stored in the TIN, because the value of the grid is calculated in ArcGIS by averaging the elevation data in a given surface area, which is 25 sq. ft. Consequently, the data variance transferred to each cross-section will impact the model calibration, especially on low flow conditions when the water levels are more sensitive to the river bottom shape and elevations. To minimize the data error, the cross-section cut lines were carefully digitized in ArcGIS, as close as possible to the bathymetric points from the hydrographic survey, and the cross-section data was reviewed and adjusted in HEC-RAS.

SWFWMD recently completed the Vegetation Transect Survey that is used to characterize wetlands and soils within the floodplain. There are a total of 26 vegetation transects surveyed, and 24 of the vegetation transects were incorporated into the existing river geometry data in HEC-RAS, by adding eighteen (18) additional cross-sections and updating six (6) existing cross-sections generated from the DEM data. In summary, a total of 1,083 cross-sections were used in the HEC-RAS model.

All elevations used in the HEC-RAS model are in the North American Vertical Datum of 1988 (NAVD 88). All the topographic data, including DEM, hydrographic and vegetation transect survey, was provided in NAVD 1988. For the data that was in the National Geodetic Vertical Datum of 1929 (NGVD 29), for example, the USGS gage stage data and rating curves, a site-specific datum conversion factor was determined using the software named "VERTCON" provided by National Oceanic and Atmospheric Administration (NOAA).

2.1.1 Manning's n Value

The parameterization of Manning's n is very important to the accuracy of the simulated water surface levels in hydraulic modeling. The selection of the Manning's n values follows the guidance of HEC-RAS Hydraulic Reference Manual (Table 3-1, Appendix C). The Manning's n value is highly variable and depends on several factors including: surface roughness; vegetation; channel irregularities; channel alignment; scour and deposition; obstructions; size and shape of the channel; stage and discharge; seasonal changes; temperature; and suspended material and bedload. With the assistance of the 2006 aerial map, 2007 land use map, and the available field observation data, the natural conditions of the main channel and floodplain were evaluated and used for the determination of the Manning's n value for each cross section. The initial values of Manning's n

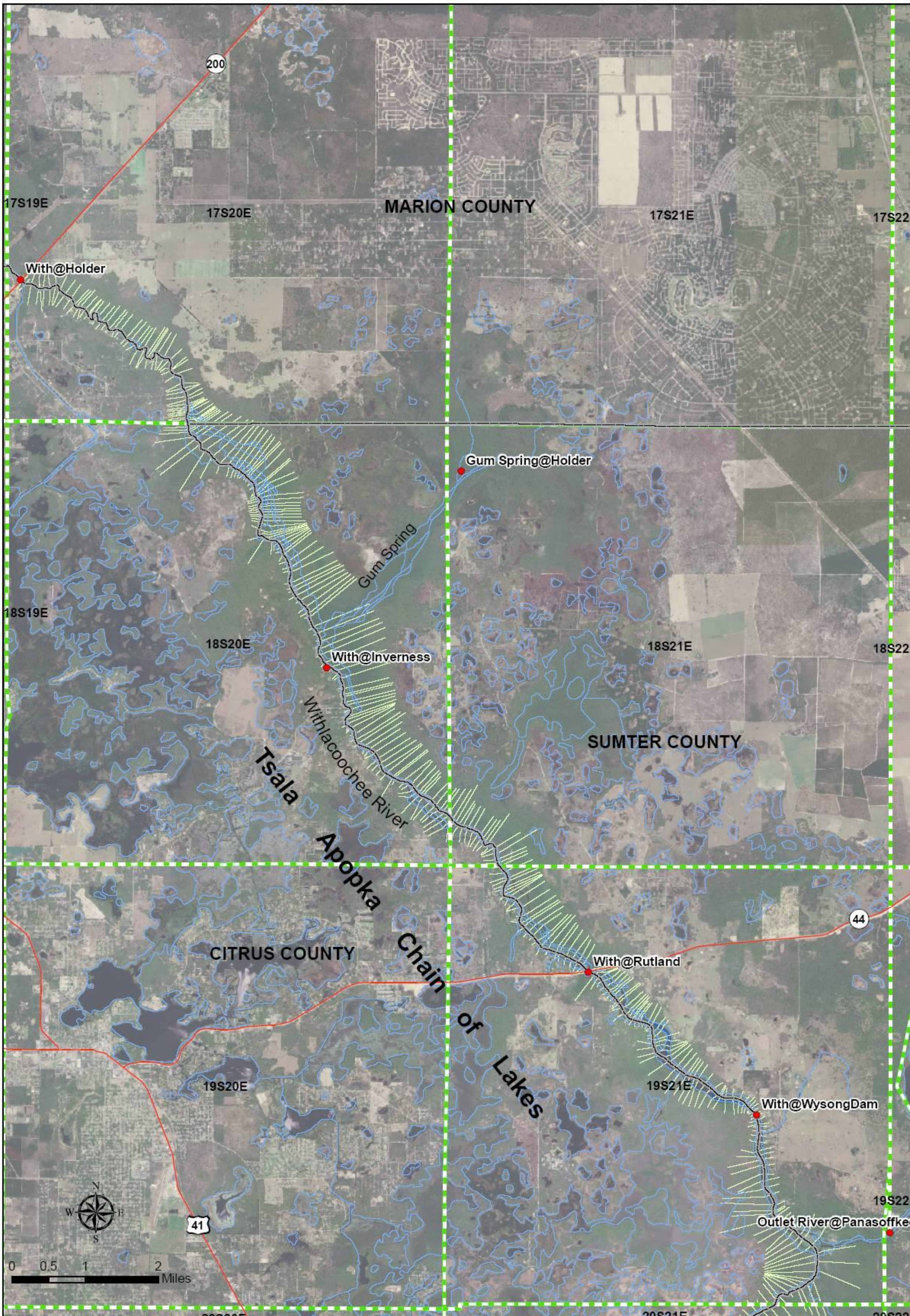

200
17S19E
17S20E
MARION COUNTY
17S21E
17S22E
With@Holder
Gum Spring@Holder
Gum Spring
18S19E
18S20E
With@Inverness
18S21E
18S22E
Withlacoochee River
SUMTER COUNTY
Tsala
Apopka
Chain
of
Lakes
44
CITRUS COUNTY
With@Rutland
19S20E
19S21E
With@WysongDam
19S22E
Outlet River@Panasoffkee
41
0 0.5 1 2
Miles
20S20E
20S21E
20S22E

Figure 2.1 Cross-Sections from With @ Holder to With @ Wysong Dam

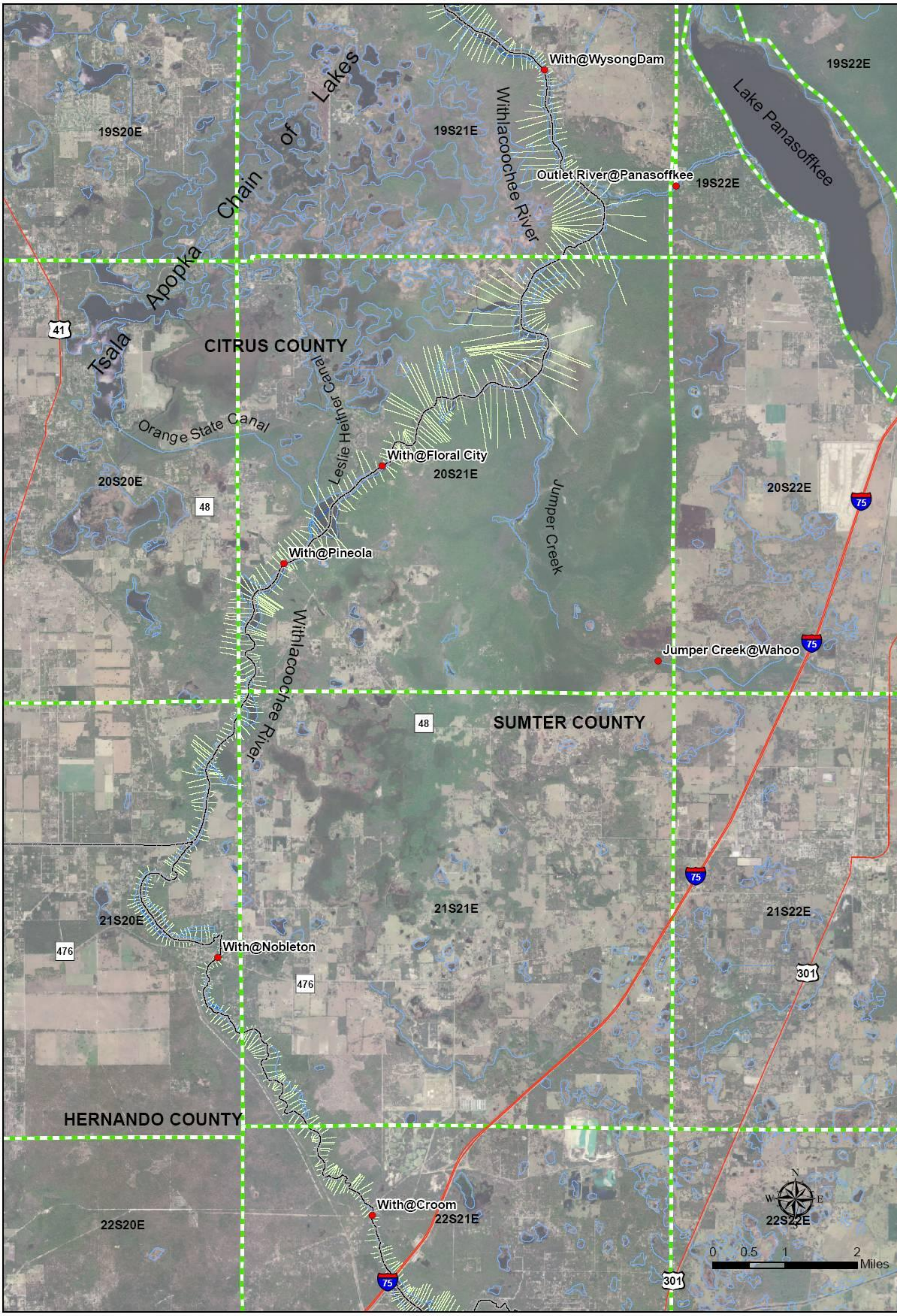
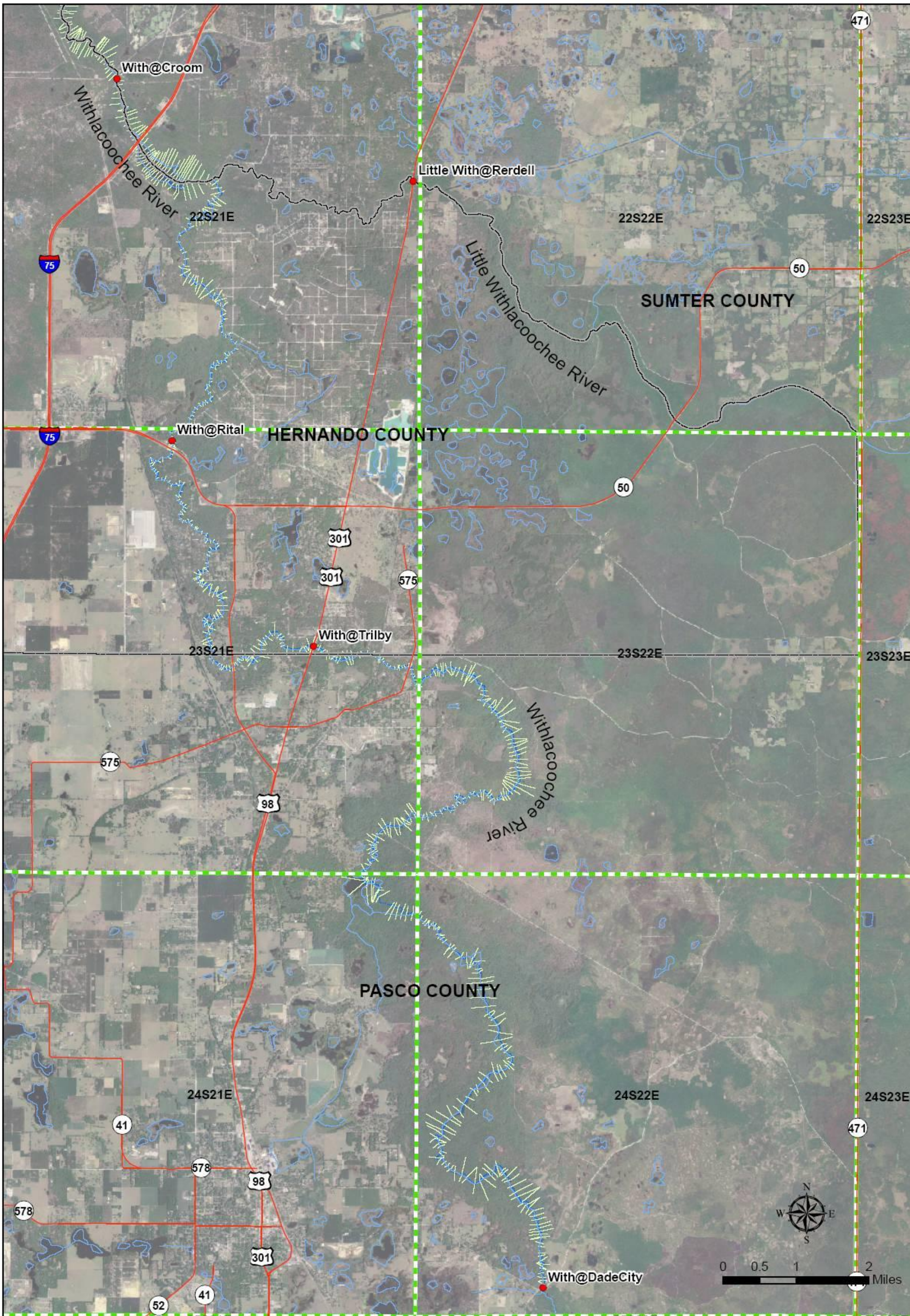


Figure 2.2 Cross-Sections from With @ Wysong Dam to With @ Croom



With@Croom
Withlacoochee River
22S21E
Little With@Rerdell
22S22E
22S23E
Little Withlacoochee River
SUMTER COUNTY
With@Rital
HERNANDO COUNTY
With@Trilby
23S21E
23S22E
23S23E
Withlacoochee River
PASCO COUNTY
24S21E
24S22E
24S23E
With@DadeCity
25S21E
25S22E
25S23E
0 0.5 1 2 Miles

Figure 2.3 Cross-Sections from With @ Croom to With @ Dade City were assigned within the suggested range in Table 3-1. The Manning's n value will be further adjusted in the model calibration process by using the USGS stream gauging data.

2.1.1 Contraction and Expansion Coefficients

In HEC-RAS Hydraulic Reference Manual, Chapter 2, the expansion and contraction coefficients are discussed: "*Where the change in river cross section is small, and the flow is subcritical, coefficients of contraction and expansion are typically on the order of 0.1 and 0.3, respectively; and when the change in effective cross section area is abrupt such as bridges, contraction and expansion coefficients of 0.3 and 0.5 are often used.*"

The *subcritical* flow regime is used for steady state flow simulation in the HEC-RAS modeling. For most of the river segments of the Withlacoochee River, the change in effective cross section area is not abrupt. So, the expansion and contraction coefficients of 0.1 and 0.3 were used in this project, except at bridges, where 0.3 and 0.5 were selected (as recommended in HEC-RAS Hydraulic Reference Manual).

2.2 Channel Flow Profiles

There are two major challenges in modeling the middle part of the study area in HEC-RAS. The first challenge is to model the flow diverting from the Withlacoochee River to the Tsala Apopka Chain of Lakes. The chain of lakes are currently connected with the Withlacoochee River by two (2) intake canals, one outfall canal, and the associated gates and control structures. Another challenge is to model the Wysong-Coogler Adjustable Water Conservation Structure (Wysong AWCS, a.k.a. Wysong Dam), which was removed in 1988 and rebuilt in 2002. The Wysong AWCS has significantly altered the existing river flow regime, for example, the stage/flow relationship upstream of the dam. USGS With @ Croom is documented to be outside of the backwater impact zone of the Wysong AWCS, and therefore it is appropriate to be used as the downstream boundary for the HEC-RAS modeling of the river segment upstream.

To better resolve the complexity due to the Wysong Dam as well as the flow diversion to Tsala Apopka Chain of Lakes, the study area is intentionally divided into three small segments: Lower Segment, Middle Segment, and Upper Segment. As shown in Figure 2.1 thru Figure 2.3, Lower Segment is from USGS With @ Holder to USGS With @ Wysong Dam; Middle Segment is from USGS With @ Wysong Dam to USGS With @ Croom; and Upper Segment is from USGS With @ Croom to USGS With @ Dade City. In the Middle Segment, more consideration will be undertaken to simulate the structure operations and to evaluate the flow diversion.

The approach of using three segments also takes advantage of three reliable long-term USGS gages (USGS With @ Holder, With @ Wysong Dam, and With @ Croom), which were designated as the downstream boundaries for the segments.

The USGS stream flow records were collected at USGS gages along the Withlacoochee River and its major tributaries during the data collection task, as seen in Appendix B. There is no significant surface-groundwater interchange documented in the study area.

A channel flow profile is used to describe the flow changes along the river in a given downstream steady state flow rate. The first step of the procedure is to estimate the proportional relationship between the various upstream USGS gages and the downstream boundary USGS gage. Second, a linear interpolation is applied to determine the value of the cross-sections based on the known values at the upstream/downstream USGS gages. Third, in the statistical analysis of the historical flow data of the USGS gages at the downstream boundaries, the range and distribution of the flow records are summarized, and seventeen (17) fixed flow rates ranged from 2 to 90 upper percentiles, in general, are picked for each segment. Finally, the channel flow profiles based on the 17 flow rates at the downstream boundary are created and imported to HEC-RAS. The details of the analysis for the Lower, Middle, and Upper Segments are described below.

2.2.1 Lower Segment Channel Flow Profiles

Five (5) USGS gages are available for the analysis in the Lower Segment: With @ Holder, Gum Spring @ Holder, With @ Inverness, With @ Rutland, and With @ Wysong Dam, as seen in Figure 2.1. The channel flow profile analysis for this segment is based on the downstream boundary, i.e., USGS With @ Holder.

USGS With @ Rutland, located 3.5 miles downstream of the Wysong Dam, has a very short record history (2005 ~ present), and therefore it is excluded from the analysis of the channel flow profiles.

The Gum Spring, a spring-feed creek, joins the Withlacoochee River just downstream of USGS With @ Inverness. The historical data of Flow @ Gum Spring and Flow @ Holder is plotted in Figure 2.4. It is observed that on low flow conditions when Flow @ Holder is less than 1,250 cfs, Flow @ Gum Spring vs. Flow @ Holder is in a good linear relationship; while on high flow conditions when Flow @ Holder is greater than 1,250 cfs, Flow @ Gum Spring is independent of Flow @ Holder. To improve the results of the regression analysis, a break point at 1,250 cfs of Flow @ Holder was introduced, and the R^2 value was calculated as 0.73, as shown in Figure 2.4.

USGS With @ Inverness is just upstream of the confluence of the Gum Spring and the Withlacoochee River, and it is reasonable to use the same break point at 1,250 cfs of Flow @ Holder in the regression analysis. The results of the linear regression analysis of Flow @ Inverness vs. Flow @ Holder are shown in Figure 2.5, and the R^2 value is 0.99.

The regression analysis of Flow @ Wysong Dam vs. Flow @ Holder is shown in Figure 2.6, and the R^2 value is 0.95.

As seen in Table 2.1, a total of 17 flow rates at USGS With @ Holder were selected with a range of 150 cfs to 2,120 cfs (2 to 90 upper percentiles of the historical flow record). According to the regression analysis above, the flow rates at Gum Spring @ Holder, With @ Inverness, and With @ Wysong Dam were calculated and listed in Table 2.1, for the 17 channel flow profiles. The complete table of the channel flow profiles, including all cross-sections, can be found in the HEC-RAS input file.

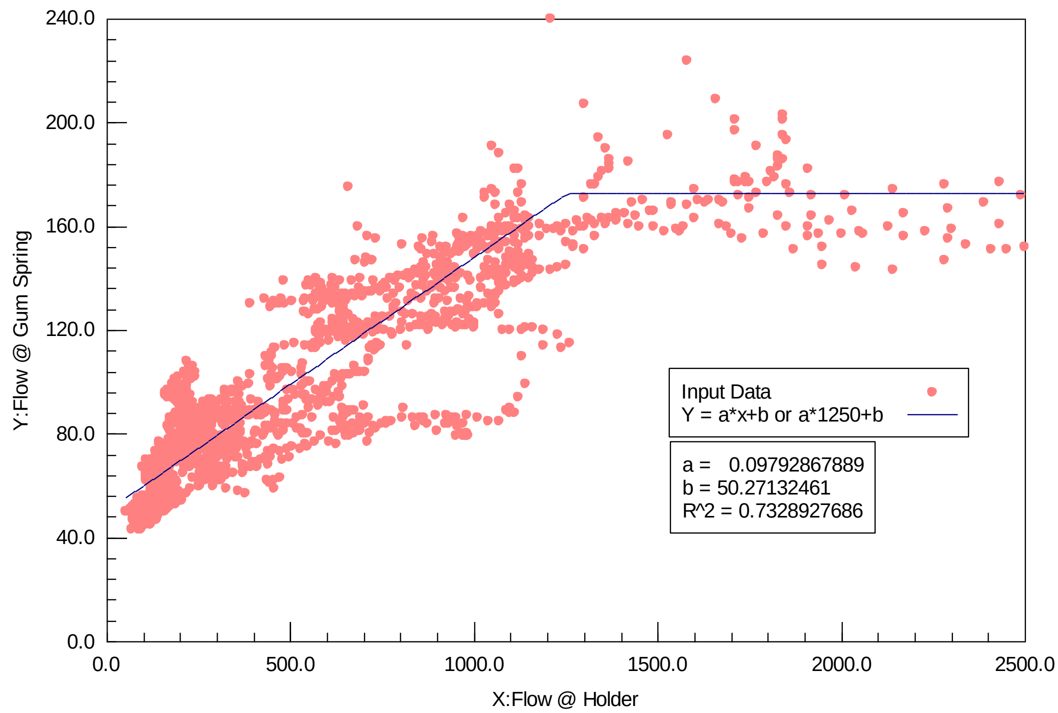


Figure 2.4 Regression Analysis of Flow @ Gum Spring vs. Flow @ Holder

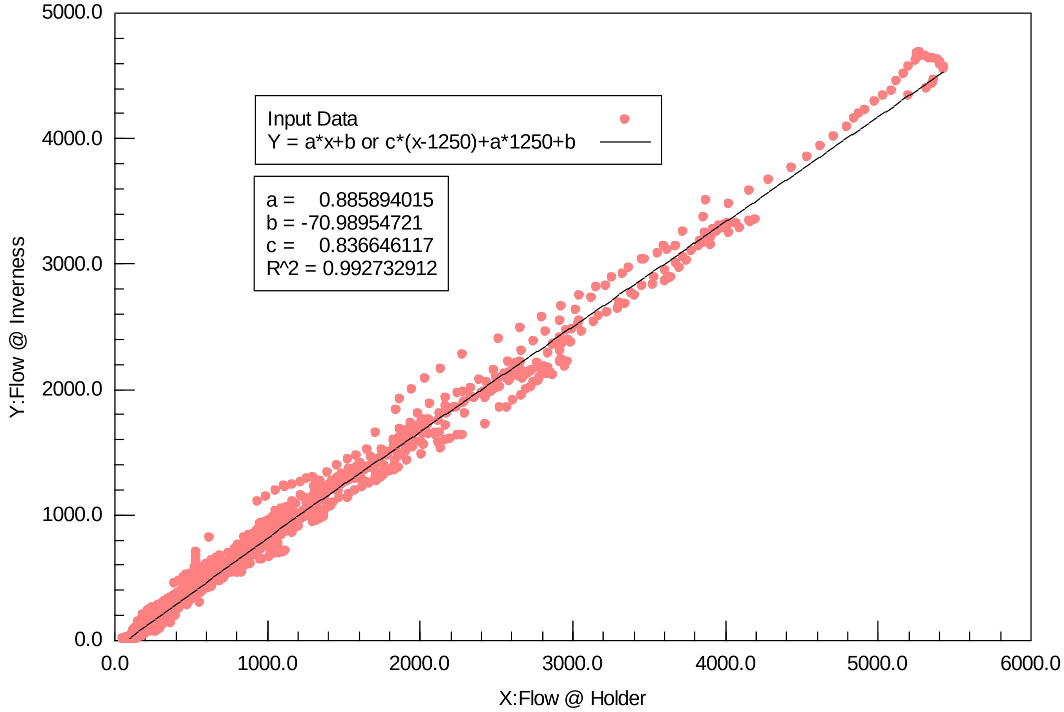


Figure 2.5 Regression Analysis of Flow @ Inverness vs. Flow @ Holder

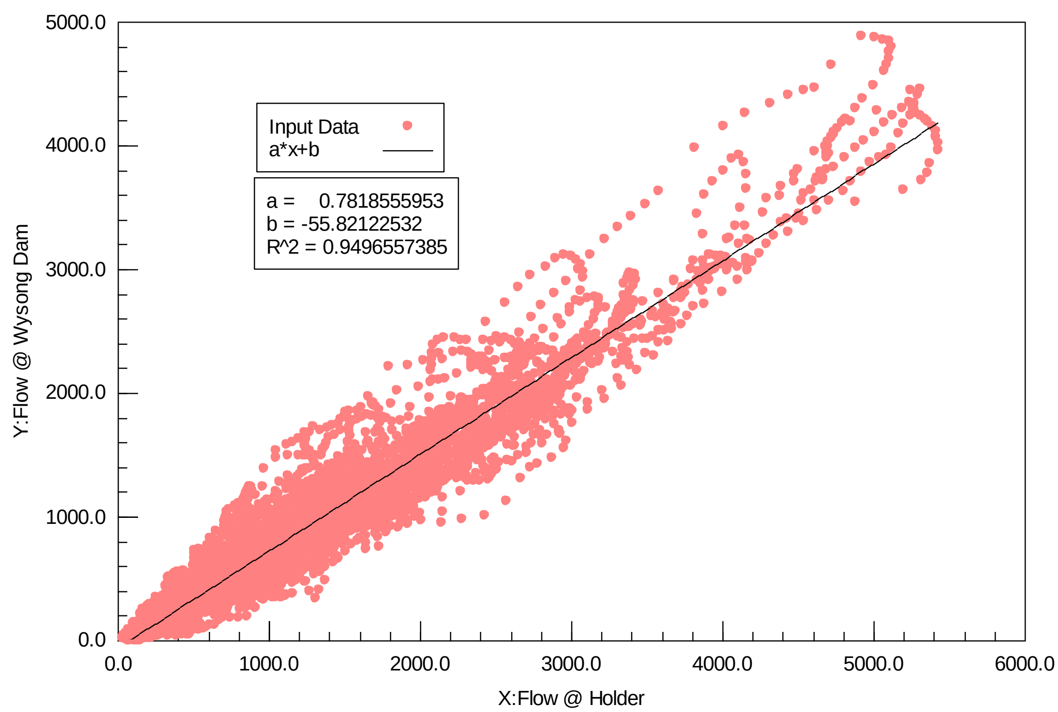


Figure 2.6 Regression Analysis of Flow @ Wysong Dam vs. Flow @ Holder

Table 2.1 Channel Flow Profiles of Lower Segment

USGS Station		With @ Holder (02313000)	Gum Spring @ Holder (02312764)	With @ Inverness (02312762)	With @ Wysong Dam (02312720)
STA in HEC-RAS		0.00	8.05*	8.39	17.84
Flow Rate (cfs)	1	150	64.96	61.89	61.46
	2	200	69.86	106.19	100.55
	3	250	74.75	150.48	139.64
	4	300	79.65	194.78	178.74
	5	350	84.55	239.07	217.83
	6	450	94.34	327.66	296.01
	7	500	99.24	371.96	335.11
	8	550	104.13	416.25	374.20
	9	700	118.82	549.14	491.48
	10	850	133.51	682.02	608.76
	11	1100	157.99	903.49	804.22
	12	1250	172.68	1036.38	921.50
	13	1400	172.68	1161.87	1038.78
	14	1650	172.68	1371.04	1234.24
	15	1800	172.68	1496.53	1351.52
	16	2000	172.68	1663.86	1507.89
	17	2120	172.68	1764.26	1601.71

* STA 8.05 is the confluence of the Gum Spring and the Withlacoochee River, and the flow rates listed here refer to the flow in Gum Spring.

2.2.2 Middle Segment Channel Flow Profiles

Seven (7) USGS gages are available in the Middle Segment of the study area: With @ Wysong Dam, Outlet River @ Panasoffkee, Jumper Creek @ Wahoo, With @ Floral City, With @ Pineola, With @ Nobleton, and With @ Croom. The channel flow profile analysis for this segment is based on the downstream boundary, i.e., USGS With @ Wysong Dam.

USGS With @ Pineola and With @ Flora City are very close to each other and both refer to the flow at USGS With Pineola, or the CR 48 Bridge. With @ Pineola is excluded from the analysis due to its short record history (2005~present). USGS With @ Nobleton has a short record history (2004~present) and is close to With @ Croom, and therefore it is excluded from the analysis.

The Outlet River of Lake Panasoffkee, the major tributary of the Withlacoochee River in the Middle Segment, joins the Withlacoochee River approximately two (2) miles upstream of the Wysong Dam. USGS Outlet River @ Panasoffkee, a long-term stream gage since 1962, is located 2 miles upstream of the mouth of the Outlet River. The Jumper Creek is another tributary, which discharges into the Withlacoochee River about 5.5 miles upstream of the Wysong Dam, and the stream flow records are available at USGS Jumper Creek @ Wahoo, since 1979.

To improve the accuracy of the regression analysis, not all the historical data collected were used in the analysis; for example, the flow records at With @ Wysong Dam were limited to be less than 1,500 cfs (over 90% time) and the outliers at various USGS gages were eliminated as well.

As shown in Figure 2.7 thru Figure 2.10, the upstream/downstream flow proportional relationships are different on low flow conditions when Flow @ Wysong Dam is less than 500 cfs and on high flow conditions when Flow @ Wysong Dam is greater than 500 cfs. A break point at 500 cfs of Flow @ Wysong Dam was introduced into the linear regression analysis for Flow @ Outlet River vs. Flow @ Wysong Dam, Flow @ Jumper Creek vs. Flow @ Wysong Dam, Flow @ Floral City vs. Flow @ Wysong Dam, and Flow @ Croom vs. Flow @ Wysong Dam, and the R^2 value was calculated as 0.68, 0.46, 0.86 and 0.72, respectively, as seen in Figure 2.7 thru Figure 2.10.

As seen in Table 2.2, a total of 17 flow rates at USGS With @ Wysong Dam were selected with a range of 60 cfs to 1,300 cfs (5 to 90 upper percentiles of the historical flow record). According to the regression analysis above, the flow rates at Outlet River @ Panasoffkee, Jumper Creek @ Wahoo, With @ Floral City, and With @ Croom were calculated and listed in Table 2.2, for the 17 channel flow profiles. The complete table of the channel flow profiles, including all cross-sections, can be found in the HEC-RAS input file.

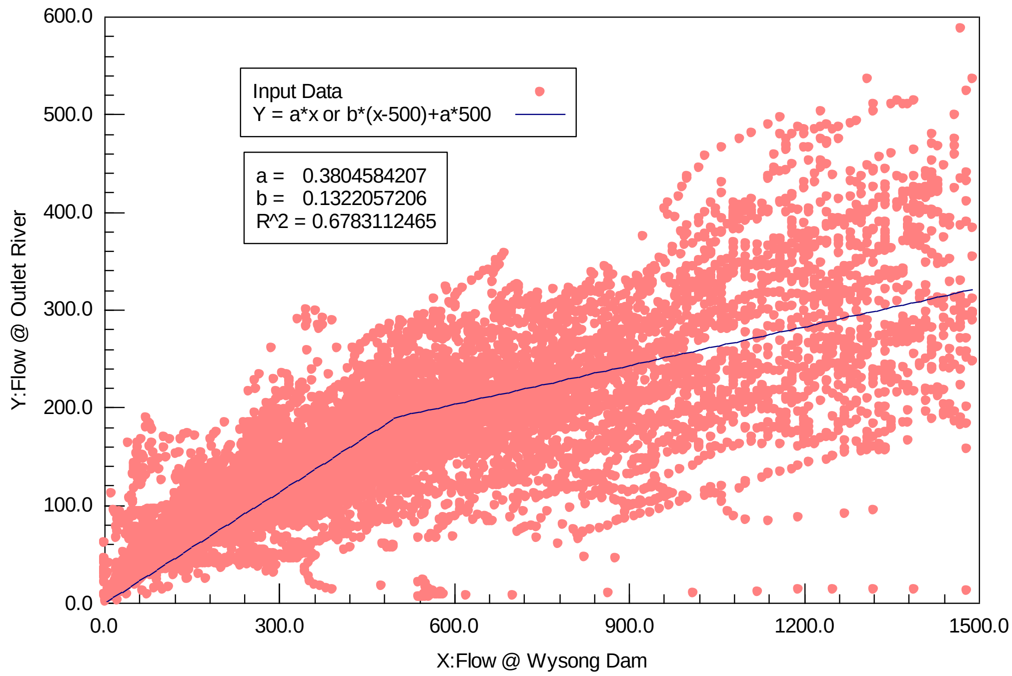


Figure 2.7 Regression Analysis of Flow @ Outlet River vs. Flow @ Wysong Dam

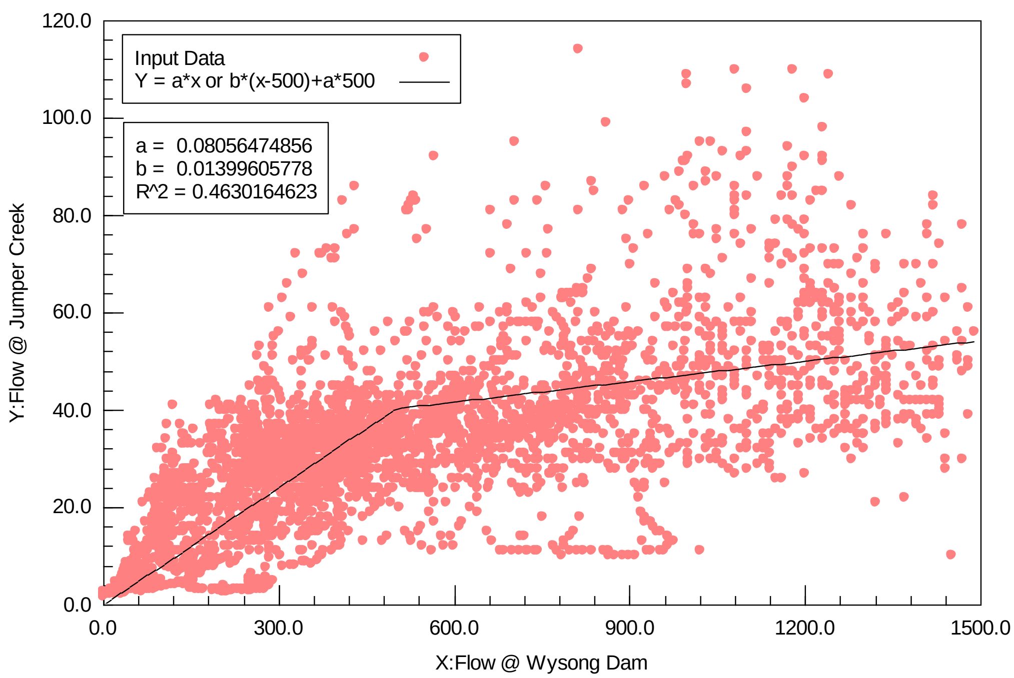


Figure 2.8 Regression Analysis of Flow @ Jumper Creek vs. Flow @ Wysong Dam

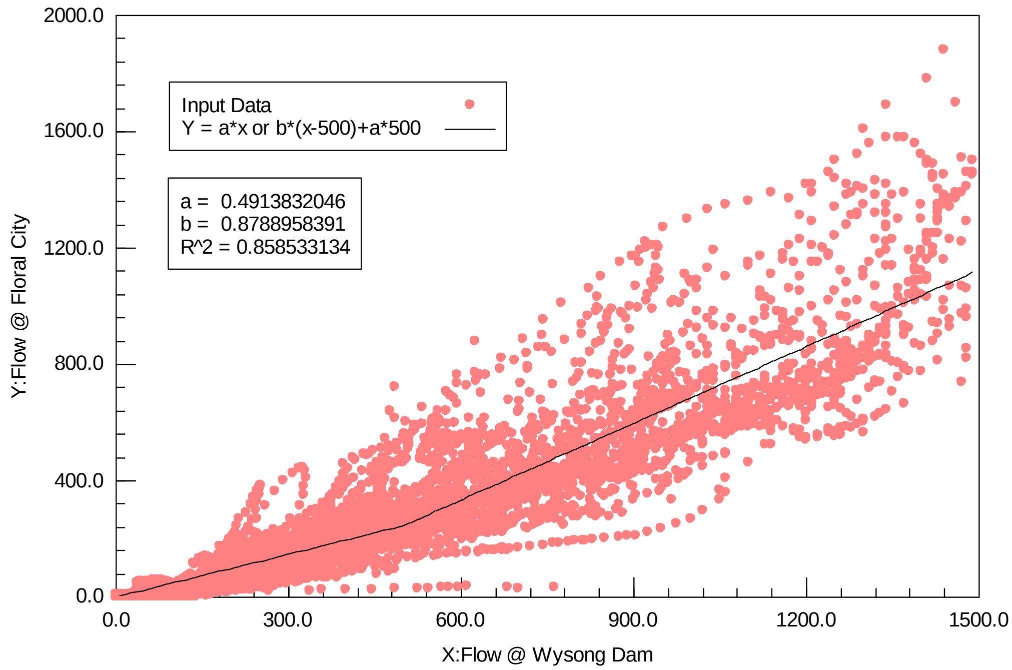


Figure 2.9 Regression Analysis of Flow @ Floral City vs. Flow @ Wysong Dam

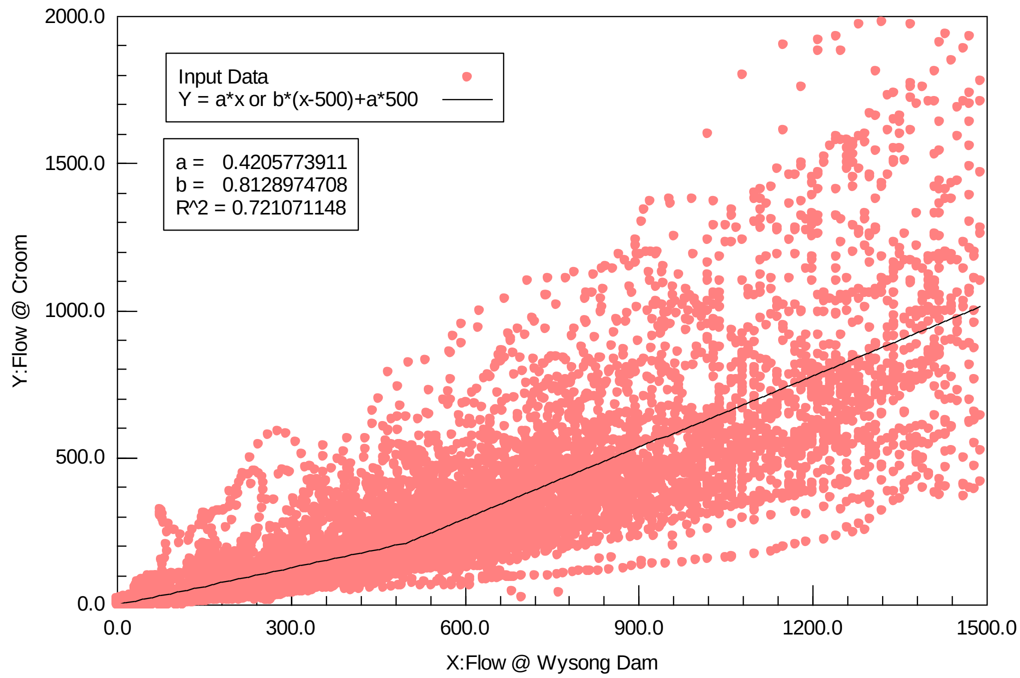


Figure 2.10 Regression Analysis of Flow @ Croom vs. Flow @ Wysong Dam

Table 2.2 Channel Flow Profiles of Middle Segment

USGS Station		**With @ Wysong Dam (02312720)**	**Outlet River @ Panasoffkee (02312700)**	**Jumper Creek @ Wahoo (02312645)**	**With @ Floral City (02312600)**	**With @ Croom (02312500)**
STA in HEC-RAS		**17.84**	**19.93***	**23.43****	**28.38**	**42.24**
Flow Rate (cfs)	**1**	60	22.83	4.83	29.48	25.23
	2	90	34.24	7.25	44.22	37.85
	3	130	49.46	10.47	63.88	54.68
	4	170	64.68	13.70	83.54	71.50
	5	188	71.53	15.15	92.38	79.07
	6	250	95.11	20.14	122.85	105.14

	7	300	114.14	24.17	147.41	126.17
	8	330	125.55	26.59	162.16	138.79
	9	410	155.99	33.03	201.47	172.44
	10	460	175.01	37.06	226.04	193.47
	11	510	191.55	40.42	254.48	218.42
	12	600	203.45	41.68	333.58	291.58
	13	650	210.06	42.38	377.53	332.22
	14	900	243.11	45.88	597.25	535.45
	15	1100	269.55	48.68	773.03	698.03
	16	1250	289.38	50.78	904.86	819.96
	17	1300	295.99	51.48	948.81	860.61

* STA 19.93 is the confluence of the Outlet River and the Withlacoochee River, and the flow rates refer to the flow at the Outlet River of Lake Panasoffkee.

* * STA 23.43 is the confluence of the Jumper Creek and the Withlacoochee River, and the flow rates refer to the flow at the Jumper Creek.

2.2.3 Upper Segment Channel Flow Profiles

Five (5) USGS gages are available in the Upper Segment of the study area: With @ Croom, Little With @ Rerdell, With @ Rital, With @ Trilby, and With @ Dade City, as seen in Figure 2.3. The channel flow profile analysis for this segment is based on the downstream boundary, i.e., USGS With @ Croom.

USGS With @ Rital has a short record data (2004~present), and therefore it is excluded from the analysis of the channel flow profiles.

Little Withlacoochee River, the major tributary of the Withlacoochee River, joins the Withlacoochee River about 2.25 miles upstream of USGS With @ Croom. USGS Little With @ Rerdell, a long-term stream gage back to 1958, is located 4.8 miles upstream from the confluence.

The regression analysis of Flow @ Little With/Rerdell vs. Flow @ Croom is shown in Figure 2.11, and the R^2 value is 0.66. Similar regression analysis of Flow @ Trilby vs. Flow @ Croom, and Flow @ Dade City vs. Flow @ Croom are shown in Figure 2.12 and Figure 2.13, and the R^2 values are 0.93 and 0.56, respectively. The poor regression analysis result of Flow @ Dade City vs. Flow @ Croom may be due to the long distance between the gage, about 35 miles, and the associated gain/loss of flow, including the undocumented groundwater loss at the Dobes Hole near Dade City.

As seen in Table 2.3, a total of 17 flow rates at USGS With @ Croom were selected with a range of 15 cfs to 800 cfs (5 to 90 upper percentiles of the historical flow record). According to the regression analysis above, the flow rates at Little With @ Rerdell, With @ Rital, With @ Trilby, and With @ Dade City were calculated and listed in Table 2.3, for the 17 channel flow profiles. The complete table of the channel flow profiles, including all cross-sections, can be found in the HEC-RAS input file.

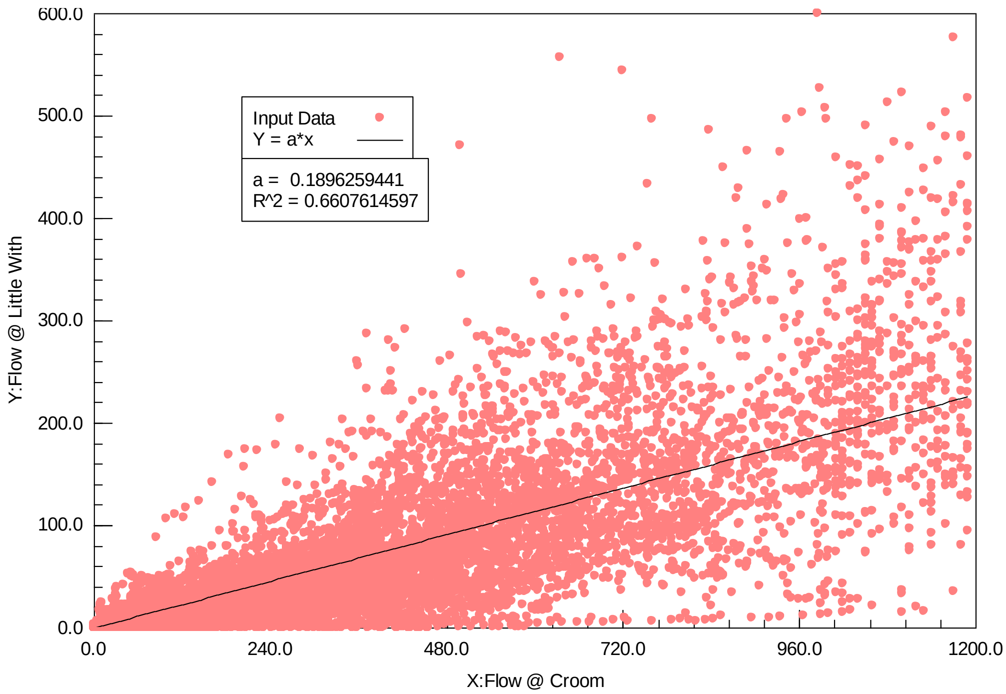


Figure 2.11 Regression Analysis of Flow @ Little With vs. Flow @ Croom

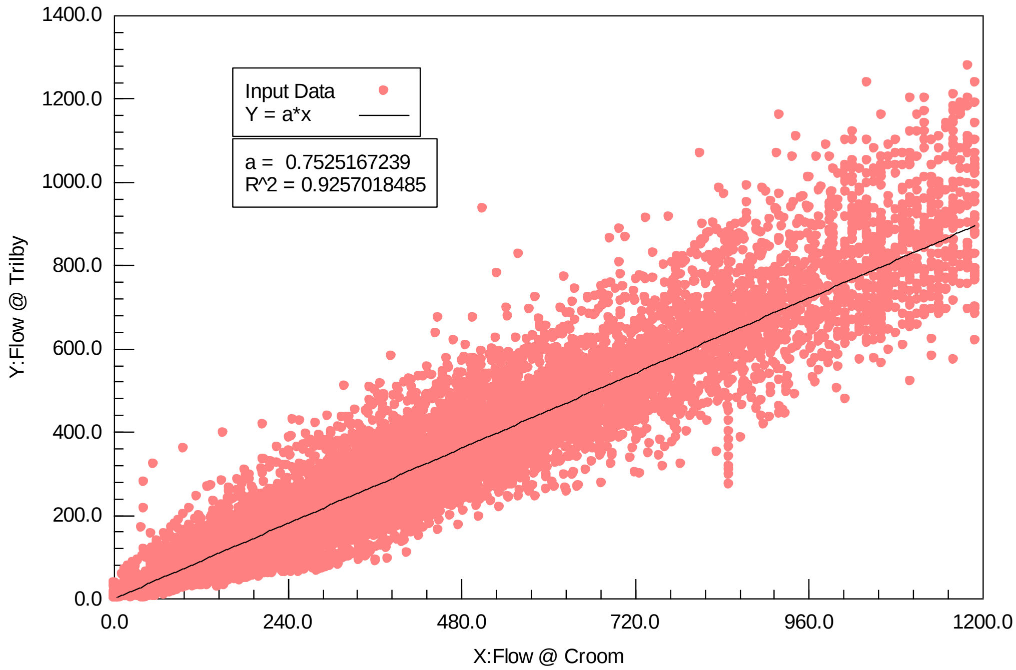


Figure 2.12 Regression Analysis of Flow @ Trilby vs. Flow @ Croom

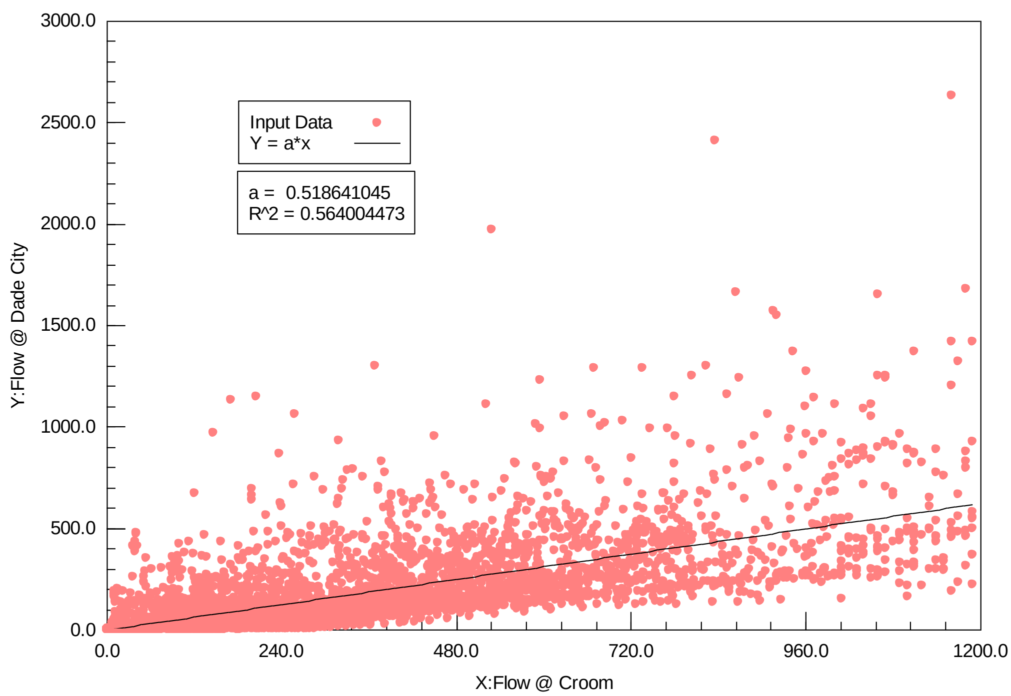


Figure 2.13 Regression Analysis of Flow @ Dade City vs. Flow @ Croom

Table 2.3 Channel Flow Profiles of Upper Segment

USGS Station		With @ Croom (02312500)	Little With @ Rerdell (02312200)	With @ Trilby (02312000)	With @ Dade City (02311500)
STA in HEC-RAS		42.24	44.51*	58.56	77.25
Flow Rate (cfs)	1	15	2.84	11.29	7.78
	2	20	3.79	15.05	10.37
	3	35	6.64	26.34	18.15
	4	50	9.48	37.63	25.93
	5	70	13.27	52.68	36.30
	6	80	15.17	60.20	41.49
	7	105	19.91	79.01	54.46
	8	125	23.70	94.06	64.83
	9	140	26.55	105.35	72.61
	10	175	33.18	131.69	90.76
	11	190	36.03	142.98	98.54
	12	220	41.72	165.55	114.10
	13	300	56.89	225.76	155.59
	14	400	75.85	301.01	207.46
	15	600	113.78	451.51	311.18
	16	700	132.74	526.76	363.05
	17	800	151.70	602.01	414.91

* STA 44.51is the confluence of the Little Withlacoochee River and the Withlacoochee River, and the flow rates refer to the flow at the Little Withlacoochee River.

2.3 Downstream Boundary Conditions

2.3.1 USGS Defined and Shift Corrected Rating Curves

For a steady-state model simulation, a flow-stage rating curve is frequently set as the downstream boundary conditions. As mentioned above, the study area was divided into three segments for the best results of the model calibration, and the downstream boundary conditions for each segment are discussed below.

The USGS published flow-stage rating curves were downloaded from the USGS web site for various USGS gages in the study area, and were used to generate the downstream boundary conditions. There are two kinds of rating curves provided by USGS for each gage: 1) Defined Rating Curve, and 2) Shift Corrected Rating Curve with the shift adjustment. The shift adjustment indicates a temporary change of the channel bed caused by scour or fill, growth/removal of vegetation or algae, and/or accumulation/removal of debris. The Shift Corrected Rating Curve may be updated monthly for some gages, or has no changes during a long period for other gages.

Among the USGS gages in the study area, the biggest shift adjustment values were observed in the Middle Segment from USGS With @ Wysong Dam to With @ Croom, where the stage-flow relationship is dramatically impacted by the operation of the Wysong Dam. It is also noticed that Year 2008 is a dry-water year with the flow records in a low level; however to maintain the water level upstream of the Wysong Dam, the gate structure has been maintained at the highest position. As shown in Figure 2.14, the Shift Corrected Rating Curve at USGS With @ Floral City falls outside of the normal range of the historical record. The shift adjustment value of 2.74 ft indicates a flow-stage pattern change in Year 2008 when the water levels were relative high with the low flow rates. Apparently, the Defined Rating Curve of USGS With @ Floral City is more appropriate to represent the normal flow regime, and similar conclusion can be reached for other gages.

For this project, the **USGS Defined Rating Curve** was used for most of the boundary conditions and the calibration targets in all three segments.

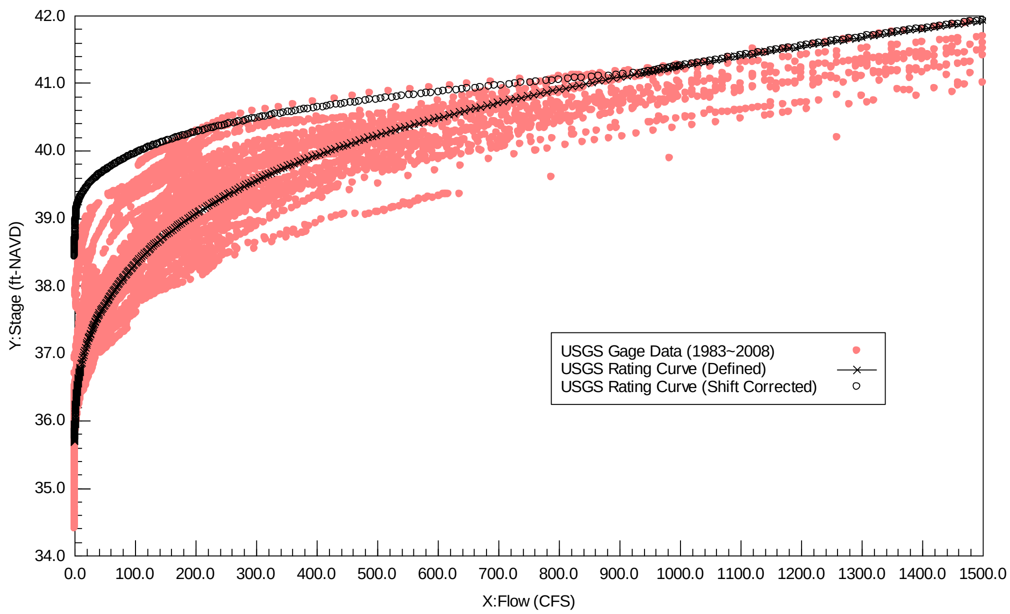


Figure 2.14 Flow-Stage Rating Curves of With @ Floral City

2.3.2 Lower Segment Boundary Conditions

USGS With @ Holder (02313000) is the downstream boundary of the Lower Segment. The published rating curves are available at the following USGS web site:

http://waterdata.usgs.gov/nwisweb/data/exsa_rat/02313000.rdb

The historical flow record (Daily Average from 1928 to 2008), a polynomial regression curve generated by EAS, and the USGS rating curves (Defined and Shift Corrected) of USGS With @ Holder are shown in Figure 2.15. The polynomial regression curve with a R^2 value of 0.98 is almost identical to the USGS published rating curves at this gage.

The **USGS Defined Rating Curve** of USGS With @ Holder was selected as the downstream boundary conditions for the Lower Segment. The flow/stage data for the 17 channel flow profiles of the Lower Segment was estimated and is listed in Table 2.4.

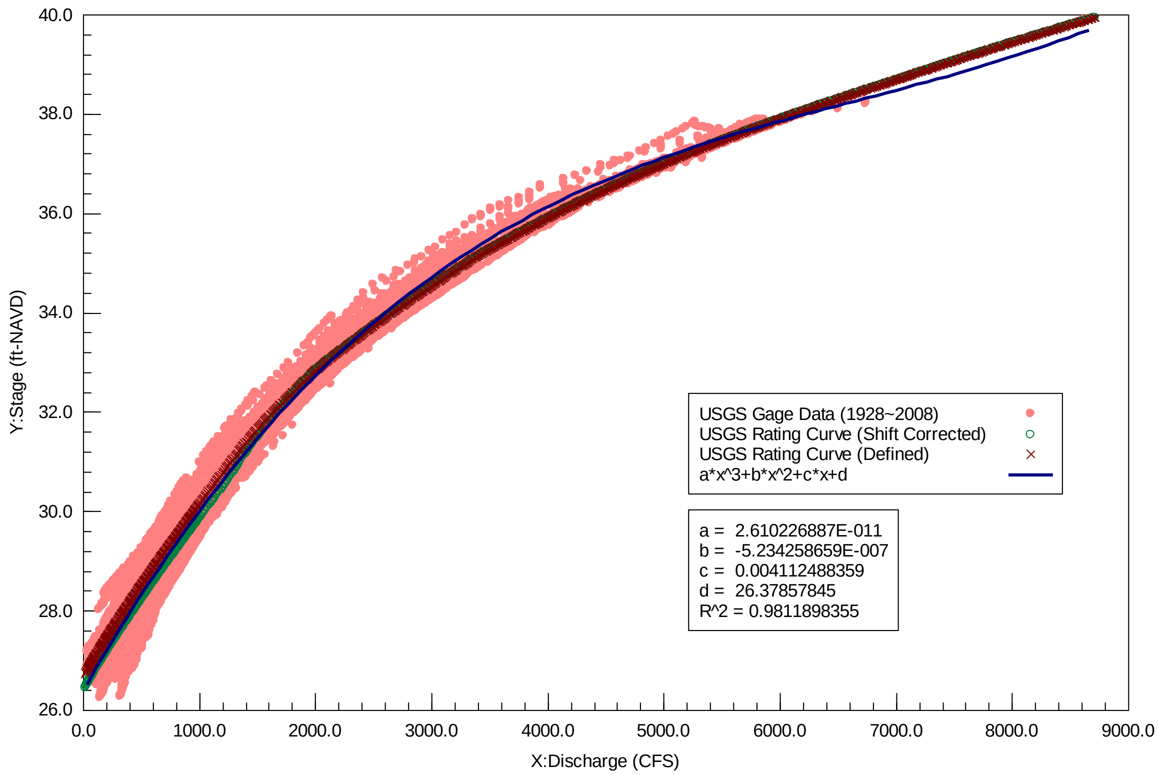


Figure 2.15 Flow-Stage Rating Curves of With @ Holder

Table 2.4 Lower Segment Boundary Conditions at With @ Holder

Profile	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Flow (cfs)	150	200	250	300	350	450	500	550	700	850	1100	1250	1400	1650	1800	2000	2120
Stage (ft-NAVD)	27.27	27.46	27.64	27.82	28.00	28.34	28.51	28.68	29.18	29.67	30.46	30.93	31.39	32.04	32.39	32.83	33.06

2.3.3 Middle Segment Boundary Conditions

USGS With @ Wysong Dam (02312720) is the downstream boundary of the Middle Segment. The published rating curves are available at the following USGS web site:

http://waterdata.usgs.gov/nwisweb/data/exsa_rat/02312720.rdb

The historical flow record (Daily Average from 1965 to 2008), a polynomial regression curve generated by EAS, and the USGS rating curves (Defined and Shift Corrected) of USGS With @ Wysong Dam are shown in Figure 2.16. The USGS rating curves have a good fit on the historical flow records on low flow conditions; however, on high flow conditions the USGS rating curves fall outside of the normal range. The polynomial regression curve has a fairly good fit to the historical flow records on the normal and high flow conditions, but does not match the historical flow records on low flow conditions. The simulated rating curve from the Lower Segment HEC-RAS model has a better fit to the historical data both prior and post the 2002 re-construction project of the Wysong AWCS.

The **simulated rating curve** from the Lower Segment HEC-RAS model was selected as the boundary conditions of the Middle Segment. The flow/stage data for the 17 channel flow profiles of the Middle Segment was estimated and is listed in Table 2.5.

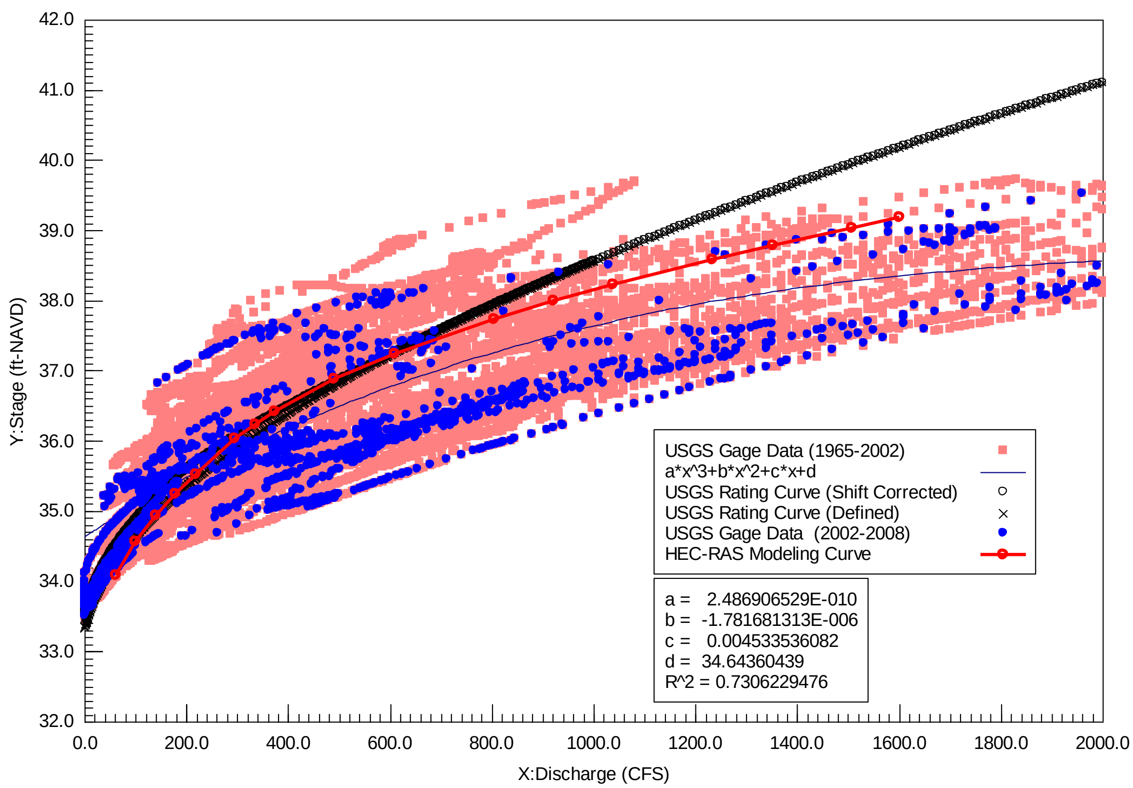


Figure 2.16 Flow-Stage Rating Curves of With @ Wysong Dam

Table 2.5 Middle Segment Boundary Conditions at With @ Wysong Dam

Profile	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Flow (cfs)	60	90	130	170	188	250	300	330	410	460	510	600	650	900	1100	1250	1300

Stage (ft-NAVD)	34.27	34.44	34.85	35.18	35.32	35.75	36.05	36.21	36.57	36.77	36.94	37.22	37.35	37.95	38.35	38.62	38.70

2.3.4 Upper Segment Boundary Conditions

USGS With @ Croom (02312500) is the downstream boundary of the Upper Segment. The published rating curves are available at the following USGS web site:

http://waterdata.usgs.gov/nwisweb/data/exsa_rat/02312500.rdb

The historical flow record (Daily Average from 1939 to 2008), a polynomial regression curve generated by EAS, and the USGS rating curves (Defined and Shift Corrected) are shown in Figure 2.17. There is a shift adjustment of 0.53 ft between the USGS Shift Corrected and Defined Rating Curves at this USGS gage.

The USGS Defined Rating Curve of USGS With @ Croom is selected as the boundary conditions for the Upper Segment. The flow/stage data for the 17 channel flow profiles of the upper Segment was estimated and is listed in Table 2.6.

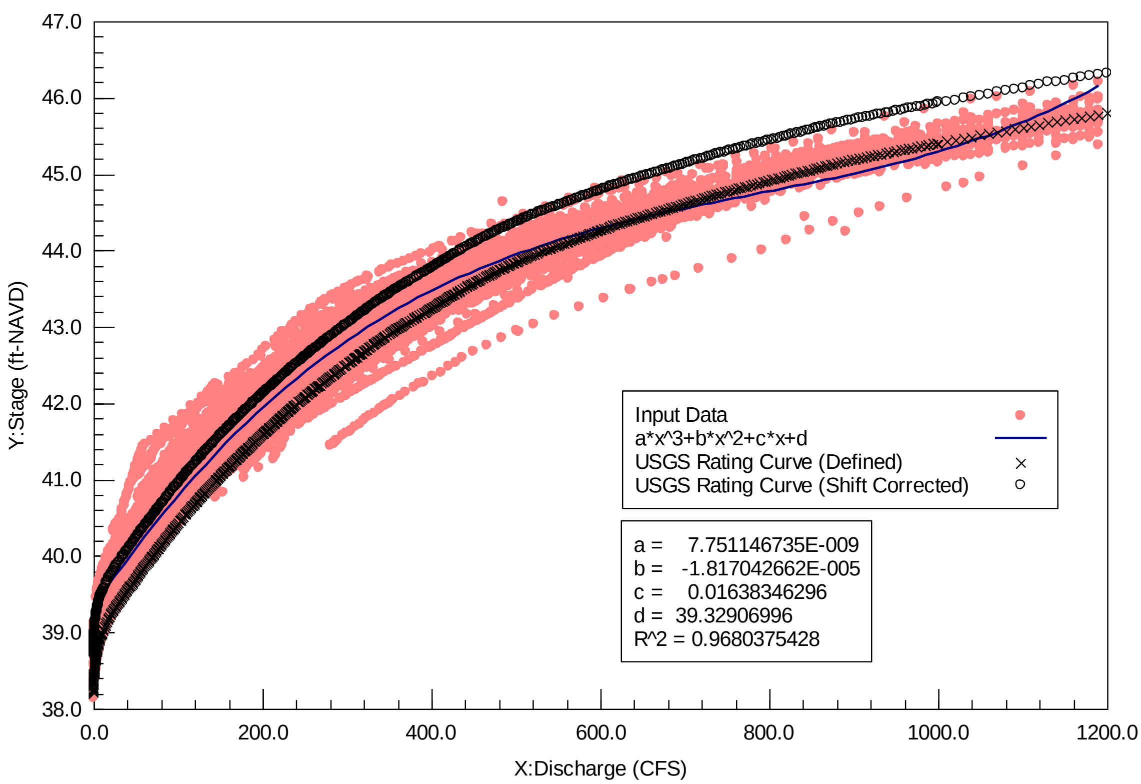


Figure 2.17 Flow-Stage Rating Curves of With @ Croom

Table 2.6 Upper Segment Boundary Conditions at With @ Croom

Profile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Flow (cfs)	15	20	35	50	70	80	105	125	140	175	190	220	300	400	600	700	800
Stage (ft-NAVD)	39.12	39.23	39.47	39.70	40.00	40.14	40.49	40.75	40.93	41.33	41.49	41.79	42.50	43.24	44.26	44.61	44.91

2.4 Structures and Operations

2.4.1 Wysong Adjustable Water Conservation Structure (AWCS)

The Wysong AWCS is located within the middle portion of the Withlacoochee River on the Citrus and Sumter county line. The Wysong Dam was originally constructed as an inflatable structure in 1964, and was taken out of service in 1988. The new Wysong AWCS was constructed by the District in Oct 2002 to improve navigation and water conservation in Lake Panasoffkee, Tsala Apopka Chain of Lakes and the middle Withlacoochee River on low flow conditions. The facility is to be operated in accordance with the original conditions of United States Army Corps of Engineers (USACE) Section 7 and 9 permits.

The Section 9 permit indicates the maximum upstream water elevation of the Wysong AWCS should not exceed 39.5 ft-NGVD, or 38.63 ft-NAVD. During the design phase of the Wysong AWCS by HDR, Inc., an analysis of the historic Wysong flows indicated that a flow lower than 188 cfs occurs 85 percent of the time. This minimum flow is temporally used to regulate the dam structure before the Minimum Flows and Levels (MFLs) is adopted for the Withlacoochee River.

The Wysong AWCS has thirteen (13) individual steel gates (19'-1" wide each) constructed on a concrete and steel foundation, and the total width of dam is 248'-1". The adjustable dam can be operated in two independent groups: Low Gate with one single steel gate (19'-1" wide) and Main Gate with 12 steel gates (229' wide). Both the Low Gate and the Main Gate can be operated between the foundation crest elevation of 34 ft-NGVD (33.13 ft-NAVD) and the gate crest elevation of 39 ft-NGVD (38.13 ft-NAVD). The design high elevation of 39.5 ft-NGVD (38.63 ft-NAVD) and the minimum flow requirement of 188 cfs are the major criteria used in this modeling.

As discussed in the previous sections, 17 channel flow profiles were modeled in HEC-RAS, to examine the model accuracy on various flow conditions. As part of the model parameterization, the gate opening value should be designated for the 17 channel flow profiles. However during our data collection, there is no official or documented operating curve to relate the gate opening to the flow rate.

From June 2008, USGS reinstalled the stream gage (USGS 02312719) on the upstream side of the dam. The stage/flow hydrographs at both downstream side (USGS 02312720) and upstream side (USGS 02312719) of the dam are plotted in Figure 2.18. It is noted that the upstream water levels are generally controlled between the gate crest elevation of 38.13 ft-NAVD and the permitted maximum elevation of 38.63 ft-NAVD, as shown in Figure 2.19. During the storm event in August 2008, the structure was operated at a lower level to release extra stormwater for flood protection purposes. However, the short-term history of the upstream water levels (USGS 02312719) makes it difficult to generate a reliable relationship of gate opening vs. flow rate.

Given the limitations discussed above, the closest upstream calibration gage, USGS With @ Floral City, was used to adjust the opening value of the Wysong Dam structure. To match the defined rating curve of With @ Floral City, the openings of the Low Gate and Main Gate were assigned specific values for the 17 channel flow profiles, as seen in Table 2.7. The simulated water levels upstream of the dam are lower than the design high elevation of 38.63 ft-NAVD, except for Flow Profile No. 16 & 17 where the downstream water levels are too high.

As shown in Table 2.7 and Figure 2.18, the simulated water levels upstream of the dam are much lower than the USGS gage data in Year 2008. The reasons are: 1) the HEC-RAS modeling is to simulate the long-term river flow conditions by using the USGS Defined Rating Curves, and 2) the upstream USGS gage has a very short record history, since 2008.

In summary, it is a good approach to apply the long-term USGS flow records and rating curves in the model simulation, other than to manipulate the operation rule of the structure or wait for more gage records to become available. Once the HEC-RAS model is calibrated for this segment, the model could be used to run various scenarios by re-configuring the gate opening, if needed.

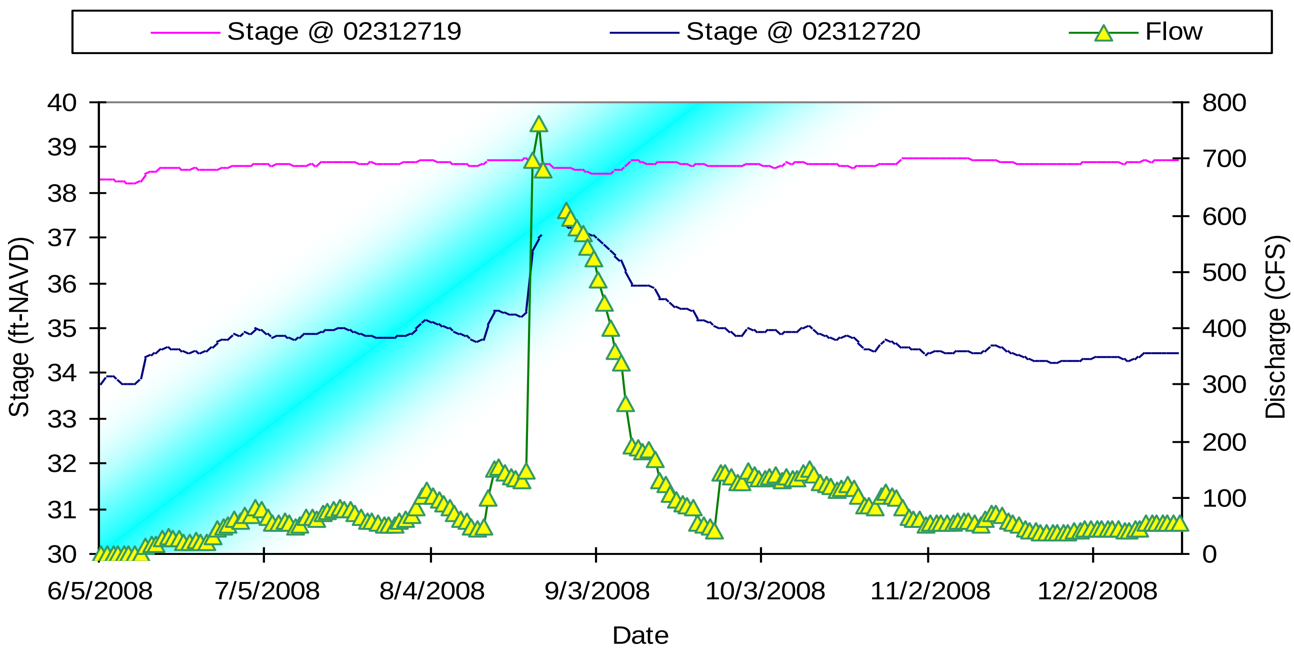


Figure 2.18 Stage/Flow Hydrographs at Upstream/Downstream of Wysong Dam

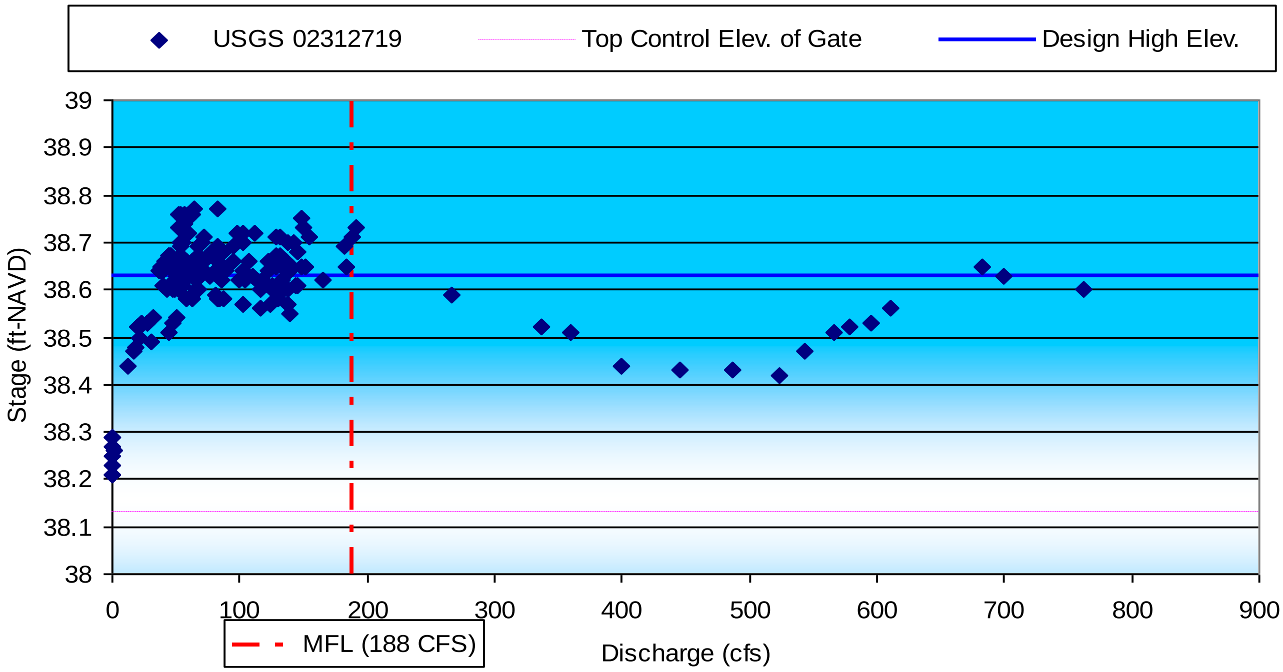


Figure 2.19 Flow-Stage Relationship at Upstream of Wysong Dam

Table 2.7 Wysong AWCS Gate Openings Table

Profile	Flow (cfs)	DS Water level (ft-NAVD)	US Water Level (ft-NAVD)	Diff. (ft)	Crest Elev. (ft-NAVD)	Design High (ft-NAVD)	Main Gate Opening (ft)	Low Gate Opening (ft)	Lower than Design High?
1	60	34.27	**37.31**	3.04	38.13	38.63	1	1	Yes
2	90	34.51	**37.37**	2.86	38.13	38.63	1	1	Yes
3	130	34.92	**37.44**	2.52	38.13	38.63	1	1	Yes
4	170	35.24	**37.5**	2.26	38.13	38.63	1	1	Yes
5	188	35.38	**37.53**	2.15	38.13	38.63	1	1	Yes
6	250	35.81	**37.50**	1.69	38.13	38.63	1	2	Yes
7	300	36.10	**37.57**	1.47	38.13	38.63	1	2	Yes
8	330	36.25	**37.61**	1.36	38.13	38.63	1	2	Yes
9	410	36.62	**37.64**	1.02	38.13	38.63	1	2.5	Yes
10	460	36.81	**37.70**	0.89	38.13	38.63	1	2.5	Yes
11	510	36.97	**37.77**	0.80	38.13	38.63	1	2.5	Yes
12	600	37.24	**37.88**	0.64	38.13	38.63	1	2.5	Yes
13	650	37.38	**37.93**	0.55	38.13	38.63	1	2.5	Yes
14	900	37.97	**38.32**	0.35	38.13	38.63	1	2.5	Yes
15	1100	38.37	**38.43**	0.06	38.13	38.63	3	5	Yes
16	1250	38.64	**38.67**	0.03	38.13	38.63	5	5	**No**
17	1300	38.72	**38.75**	0.03	38.13	38.63	5	5	**No**

2.4.2 Structures of Tsala Apopka Chain of Lakes

There are two intake canals from the Withlacoochee River to the Tsala Apopka Chain of Lakes: Orange State Canal and Leslie Heifner Canal. These canals are both structure controlled; however, no flow record is available from either USGS or SWFWMD. The upstream and downstream water levels of the Leslie Heifner control structure were monitored by SWFWMD; however, it is very difficult to estimate the rate curve without knowing the measured flow rates and gate condition setting. No water level data is available for the Orange State Canal. Therefore, the flow diversion to the Tsala Apopka Chain of Lakes was not simulated in the HEC-RAS modeling.

As the outfall canal of Tsala Apopka Chain of Lakes, Canal C-334 joins the Withlacoochee River about 500 ft upstream of the USGS gage With @ Holder. The flow data is recorded at structure S-353, or USGS 02312975. The historic flow data at USGS 02312975 indicates that the structure was closed in normal conditions, and was opened during big storms. So, the flow through the Outfall Canal is not included in the HEC-RAS model.

2.4.3 Bridges

There are ten (10) bridges in the study area of the Withlacoochee River, as summarized in Table 2.8. Pertinent data of the bridges was obtained from various agencies (SWFWMD, FDOT, and CSX). The bridge data, including the construction plans, as-built plans, and hydrographic survey, was reviewed and incorporated into the HEC-RAS model.

Table 2.8 Summary of the Bridges on the Withlacoochee River

ID	Name	STA in HEC-RAS	Data Source	County	STR	Structure ID
1	SR 200	0.005	SWFWMD	Citrus/Marion	30 17 20	020008
2	SR 44	14.50	SWFWMD	Citrus/Sumter	08 19 21	180067
3	CR 48	28.37	SWFWMD	Citrus/Sumter	30 20 21	184006
4	CR 476	36.514	SWFWMD	Hernando/Sumter	24 21 20	184019
5	I-75	43.20	FDOT	Hernando/Sumter	16 22 21	080025
6	SR 50	50.85	FDOT	Hernando	04 23 21	080064
7	US 98	56.76	FDOT	Pasco	22 23 21	140066
8	US 301	58.58	FDOT	Hernando	14 23 21	080030
9	CSX Rail Road	59.73	CSX/SWFWMD	Pasco	24 23 21	
10	SR 575	60.23	FDOT	Pasco	24 23 21	140031

3.0 Model Calibration

3.1 Calibration Targets

The HEC-RAS modeling for the Withlacoochee River in the study area is divided into three segments: Lower, Middle and Upper Segments. Each segment was simulated for 17 channel flow profiles. Manning's n and other parameters were adjusted for each cross-section to fit the simulated water levels to the calibration targets at various USGS gages. The difference between the simulated water levels and calibration targets is required to be within ±0.5 ft. No significant changes were noticed between the final and initial Manning's n values during the model calibration process; therefore, these minor changes are not documented in this report.

The calibration targets were mostly derived from the published USGS Defined Rating Curves with one exception for USGS With @ Inverness, where the regression curve generated from the historical data was selected as the calibration targets.

The details of the model calibration for Lower, Middle, and Upper Segments are described below.

3.1.1 Lower Segment Model Calibration

Two (2) USGS gages are available for model calibration of the Lower Segment: USGS With @ Inverness (02312762) and USGS With @ Wysong Dam (02312720).

For USGS With @ Inverness, the regression curve generated from the historical data was selected for the calibration targets in this location, due to the poor quality of the USGS Rating Curve, as seen in Figure 3.1. Table 3.1 lists the summary of the model calibration results, which indicates the model results are satisfied with the calibration criteria of ±0.5 ft.

For USGS With @ Wysong Dam, the USGS Defined Rating Curve was selected as the calibration target. The model calibration results are summarized in Table 3.2 and Figure 3.2. The USGS Defined Rating Curve does not fit the historical flow records for high flow conditions. On the other hand, the simulated water levels are more reasonable than the Defined Rating Curve.

3.1.2 Middle Segment Model Calibration

Four (4) USGS gages are available for model calibration of the Middle Segment: USGS With @ Floral City (02312600), USGS With @ Pineola (02312598), USGS With @ Nobleton (02312558), and USGS With @ Croom (02312500).

For all four of the USGS gages listed above, the USGS Defined Rating Curves were selected as the calibration targets. The model calibration results are summarized in Table 3.3 thru Table 3.6, and Figure 3.3 thru Figure 3.6.

Per comments from the SWFWMD, the published vertical datum of USGS With @ Nobleton is incorrect. The modified datum of the gage is at NAVD of 1988, and as shown in Figure 3.5 and Table 3.5, the simulated model results fit well to the Defined Rating Curves and the gage data.

3.1.3 Upper Segment Model Calibration

Two (2) USGS gages are available for model calibration of the Upper Segment: USGS With @ Trilby (02312000) and USGS With @ Dade City (02311500). For these two USGS gages, the USGS Defined Rating Curves were selected as the calibration targets. The model calibration results are summarized in Table 3.7 thru Table 3.8, and Figure 3.7 thru Figure 3.8.

3.2 Channel Profile Plots

The water level profiles for all 17 channel flow profiles are presented in Figures 3.9 thru 3.11, for the Lower Segment, Middle Segment, and Upper Segment, respectively.

4.0 Conclusion and LIMITATIONS

HEC-RAS 4.0, HEC-GeoRAS 4.1.1, ArcGIS 9.2, and other software were used to develop the HEC-RAS model for estimating the MFL's for the middle Withlacoochee River system. The 77 river miles long study area was divided and modeled in three segments: Lower Segment, Middle Segment and Upper Segment. Detailed model calibrations were performed for each segment, independently. The difference in value between the simulated results and the calibration targets falls within the calibration criteria of ±0.5 ft. The calibrated HEC-RAS model can be used for habitat study in the Withlacoochee River.

There are several challenges and limitations in the current HEC-RAS modeling, mostly due to the data deficiency, as listed in the following:

1). reverse flow was observed from the mouth of the Outlet River of Panasoffkee Lake to USGS With @ Nobleton.

2). impacts of the operation rule of Wysong AWCS during the dry season.

3). flow diversion to the Tsala Apopka Lake thru Orange State Canal and Leslie Heifner Canal.

The limitation in the present study could be overcome by recalibrating the HEC-RAS model when additional data becomes available.

Table 3.1 Model Calibration on USGS With @ Inverness – USGS 02312762 (STA: 8.39)

Profile	With @ Holder Flow (cfs)	With @ Inverness Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	150	61.89	32.04	31.73	**-0.31**
2	200	106.19	32.22	32.09	**-0.13**
3	250	150.48	32.40	32.41	**0.01**
4	300	194.78	32.58	32.69	**0.11**
5	350	239.07	32.75	32.95	**0.20**
6	450	327.66	33.08	33.40	**0.32**
7	500	371.96	33.24	33.61	**0.37**
8	550	416.25	33.39	33.80	**0.41**
9	700	549.14	33.84	34.28	**0.44**
10	850	682.02	34.25	34.64	**0.39**
11	1100	903.49	34.87	35.09	**0.22**
12	1250	1036.38	35.20	35.31	**0.11**
13	1400	1161.87	35.49	35.49	**0.00**
14	1650	1371.04	35.93	35.77	**-0.16**
15	1800	1496.53	36.16	35.93	**-0.23**
16	2000	1663.86	36.45	36.14	**-0.31**
17	2120	1764.26	36.61	36.26	**-0.35**

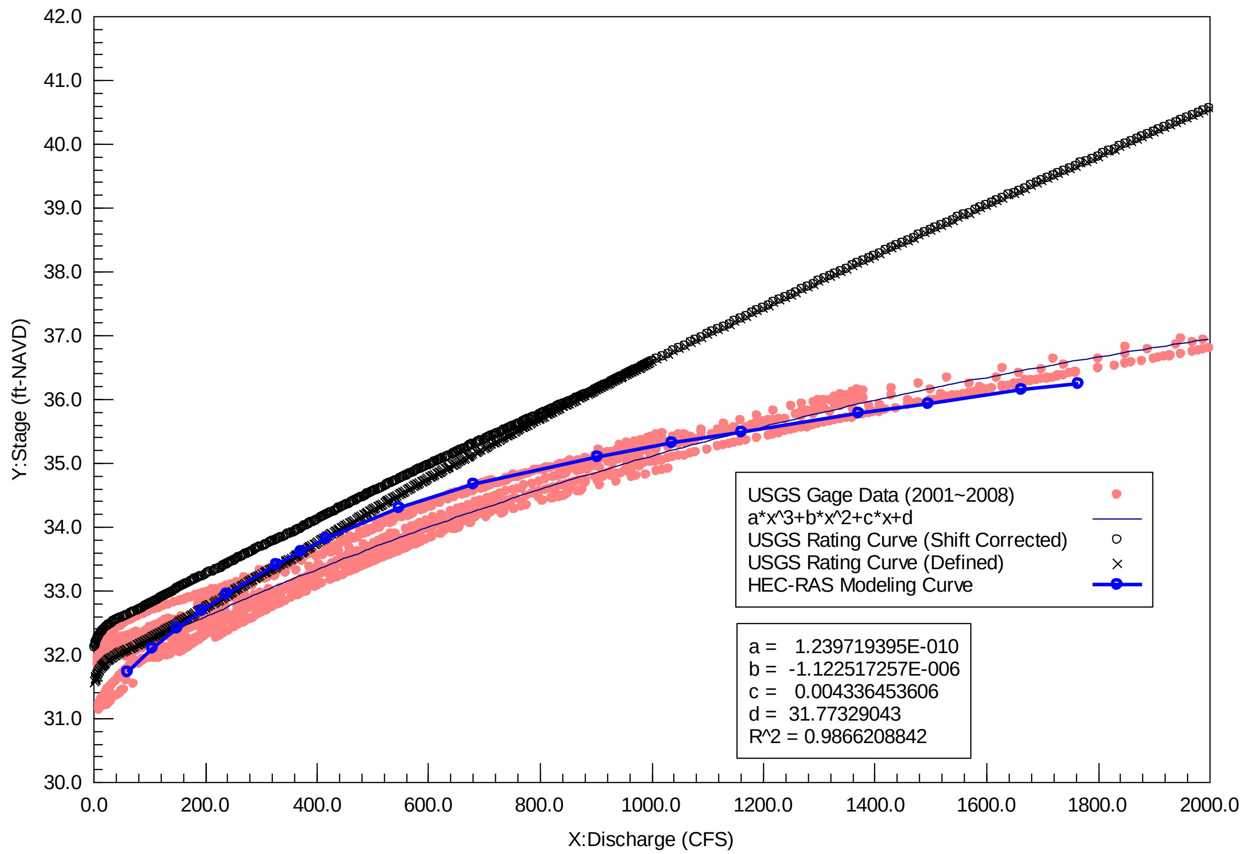


Figure 3.1 Flow-Stage Rating Curve @ Inverness – USGS 02312762

Table 3.2 Model Calibration on USGS With @ Wysong Dam – USGS 02312720 (STA: 17.84)

Profile	With @ Holder Flow (cfs)	With @ Wysong Dam Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	150	61.46	34.28	34.09	**-0.19**
2	200	100.55	34.65	34.56	**-0.09**
3	250	139.64	34.95	34.93	**-0.02**
4	300	178.74	35.22	35.25	**0.03**
5	350	217.83	35.46	35.53	**0.07**
6	450	296.01	35.90	36.03	**0.13**
7	500	335.11	36.09	36.24	**0.15**
8	550	374.20	36.28	36.42	**0.14**
9	700	491.48	36.79	36.88	**0.09**
10	850	608.76	37.25	37.24	**-0.01**
11	1100	804.22	37.94	37.73	**-0.21**
12	1250	921.50	38.32	37.99	**-0.33**
13	1400	1038.78	38.68	38.23	**-0.45**
14	1650	1234.24	39.23	38.59	**-0.64**
15	1800	1351.52	39.55	38.79	**-0.76**
16	2000	1507.89	39.95	39.04	**-0.91**
17	2120	1601.71	40.18	39.18	**-1.00**

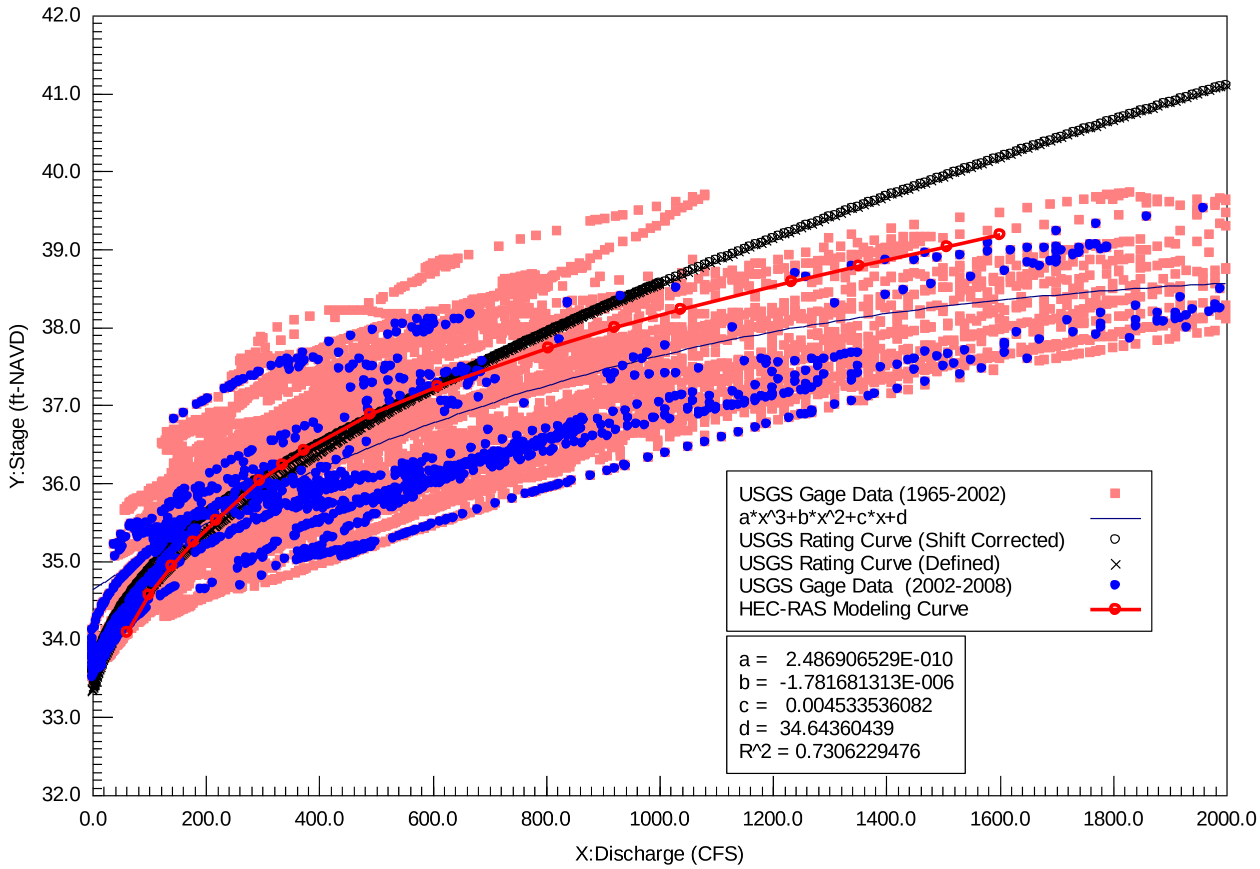


Figure 3.2 Flow-Stage Rating Curve @ Wysong Dam – USGS 02312720

Table 3.3 Model Calibration on USGS With @ Floral City – USGS 02312600 (STA: 26.30)

Profile	With @ Wysong Dam Flow (cfs)	With @ Floral City Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	60	29.48	37.36	37.43	**0.07**
2	90	44.22	37.64	37.60	**-0.04**
3	130	63.88	37.91	37.82	**-0.09**
4	170	83.54	38.15	38.03	**-0.12**
5	188	92.38	38.24	38.13	**-0.11**
6	250	122.85	38.53	38.39	**-0.14**
7	300	147.41	38.73	38.62	**-0.11**
8	330	162.16	38.83	38.75	**-0.08**
9	410	201.47	39.08	39.06	**-0.02**
10	460	226.04	39.21	39.24	**0.03**
11	510	254.48	39.36	39.42	**0.06**
12	600	333.58	39.70	39.82	**0.12**
13	650	377.53	39.86	40.00	**0.14**
14	900	597.25	40.48	40.54	**0.06**
15	1100	773.03	40.86	40.87	**0.01**
16	1250	904.86	41.10	41.08	**-0.02**
17	1300	948.81	41.17	41.14	**-0.03**

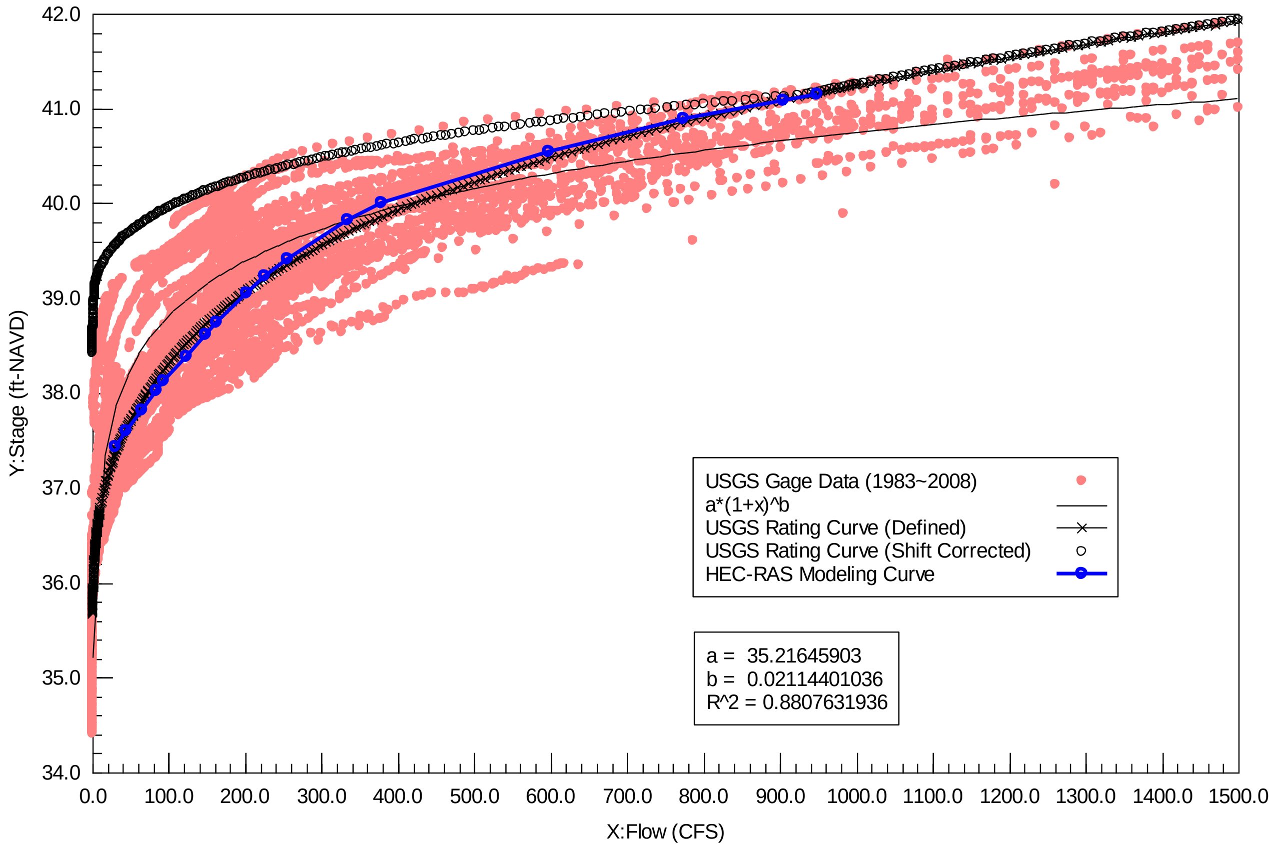


Figure 3.3 Flow-Stage Rating Curve @ Floral City – USGS 02312600

Table 3.4 Model Calibration on USGS With @ Pineola – USGS 02312598 (STA: 28.38)

Profile	With @ Wysong Dam Flow (cfs)	With @ Pineola Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	60	29.48	37.59	37.43	**-0.16**
2	90	44.22	37.68	37.6	**-0.08**
3	130	63.88	37.90	37.83	**-0.07**
4	170	83.54	38.18	38.05	**-0.13**
5	188	92.38	38.31	38.14	**-0.17**
6	250	122.85	38.64	38.41	**-0.23**
7	300	147.41	38.87	38.65	**-0.22**
8	330	162.16	38.99	38.78	**-0.21**
9	410	201.47	39.28	39.09	**-0.19**
10	460	226.04	39.45	39.27	**-0.18**
11	510	254.48	39.62	39.46	**-0.16**
12	600	333.58	40.01	39.87	**-0.14**
13	650	377.53	40.13	40.05	**-0.08**
14	900	597.25	40.49	40.62	**0.13**
15	1100	773.03	40.67	40.98	**0.31**
16	1250	904.86	40.79	41.2	**0.41**
17	1300	948.81	40.82	41.26	**0.44**

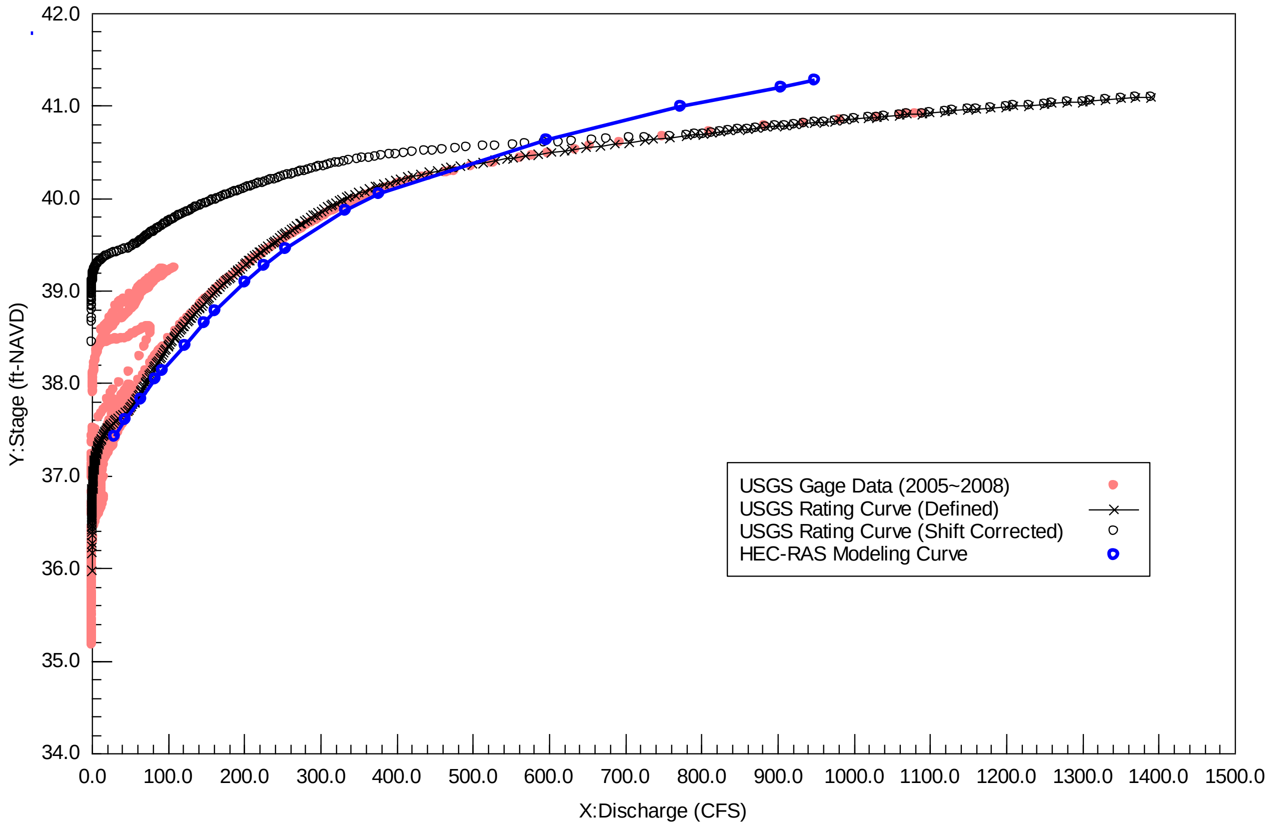


Figure 3.4 Flow-Stage Rating Curve @ Pineola – USGS 02312598

Table 3.5 Model Calibration on USGS With @ Nobleton – USGS 02312558 (STA: 36.41)

Profile	With @ Wysong Dam Flow (cfs)	With @ Nobleton Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	60	27.02	37.48	37.56	**0.08**
2	90	40.53	37.85	37.80	**-0.05**
3	130	58.55	38.21	38.09	**-0.12**
4	170	76.56	38.49	38.36	**-0.13**
5	188	84.67	38.60	38.47	**-0.13**
6	250	112.59	38.91	38.81	**-0.10**
7	300	135.11	39.12	39.08	**-0.04**
8	330	148.62	39.23	39.23	**0.00**

9	410	184.65	39.49	39.61	**0.12**
10	460	207.17	39.64	39.85	**0.21**
11	510	233.59	39.78	40.06	**0.28**
12	600	309.25	40.15	40.48	**0.33**
13	650	351.28	40.33	40.66	**0.33**
14	900	561.45	41.11	41.32	**0.21**
15	1100	729.58	41.64	41.76	**0.12**
16	1250	855.68	41.98	42.04	**0.06**
17	1300	897.72	42.08	42.13	**0.05**

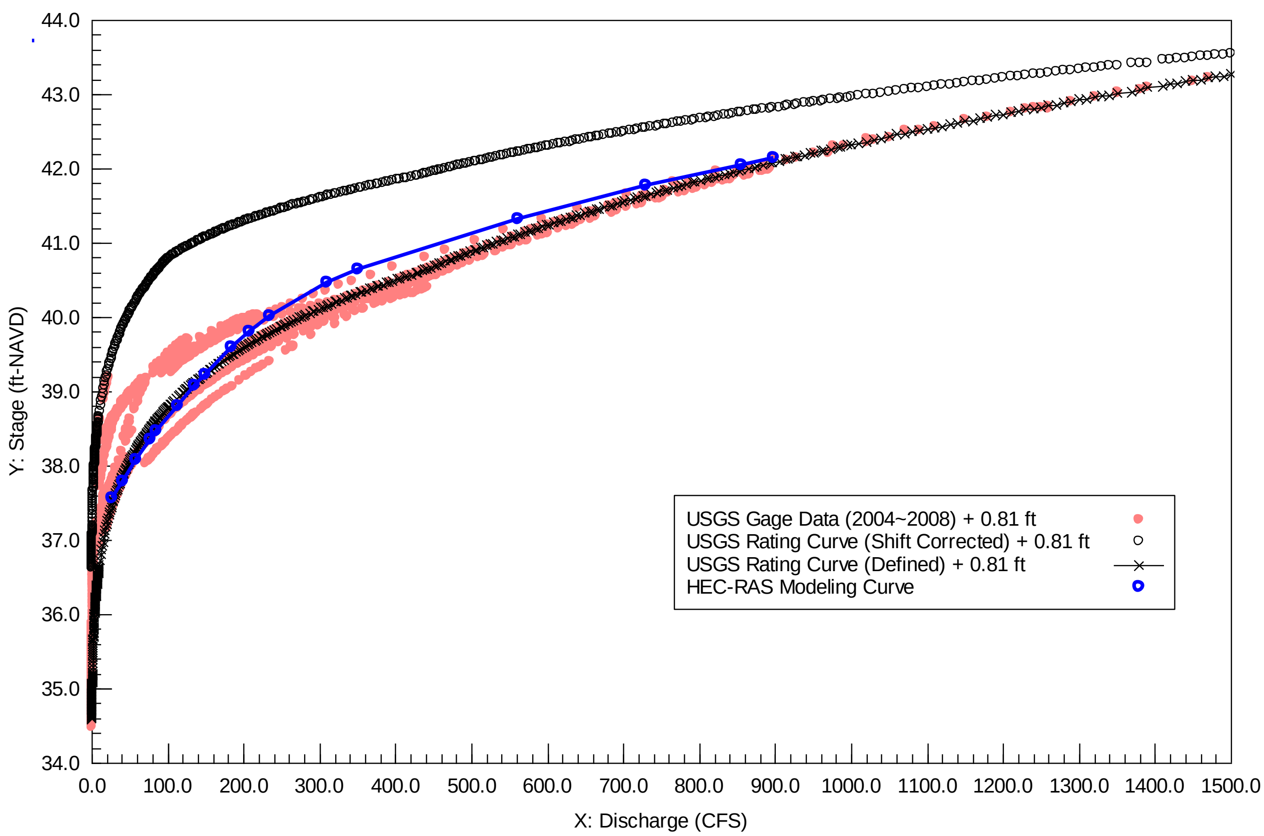


Figure 3.5 Flow-Stage Rating Curve @ Nobleton – USGS 02312558

Table 3.6 Model Calibration on USGS With @ Croom – USGS 02312500 (STA: 42.24)

Profile	With @ Wysong Dam Flow (cfs)	With @ Croom Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	60	25.23	39.31	39.02	**-0.29**
2	90	37.85	39.52	39.38	**-0.14**
3	130	54.68	39.78	39.79	**0.01**
4	170	71.50	40.02	40.14	**0.12**
5	188	79.07	40.13	40.28	**0.15**
6	250	105.14	40.50	40.72	**0.22**
7	300	126.17	40.76	41.03	**0.27**
8	330	138.79	40.92	41.21	**0.29**
9	410	172.44	41.29	41.62	**0.33**
10	460	193.47	41.52	41.85	**0.33**
11	510	218.42	41.77	42.08	**0.31**
12	600	291.58	42.44	42.66	**0.22**
13	650	332.22	42.77	42.93	**0.16**
14	900	535.45	44.00	43.84	**-0.16**
15	1100	698.03	44.60	44.37	**-0.23**
16	1250	819.96	44.97	44.70	**-0.27**
17	1300	860.61	45.09	44.80	**-0.29**

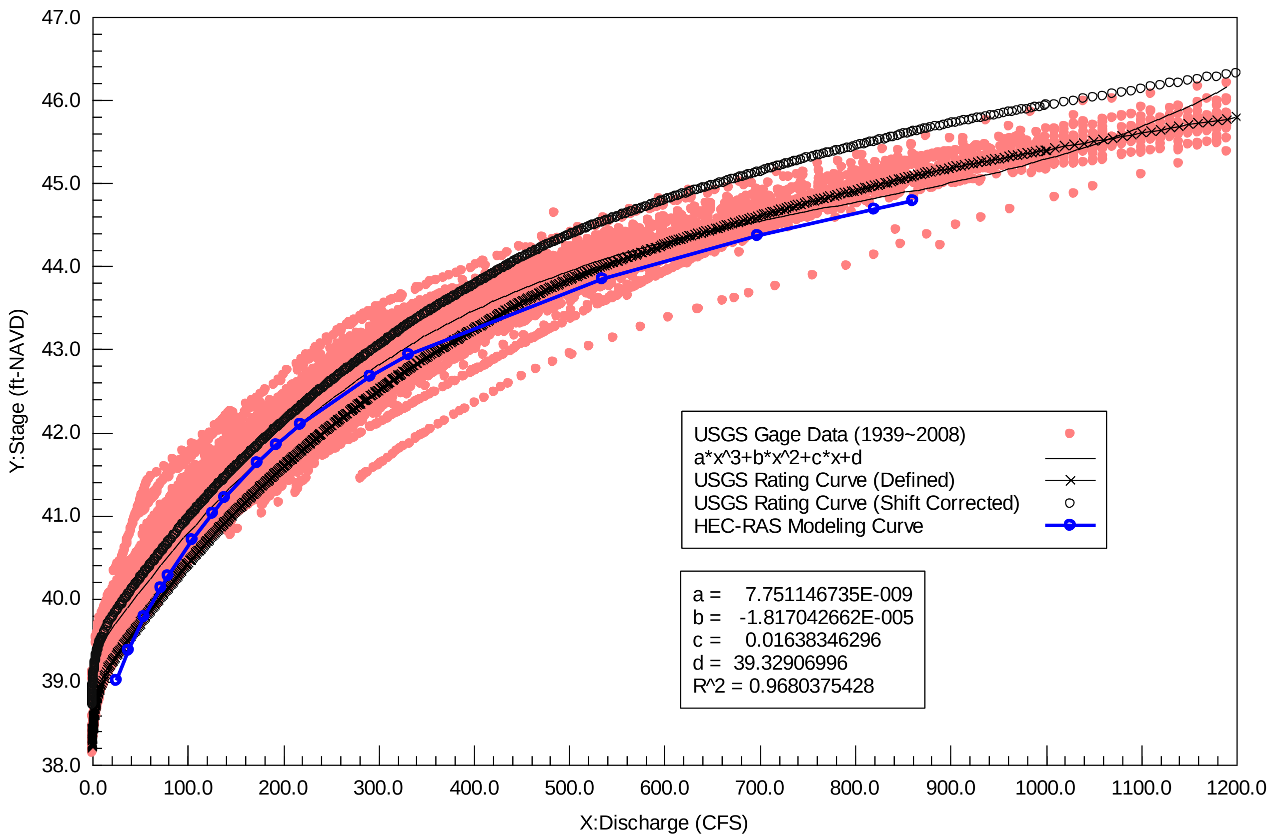


Figure 3.6 Flow-Stage Rating Curve @ Croom – USGS 02312500

Table 3.7 Model Calibration on USGS With @ Trilby – USGS 02312000 (STA: 58.56)

Profile	With @ Croom Flow (cfs)	With @ Trilby Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	15	11.29	48.78	48.67	**-0.11**
2	20	15.05	48.95	48.83	**-0.12**
3	35	26.34	49.36	49.27	**-0.09**
4	50	37.63	49.68	49.64	**-0.04**
5	70	52.68	49.95	50.07	**0.12**
6	80	60.20	50.07	50.25	**0.18**
7	105	79.01	50.39	50.68	**0.29**
8	125	94.06	50.64	51.00	**0.36**

9	140	105.35	50.84	51.21	**0.37**
10	175	131.69	51.21	51.62	**0.41**
11	190	142.98	51.37	51.78	**0.41**
12	220	165.55	51.68	52.07	**0.39**
13	300	225.76	52.46	52.77	**0.31**
14	400	301.01	53.34	53.56	**0.22**
15	600	451.51	54.91	54.94	**0.03**
16	700	526.76	55.59	55.55	**-0.04**
17	800	602.01	56.19	56.12	**-0.07**

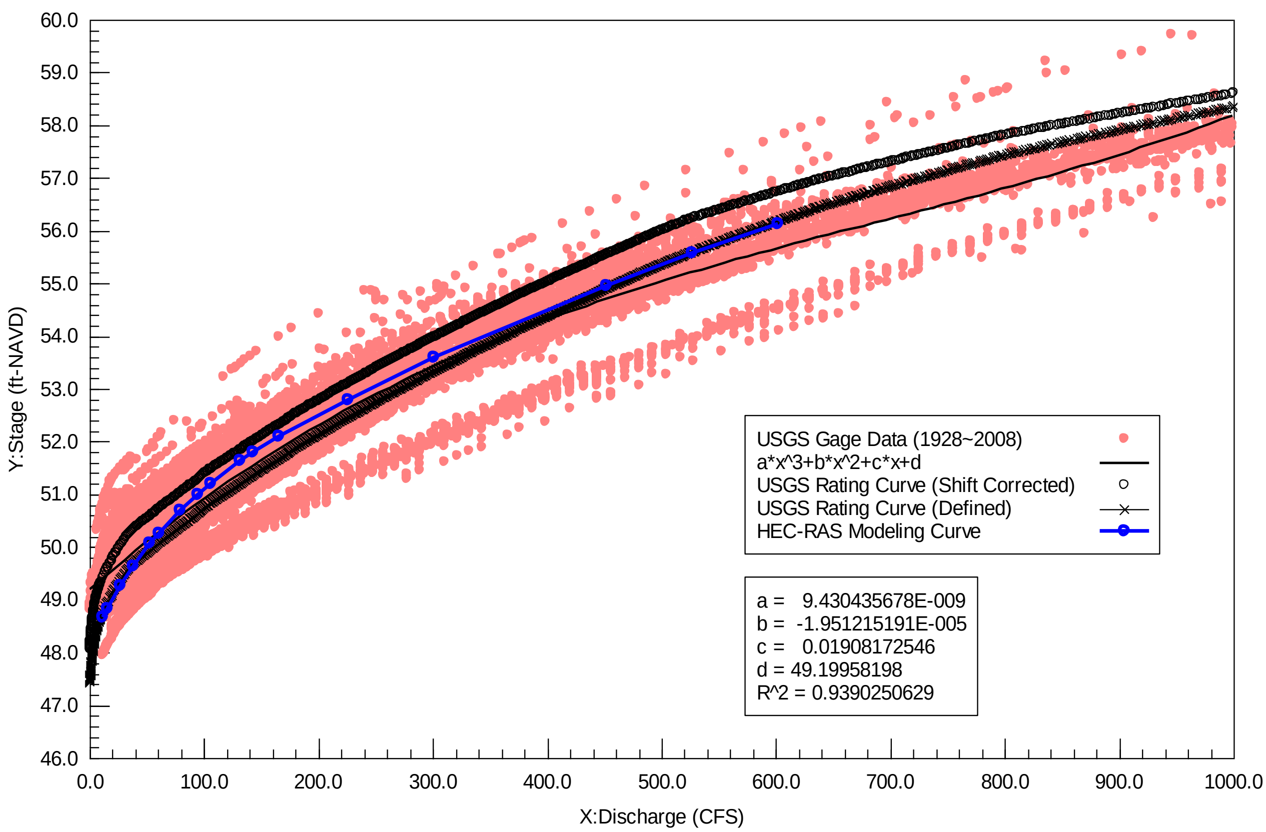


Figure 3.7 Flow-Stage Rating Curve @ Trilby – USGS 02312000

Table 3.8 Model Calibration on USGS With @ Dade City – USGS 02311500 (STA: 77.25)

Profile	With @ Croom Flow (cfs)	With @ Dade City Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	15	7.78	67.79	67.48	**-0.31**
2	20	10.37	68.05	67.64	**-0.41**
3	35	18.15	68.38	68.01	**-0.37**
4	50	25.93	68.66	68.30	**-0.36**
5	70	36.30	68.91	68.61	**-0.30**
6	80	41.49	69.03	68.73	**-0.30**
7	105	54.46	69.26	69.01	**-0.25**
8	125	64.83	69.43	69.19	**-0.24**
9	140	72.61	69.54	69.31	**-0.23**
10	175	90.76	69.78	69.56	**-0.22**
11	190	98.54	69.87	69.65	**-0.22**
12	220	114.10	70.03	69.83	**-0.20**
13	300	155.59	70.41	70.24	**-0.17**
14	400	207.46	70.78	70.66	**-0.12**
15	600	311.18	71.38	71.35	**-0.03**
16	700	363.05	71.62	71.64	**0.02**
17	800	414.91	71.84	71.91	**0.07**

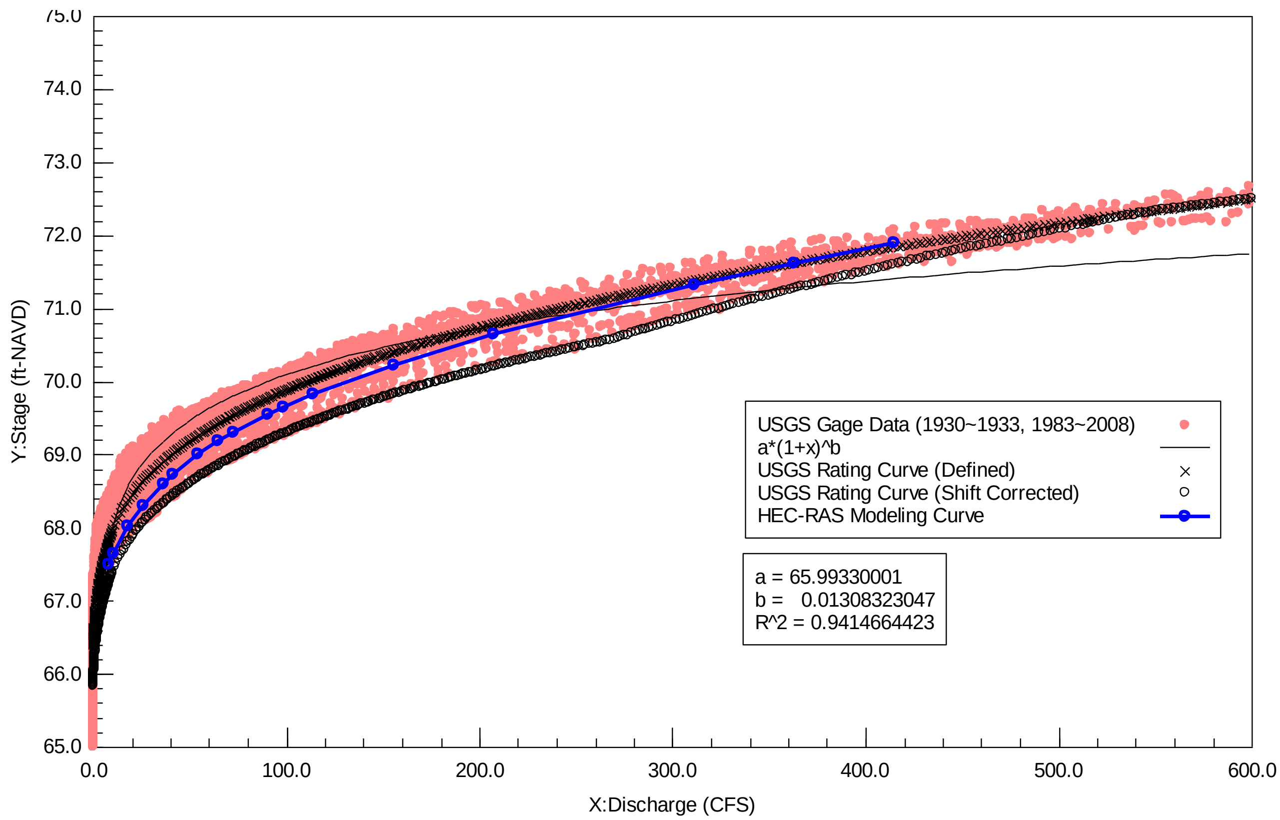


Figure 3.8 Flow-Stage Rating Curve @ Dade City – USGS 02311500

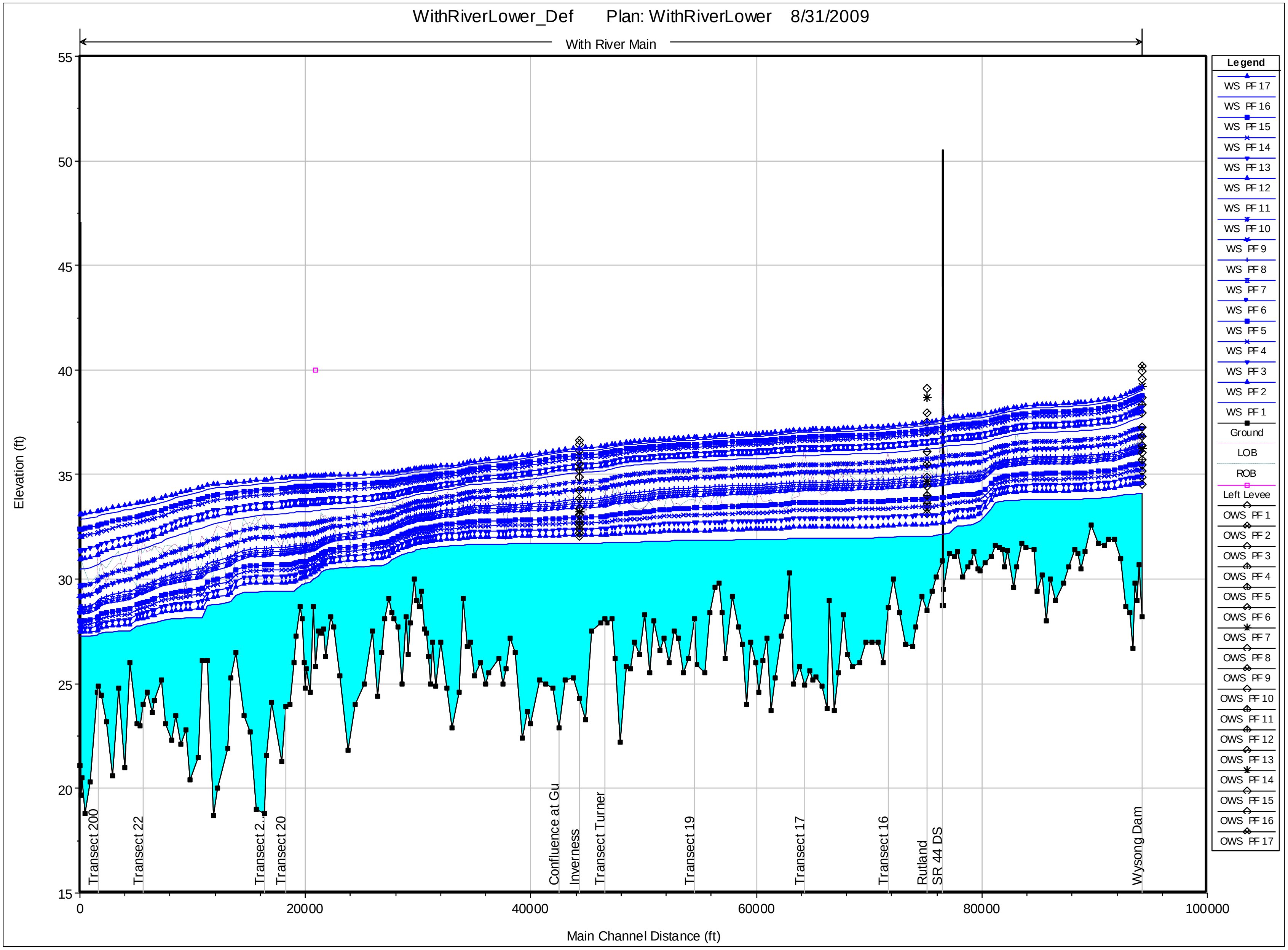

WithRiverLower_Def Plan: WithRiverLower 8/31/2009
With River Main
Elevation (ft)
Main Channel Distance (ft)
Legend
WS PF 17
WS PF 16
WS PF 15
WS PF 14
WS PF 13
WS PF 12
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
LOB
ROB
Left Levee
OWS PF 1
OWS PF 2
OWS PF 3
OWS PF 4
OWS PF 5
OWS PF 6
OWS PF 7
OWS PF 8
OWS PF 9
OWS PF 10
OWS PF 11
OWS PF 12
OWS PF 13
OWS PF 14
OWS PF 15
OWS PF 16
OWS PF 17
Transect 200
Transect 22
Transect 2...
Transect 20
Confluence at Gu
Inverness
Transect Turner
Transect 19
Transect 17
Transect 16
Rutland
SR 44 DS
Wysong Dam

Figure 3.9 Profile Plot of the Lower Segment of the Withlacoochee River (Holder – Wysong Dam)

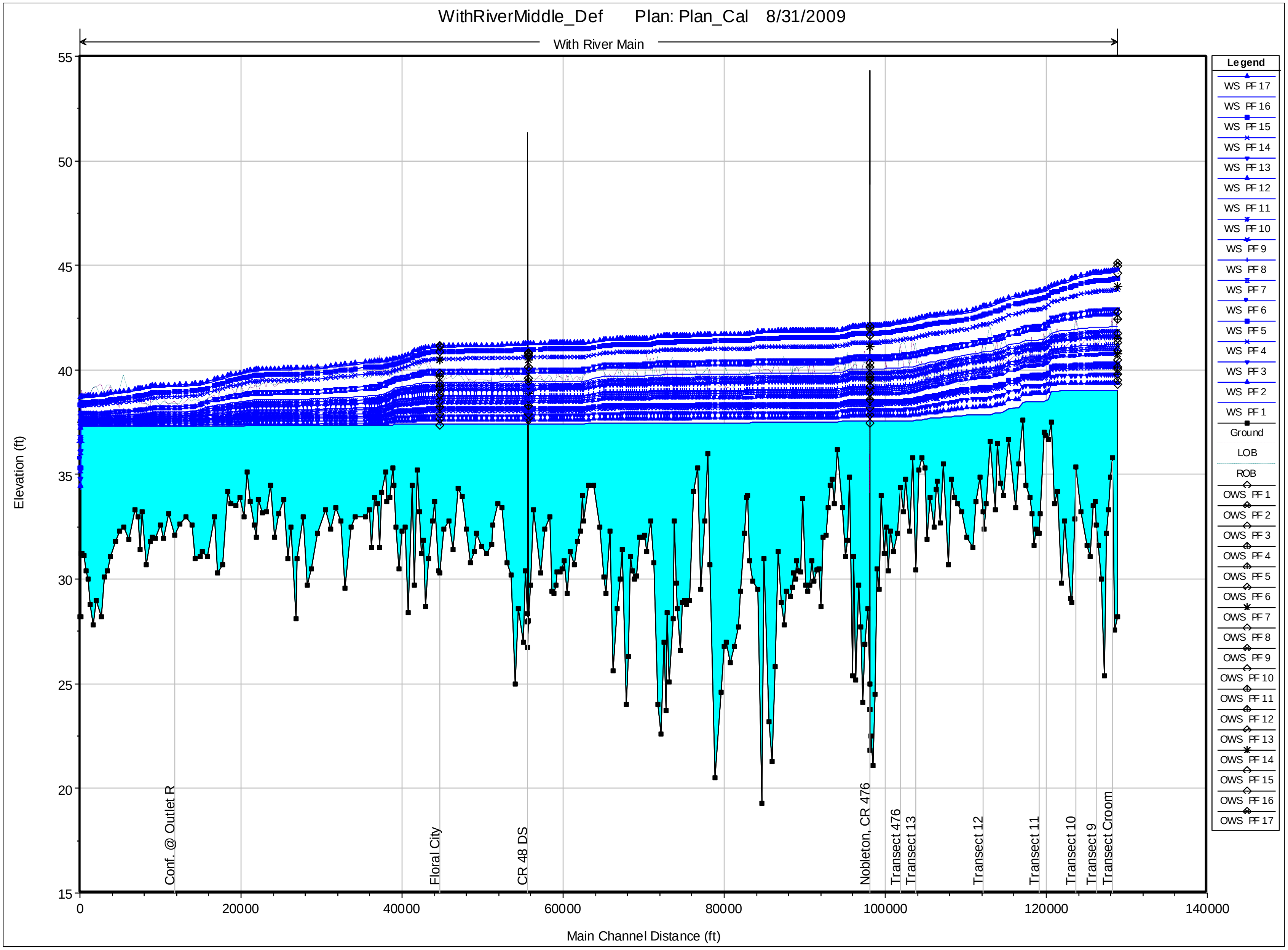
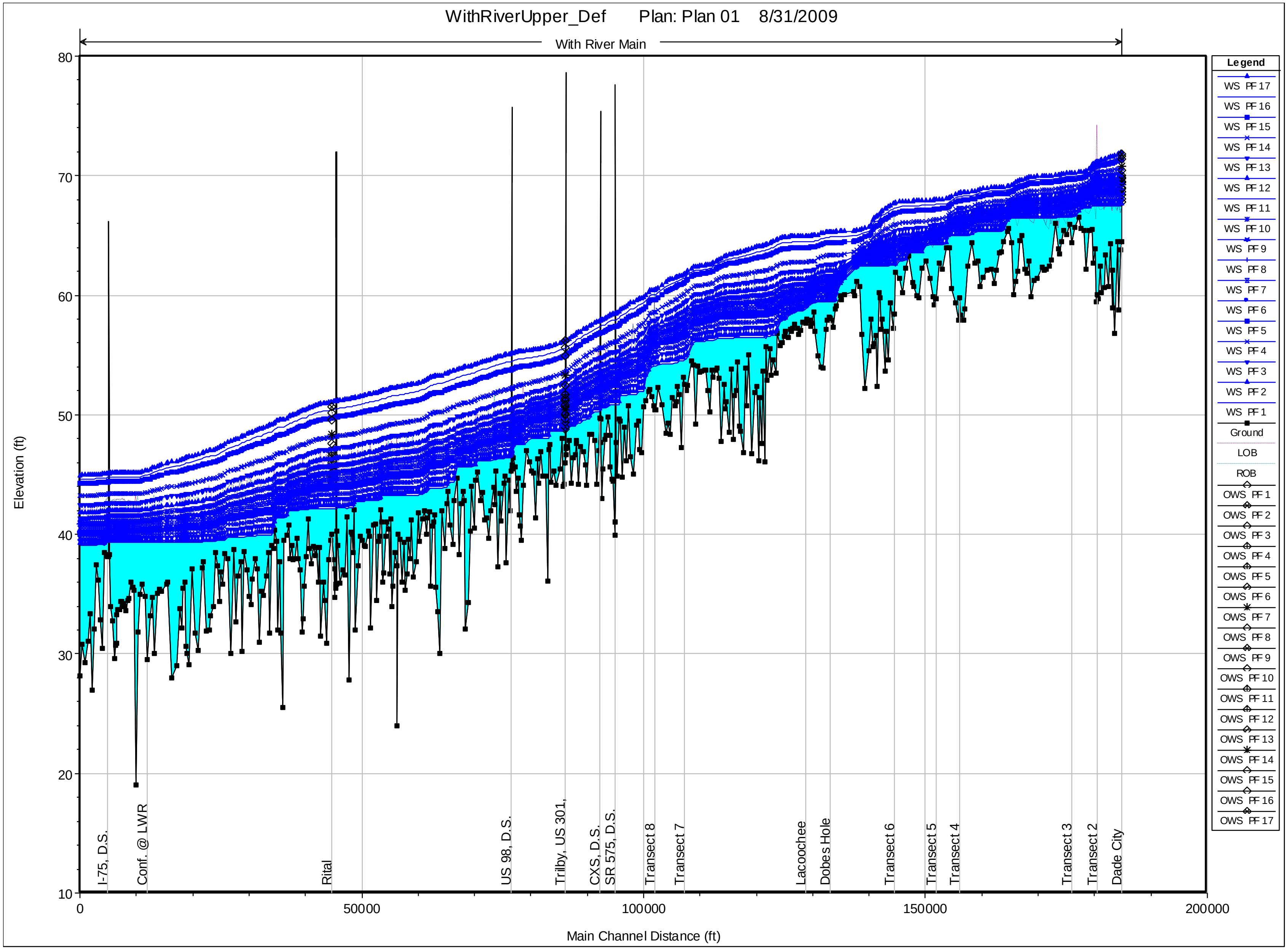

WithRiverMiddle_Def Plan: Plan_Cal 8/31/2009
With River Main
Legend
WS PF 17
WS PF 16
WS PF 15
WS PF 14
WS PF 13
WS PF 12
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
LOB
ROB
OWS PF 1
OWS PF 2
OWS PF 3
OWS PF 4
OWS PF 5
OWS PF 6
OWS PF 7
OWS PF 8
OWS PF 9
OWS PF 10
OWS PF 11
OWS PF 12
OWS PF 13
OWS PF 14
OWS PF 15
OWS PF 16
OWS PF 17
Elevation (ft)
Main Channel Distance (ft)
Conf. @ Outlet R
Floral City
CR 48 DS
Nobleton, CR 476
Transect 476
Transect 13
Transect 12
Transect 11
Transect 10
Transect 9
Transect Croom

Figure 3.10 Profile Plot of the Middle Segment of the Withlacoochee River (Wysong Dam – Croom)



WithRiverUpper_Def Plan: Plan 01 8/31/2009
With River Main
Elevation (ft)
Main Channel Distance (ft)
Legend
WS PF 17
WS PF 16
WS PF 15
WS PF 14
WS PF 13
WS PF 12
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
LOB
ROB
OWS PF 1
OWS PF 2
OWS PF 3
OWS PF 4
OWS PF 5
OWS PF 6
OWS PF 7
OWS PF 8
OWS PF 9
OWS PF 10
OWS PF 11
OWS PF 12
OWS PF 13
OWS PF 14
OWS PF 15
OWS PF 16
OWS PF 17
I-75, D.S.
Conf. @ LWR
Rital
US 98, D.S.
Trilby, US 301,
CXS, D.S.
SR 575, D.S.
Transect 8
Transect 7
Lacoochee
Dobes Hole
Transect 6
Transect 5
Transect 4
Transect 3
Transect 2
Dade City

Figure 3.11 Profile Plot of the Upper Segment of the Withlacoochee River (Croom – Dade City)

5.0 REFERENCES

Brunner, G. W., 2008. HEC-RAS, River Analysis System Hydraulic Reference Manual. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA.

Brunner, G. W., 2008. HEC-RAS, River Analysis System User's Manual. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA.

FDEP, 2005. Water Quality Status Report: Withlacoochee. Florida Department of Environmental Protection, Tallahassee, Florida.

FDEP, 2006. Water Quality Assessment Report: Withlacoochee. Florida Department of Environmental Protection, Tallahassee, Florida.

SWFWMD, 2001. Withlacoochee River Comprehensive Watershed Management Plan. Southwest Florida Water Management District, Brooksville, Florida.

SWFWMD, 2002. Upper Peace River, An Analysis of Minimum Flows and Levels, Draft. Southwest Florida Water Management District, Brooksville, Florida.

SWFWMD, 2004. Florida River Flow Patterns and the Atlantic Multidecadal Oscillation, Draft. Southwest Florida Water Management District, Brooksville, Florida.

SWFWMD, 2004. Rainbow River Surface Water Improvement and Management (SWIM) Plan. Southwest Florida Water Management District, Brooksville, Florida.

SWFWMD, 2005. Minimum and Guidance Levels for Tsala Apopka Lake in Citrus County, Florida, Draft. Southwest Florida Water Management District, Brooksville, Florida.

SWFWMD, 2005. Proposed Minimum Flows and Levels for the Middle Segment of the Peace River, from Zolfo Springs to Arcadia. Southwest Florida Water Management District, Brooksville, Florida.

SWFWMD, 2008. Structure Operations Section Hydrologic Report.

Tetra Tech, Inc, and Janicki, Environmental, Inc., 2004. Withlacoochee River Basin Feasibility Study: Hydrology and Hydraulics Data Collection and Review, Final Report, for U.S. Army Corps of Engineers, Jacksonville District.

USGS, 1978. The Hydrology of Lake Rousseau, West-Central Florida.

USGS, 1984. Simulation of Steady-State Ground Water and Spring Flow in the upper Floridan Aquifer of Coastal Citrus and Hernando Counties, Florida.

USGS, 2002. Water Resources Data - Florida, Water Year 2001, Volume 1A: Northeast Florida – Surface Water.

Warner, J. C., G. W. Brunner, B. C. Wolfe, and S. S. Piper, 2008. HEC-RAS, River Analysis System Application Guide. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA.

Appendix A Meeting Minutes

WITHLACOOCHEE RIVER MFL PROJECT – Kick Off Meeting

Location: SWFWMD, Brooksville, FL

Time: Tuesday August 20, 2008, 1:00 pm

Attendee: Dr. Marty Kelly, Dr. Adam Munson, Mr. Jason Hood – SWFWMD

Dr. Sri Rao, PE, Jiangtao Sun, PE - EAS

The major items discussed in the meeting are listed below:

- Overall Budget: $100,000.00
- Project Duration: about 6 months, final report due February 2009, the exact duration may vary depend on the Topo data availability.
- Major products:
    - HEC-RAS model input and output
    - Draft and final report to address what is the MFL for natural condition
    - No presentation or public meeting
    - Project meetings are expected
- Data sources:
    - District to give all data including survey needed, just ask the District
    - Other contacts for data: Mark Fulkerson, Gene Altman – SWFWMD Engineering Department
- River is 80 miles long, 40 mile land distance From Dade City to Holder, FL
- 4 SWFWMD MFL gages with short records and 3 USGS gages with long records are available.
- 25~30 bridges, one inflatable rubber dam (Wysong Dam) rebuilt in October 2002 after its removal in 1988, limited dam operating information; some reports may be available.
- LiDAR, cross-section survey, 30 vegetation transects, TIN data is available.
- Withlacoochee River is probably cleanest river in FL, undeveloped watershed.
- Several surface water withdrawals at Tsala Apopka Lake, competing lake and river flows, causing flow reversals from outlet channel of Panasoffkee Lake back to the inflow point at Tsala Apopka Lake. Try to set up the HEC-RAS model with and without surface water withdrawal.
- Small amount of ground water withdraw, about 6%; some springs keep feeding the river.
- Shoal, run and pool vegetation transects performed during ecological research, which may bring more useful data for model calibration. The vegetation transects should be modeled in HEC-RAS
- Similar MFL reports are available for Upper Peace River, Upper Hillsborough, and Rainbow River. District will collect all other reports for EAS later.
- HEC-RAS model is available in the Rainbow River MFL study

- Major challenge is the set-up of the inflow/outflow to various lakes along the river, for example, Tsala Apopka Lake and Panasoffkee Lake, and the rating curve for Wysong Dam
- The whole river may be divided by the USGS gage locations into several sections to build individual HEC-RAS models, if necessary.
- List of scope of work may be included:
  - Kick-off Meeting
  - Site visit
  - Data collection and Review
  - Rainbow River MFL HEC-RAS model and report review (Optional)
  - Project Meeting
  - Model set up and calibration
  - Project Meeting
  - Report

WITHLACOOCHEE RIVER MFL PROJECT – Project Meeting No.2

Location: SWFWMD, Brooksville, FL

Date: Wednesday, April 15, 2009, 1:30 pm ~ 4:00 pm

Attendees: Adam Munson, Marty Kelly, Jonathan Morales, Jason Hood - SWFWMD

Gene Altman, Doug Leeper, Mark Fulkerson - SWFWMD

Sri Rao, Jiangtao Sun, Terry Denk - EAS

EAS has completed the Data Collection, Model Development and Model Calibration tasks of the project. The following items were discussed in the meeting for Withlacoochee River (With River) HEC-RAS Modeling Project:

I. Project Background (Exhibits in 11x17 papers)

- Overall river length of the study area of the Withlacoochee River is 77.25 river miles from USGS With @ Dade City to USGS with @ Holder.
- The study area of the Withlacoochee River is divided into three segments for modeling purpose: Lower Segment, Middle Segment, and Upper Segment.

II. Data Collection (Technical Memorandum No. 1)

- Topographic Data – DEM (Mark Fulkerson) and hydrographic Survey (PBS&J)
- Structure/Bridge Data – Wysong Dam, Tsala Apopka Lake, and Bridges (SWFWMD, FDOT, CSX)
- USGS Gage Data – Historical Flow/Stage Data (daily average), USGS Rating Curves

III. Model Parameterization (Technical Memorandum No. 2)

- Geometry/X-section – 1,065 X-section using HEC-GeoRAS
  - DEM provided by Mark Fulkerson is from *LiDAR* data dated from 2004 to 2007, which does not cover the bathymetric data under water surface.
  - Hydrographic survey performed by PBS&J in 2008 was used to generate TIN, which was converted into DEM for topographic under the water surface. Part of the hydrographic survey is utilizing the ultrasonic equipment for deep water area, as stated by Mark Fulkerson.
  - A combined DEM from above data source was generated and used to create the x-sections, which was later exported into HEC-RAS.
  - Mark Fulkerson mentioned that the range line with the survey point data will improve the quality of TIN by avoiding any fake range line between the points. Jiangtao explained that all x-sections had been carefully reviewed, and such questionable range lines were noticed when we first digitized the X-section cut lines.
  - X-section data was reviewed and modified to match the lowest point/shore line of the river, which is very important for calibration of the model on low flow conditions.
  - Mark Fulkerson mentioned that the vertical datum of the USGS gages should be established throughout the District. This will be more accurate than the datum conversion thru the software given by NOAA or other agencies. Currently, EAS is using “VERTCON” provided by NOAA. But, the error will be less than 0.1 ft, which may not be a concern.

- Flow Profiles
  - For each segment (Lower, Middle, and Upper), the flow profiles are generated on the basis of the flow at the downstream boundary.
  - Major tributaries with USGS gage stations were also considered, and the flow rates from those tributaries were added to the x-section where they join the River, to indicate the flow change.
  - Static Linear Regression Analysis is the general procedure for proportional analysis. For some locations, a break point was added in the regression curve so that a separate ratio is used to present the relationship on low and high flow conditions, for example, the analysis of Flow @ Gum Spring vs. Flow @ Holder.

- Boundary Conditions
  - USGS published two kinds of rating curves: Defined and Shift Corrected. The Shift Corrected Rating Curve represents the temporary changes on the river bottom, vegetation, and maintenance operation.

- We all agreed that the Defined Rating Curve that represents the long-term relationship is suitable for this MFL study.
- For Lower and Upper Segments, the Defined Rating Curves are used for USGS @ Holder and USGS @ Croom; while for Middle segment, the defined rating curve does not agree with the historical gage data for the high flow part, therefore the simulated model results from Lower Segment is used as the boundary conditions.

- Structures and Operation – Wysong Dam
  - Wysong Dam, the downstream boundary of Middle Segment, causes significant problems for this MFL project due to its strong backwater impact to the upstream river section, up to USGS @ Nobleton.
  - This MFL project is to set up a guide for further operation of the Wysong Dam or other structures; however, for model calibration purpose, EAS has to configure the gate opening schedule so that the model could represent the historical/natural conditions in this river segment. In the mean time, the defined rating curve of the upstream gage USGS @ Floral City was used as a guide to quantify the gate opening at the Wysong Dam.
  - The structure has two gates (Low and Main) that are operated separately for better control of the upstream water level.
  - Integrated models like MIKESHE/MIKE 11 were also discussed as an option for the long-term simulation of the Withlacoochee River Watershed; but this is outside of the scope of this project.

- Structures and Operation – Tsala Apopka Lake
  - Tsala Apopka Lake has two intake canals: Orange State Canal and Leslie Heifner Canal.
  - USGS has three year stage record at the Leslie Heifner structure (below and near the structure) and stage record at the Orange State Canal near Floral City, back to 1983~1987.
  - Marty Kelly says SWFWMD may ask USGS to install a gage station at the locations where the flow rates are important for the MFL projects.
  - Based on the available data EAS can get, the flow diversion to Tsala Apopka Lake could not be estimated, therefore was not modeled.
  - Regarding the operation of the gate on these intake canals, Mr. Gene Altman suggested if other software, such as ICPR, will be better to simulate the gate open/close which depends on the lake levels. Jiangtao explained that our model is a steady state flow model, in which the gate will be constantly opened or closed, and what Gene mentioned is outside of our scope of work.
  - Per Mark Fulkerson, SWFWMD has measured stage data at upstream/downstream of the Leslie Heifner Structure back to 1990's, but no data for the Orange State Canal (Floral City Structure). (The contact information of the District staff was provided to EAS regarding this data collection.)
  - EAS will review and evaluate the stage data for Leslie Heifner Canal. The weir or manning's equation will used to calculate the flow rate, which will be incorporated into the HEC-RAS Model.

- Preliminary Model Results
  - 17 steady state flow conditions were simulate for each segments.

- The profile plots for all segments were provided, showing the river bottom, simulated water surfaces and the calibration targets (USGS Defined Rating Curve) at various locations.
- Four (4) long-term USGS gage stations, USGS @ Wysong Dam, Croom, Trilby, and Dade City, were selected and presented for a brief model calibration during the model development.

IV. Model Calibration (Technical Memorandum No. 3)

- The model calibration results were presented in both table and figure formats.
- Lower segment
  - Two (2) USGS gages are available for model calibration of Lower Segment: USGS @ Inverness, and USGS @ Wysong Dam.
  - For USGS @ Inverness, the statistical regression curve generated by EAS was used as the calibration targets, due to the poor quality of the USGS published rating curves. The simulated results fit well to the regression curve.
  - For USGS @ Wysong Dam, the rating curve is good on low flow conditions and bad on high flow conditions when compared with the historical data. The model results fit well to the defined rating curve on low flow conditions and historical data; while on high flow conditions, the model results are better in fitting the median of the historical records.
- Middle segment
  - Four (4) USGS gages are available for model calibration of Middle Segment: USGS @ Floral City, USGS @ Pineola, USGS @ Nobleton, and USGS @ Croom.
  - The gate openings of the Wysong Dam were adjusted, so that the model results match the defined rating curve @ Floral City. It is observed that the defined rating curve @ Floral City represents the long-term historical record.
  - The calibration results for this segment are fair, within ± 0.5 ft limit.
  - The vertical datum of USGS @ Nobleton is assumed to be at 0 ft of NAVD 88.
- Upper segment
  - Two (2) USGS gages are available for model calibration of Upper Segment: USGS @ Trilby and USGS @ Dade City.
  - The calibration results for this segment are fair, within ± 0.5 ft limit.

V. Conclusions

- Marty Kelly's comments on the modeling was noted below:
  - The draft report will be prepared from Technical Memorandum No.1 thru No. 3.
  - The model was well calibrated in all calibration target locations.
  - Wysong Dam is still a big concern in the MFL project, which may disqualify the Middle Segment of the Withlacoochee River (from USGS @ Wysong Dam to USGS @ Croom) to set up the MFL's.
  - Given the good calibration results at USGS @ Floral City and USGS @ Pineola, the flow diversion may not have significant impact to the MFL project.
  - The Lower and Upper segments are in good conditions since no structure or operation exists to alter the river natural flow characteristics.

- *Adam will provide the vegetation transect data (either in CAD or GIS format) to EAS. This may give additional 30 or more physical surveyed x-sections to the HEC-RAS Modeling.*
- Flow diversion to the Tsala Apopka Lake is another concern and additional work is to be performed by EAS. *EAS will collect additional data from the Operation Department for the historic operation of the gates/structures on the Orange State Canal and Leslie Heifner Canal.*

Appendix B Inventory of Data Collection

The data collected during the project period are summarized below:

Report:

For Withlacoochee River:

- Minimum and Guidance Levels for Tsala Apopka Lake in Citrus County, Florida, Nov 2005 Draft, SWFWMD
- Proposed Minimum Flows and Levels for the Middle Segment of the Peace River, from Zolfo Springs to Arcadia, Oct 2005, SWFWMD
- Upper Peace River, An Analysis of Minimum Flows and Levels, Aug 2002, SWFWMD
- Florida River Flow Patterns and the Atlantic Multidecadal Oscillation, Aug 2004 Draft, SWFWMD
- Withlacoochee River Comprehensive Watershed Management Plan, 2001, SWFWMD
- Withlacoochee River Basin Feasibility Study: Hydrology and Hydraulics Data Collection and Review, Final Report, 2004, USACE
- Water Quality Status Report: Withlacoochee, 2005, FDEP
- Water Quality Assessment Report: Withlacoochee, 2006, FDEP
- Structure Operations Section Hydrologic Report, Sep 2008, SWFWMD
- TooFar, Inc. and Wysong Dam (http://www.toofarinc.com/wysong.htm)
- Water Resources Data, Florida, Water Year 2001, Volume 1A – Water Data Report FL-01-1A (provide a list of the discontinued USGS flow/stage stations, including several stage-only stations located at the intake canals of Tsala Apopka Lake: USGS 02312772, USGS 02312773, and USGS 02312786)

For Rainbow River:

- Rainbow River Surface Water Improvement and Management (SWIM) Plan, Apr 2004, SWFWMD
- The Hydrology of Lake Rousseau, West-Central Florida, 1978, USGS
- Simulation of Steady-State Ground Water and Spring Flow in the upper Floridan Aquifer of Coastal Citrus and Hernando Counties, Florida, 1984, USGS

Document:

For Withlacoochee River:

- An E-mail To: Sri Rao, From: Adam Munson, dated Dec 3, 2008 to document the reverse flow of water between the Outlet River of Lake Panasoffkee and upstream of Bonnet Lake. Flow measurements were taken at various locations, and USGS gage data for the same date was also retrieved from the USGS website.

Map:

GIS Shape File and Images:

- USGS Topographic Map
- USGS 2004 Aerial Photo
- USGS Digital Line Graph Data, 1:24,000
- SWFWMD 2006 Aerial Photo
- SWFWMD 2006 Land Use Map
- SWFWMD Soils Map (1989 ~ 1992)
- SWFWMD Hydrography Map
- SWFWMD ERP Map
- SWFWMD Road Map
- SWFWMD Drainage Basins Map
- SWFWMD Watershed Boundaries Map
- SWFWMD Well Site Map
- SWFWMD Well Field Map
- SWFWMD Stream Flow Station Map
- SWFWMD Rainfall Station Map
- SWFWMD Evaporation Station Map
- SWFWMD 2004 LiDAR Topo Data (Mr. Mark Fulkerson)
- Proposed Withlacoochee River Vegetation Transects Map, dated Jan 26, 2008 (Mr. Adam Munson)

Data:

Bathymetric Survey Data:

- Hydrographic Survey from SWFWMD in ESRI Shape format (point), dated 12/17/2008 (Mr. Mark Fulkerson)

Vegetation Transect Data:

- 26 Vegetation Transects from SWFWMD in spreadsheet, dated 08/24/2009 (Mr. Jason Hood)

Bridge Data:

- From FDOT (Received Jan 8, 2009 thru mail)

- SR 575 in Pasco County (FDOT Structure ID# 1400310
  - US 301 in Pasco County, near USGS 02312000 With @ Trilby (FDOT Structure ID# 080030)
  - US 98 in Pasco County (FDOT Structure ID# 140066)
  - SR 50 in Hernando County, near USGS 02312300 With @ Rital (FDOT Structure ID# 080064)
  - I-75 in Hernando/Sumter Counties, downstream of Silver Lake (FDOT Structure ID# 080025)
- From CSX (Received on Feb 5, 2009 thru e-mail)
  - CSX Rail Road in Pasco County, upstream of US 301 Bridge (Mile Post S789.4) (the elevation data is derived from the hydrographic survey provided by SWFWMD)
- From SWFWMD (surveyed by Morgan & Eklund, Inc. for PBS&J, 2008)
  - CR 476 in Hernando/Sumter Counties, near USGS 02312558 With @ Nobleton
  - CR 48 in Citrus/Sumter Counties, near USGS 02312598 With @ Pineola
  - SR 44 in Citrus/Sumter Counties, near USGS 02312722 With @ Rutland
  - SR 200 in Citrus/Sumter Counties, near USGS 02313000 With @ Holder
- The following potential bridge location were verified:
  - Ranch Road in Pasco County, upstream of USGS 02311500 With @ Dade City, is outside of the study area
  - Main Line Road in Pasco County verified as a power line maintenance road low water crossing
  - Abandoned CSX Rail Road in Pasco County, upstream of SR 575

Structure Data:

- Wysong-Coogler Water Conservation Structure
  - ERP Permit Application Documentation and response to RFI's (ERP# 09-0177432-001)
    - Construction plan in AutoCAD format
    - Conceptual Design Report, dated Oct 2000
    - Operation protocol on low and high flow regimes
- Structures for Tsala Apopka Lake and Wysong-Coogler Adjustable Water Conservation Structure (Received by March 9, 2009, from SWFWMD Operation Department, Mr. Danny Brooks)

  - SWFWMD Structure Profile, Volume 2
  - Water Level Data
    - Tsala Apopka at Floral City
    - Tsala Apopka at Inverness
    - Tsala Apopka at Hernando
    - Two mile Prairie Barn
    - Withlacoochee River near Holder
    - Withlacoochee River at Hwy 48
    - 23501 Leslie Heifner downstream (Margit Crowell, April 16, 2009)
    - 23502 Leslie Heifner upstream (Margit Crowell, April 16, 2009)
  - As-builts Plans for Structures at Tsala Apopka Lake
    - Brogden Bridge Structure
    - Bryant Slough Structure
    - Golf Course Structure
    - Leslie Heifner Structure
    - Mocassin Slough Structure

- Orange State Structure
- S-353 Structure
- Van Nes Structure

- As-builts Plans for Wysong Coogler Conservation Structure (both 1964 original & 2001 re-built projects)

*Stream Gauging Data for **Withlacoochee River**:*

- USGS Stream Gauging Data (Flow and Stage):
  - USGS 02311500 With @ Dade City
  - USGS 02311700 With @ Dade City Canal Near Dade City
  - USGS 02312000 With @ Trilby
  - USGS 02312200 Little With @ Rerdell
  - USGS 02312300 With @ Rital
  - USGS 02312500 With @ Croom
  - USGS 02312558 With @ Nobleton
  - USGS 02312598 With @ Pineola
  - USGS 02312600 With @ Floral City
  - USGS 02312645 Jumper Creek @ Wahoo
  - USGS 02312700 Outlet River @ Panacoochee Retreats
  - USGS 02312719 With AB Wysong Dam (Stage only)
  - USGS 02312720 With @ Wysong Dam
  - USGS 02312722 With @ Rutland
  - USGS 02312762 With @ Inverness
  - USGS 02312764 Gum Springs @ Holder
  - USGS 02312975 Tsala Apopka Outfall Canal @ S-353
  - USGS 02312976 Tsala Apopka Outfall Canal BL S-353 (Stage only)
  - USGS 02313000 With @ Holder

- USGS Stage-Discharge Rating Curve:
  - USGS 02311500 With @ Dade City, 12/17/2008
  - USGS 02312000 With @ Trilby, 12/17/2008
  - USGS 02312200 Little With @ Rerdell, 11/17/2008
  - USGS 02312300 With @ Rital, 12/18/2008
  - USGS 02312500 With @ Croom, 12/17/2008
  - USGS 02312558 With @ Nobleton, 11/17/2008
  - USGS 02312598 With @ Pineola, 12/17/2008
  - USGS 02312600 With @ Floral City, 12/17/2008
  - USGS 02312645 Jumper Creek @ Wahoo, 6/28/2008
  - USGS 02312700 Outlet River @ Panacoochee Retreats, 9/25/2008
  - USGS 02312720 With @ Wysong Dam, 11/20/2008
  - USGS 02312722 With @ Rutland, 11/20/2008
  - USGS 02312762 With @ Inverness, 11/19/2008
  - USGS 02313000 With @ Holder, 11/20/2008

*Stream & Well Gauging for **Rainbow River**:*

- USGS Stream Gauging Data (Flow and Stage):
    - USGS 02313100 Rainbow Springs @ Dunnellon
    - USGS 02313200 With @ Dunnellon
- USGS Well Gauging Data (Stage):
    - USGS 290514082270701 Rainbow Springs Well @ Dunnellon

*Model input/output data for **Rainbow River**:*

- HEC-RAS model, working spreadsheet and report (by SWFWMD on Sep, 2008)

Appendix C Response to District's Review Comments on Draft Report

The District staff, Dr. Ahmed Said, P.E. has reviewed the draft report of the HEC-RAS Modeling of the Withlacoochee River, and review comments are attached here:

"I completed the review of the Withlacoochee River MFL project. I read the report and I run the HEC-RAS model with the input files and I checked the profiles and the outputs. I didn't see any major errors. However, there are few things that make the report more comprehensive and inclusive. These can be summarized in the following points:

1. The values of the Manning's "n" values used and explanation for why they were chosen must be provided. Also since the calibration of the model used Manual (trial & error) adjustment of Manning's n coefficients, the values before and after needs to be documented and if there is a big differences, the changes needs to be explained and interpreted.

2. The determination of bank stations is widely different from cross section to cross section. In some cross sections, the bank stations are chosen to be very wide and others are chosen very tight even though, the cross section can be much wider.

3. The expansion, contraction coefficients was used as 0.1, 0.3 in all the cross sections. This needs to be explained.

4. Nonlinear relations could be used instead of looking at the break points. I tried to use nonlinear relationship (e.g., power of exponential) and it improved R square but not too much. Therefore, the rating curves can be considered acceptable.

5. The relationship between flow of With @ Inverness and flow of With @ Holder: the first equation can work for any flow and no need for the break point in this case while it may be important in the case of the relation between the flow of Gum Spring and the flow @ Holder. For example, if flow of With @ Holder = 1250, from the first equation, With flow @ Inverness = 1037, and from second equation, flow of With @ Inverness = 0.837 (1250) - 9 = 1037. Note that an average flow of Gum Spring @ Holder = 172. However, if the flow @ Holder is greater than 1250, say 2000 cfs, then from the second equation the flow @ Inverness will be 1665 cfs, adding 172 cfs from Gum Springs, then the flow @ Holder could be 1837 cfs which shows some discrepancy. In this case if the first equation is used, then if gives 1873 cfs (1071 + 172), which is better than the second equation (closer to 2000 cfs).

In conclusion, the report is well written and informative. While the calcification of the mentioned points will not change the report it will answer some question that a technical reader may have.

Thank you for giving me this opportunity. I am ready to answer any questions you may have and also I can write more details or provide examples and suggestions if needed."

Ahmed Said, Ph.D, P.E.

EAS has received the review comments provided by the District on the draft report of Withlacoochee River HEC-RAS Modeling. The response to the review comments follows:

1. The values of the Manning's "n" values used and explanation for why they were chosen must be provided. Also since the calibration of the model used Manual (trial & error) adjustment of Manning's n coefficients, the values before and after needs to be documented and if there is a big differences, the changes needs to be explained and interpreted.

Response: the parameterization of the Manning's n in this project follows the guidance of HEC-RAS Hydraulic Reference Manual, Table 3-1, as shown below. By evaluating 2006 aerial map, land use map, and the available field observation data, the natural conditions of the main channel and floodplain were determined for each cross section. The initial values of Manning's n were assigned within the suggested range in Table 3-1. In model calibration process, the Manning's n was further adjusted to fit in the calibration targets or rating curves, but no significant difference was noticed in most of the cross sections.

A separate paragraph may be added into the final report to explain the parameterization of the initial values of the Manning's n. No additional tabulation data in the report is necessary to document the change between the initial and final values of the Manning's n.

2. The determination of bank stations is widely different from cross section to cross section. In some cross sections, the bank stations are chosen to be very wide and others are chosen very tight even though, the cross section can be much wider.

Response: The left/right canal bank polylines were digitized in ArcGIS, and checked by overlaying with 2006 Aerial Map, DEM data generated by LiDAR survey, Land Use Map, and USGS Topographic Map. Using HEC-GeoRAS 4.1.1, the bank polylines were intersected with cross section cutlines to generate the band stations. The determination of the bank stations is very important since the Manning's n values are usually associated with the bank stations.

In HEC-RAS, the bank stations were adjusted and corrected manually during the model development and calibration. It is natural that some cross sections have wider main channel, while for other cross sections, the bank stations were chosen very tight.

Additional details, for example, the "River Station" will be necessary for EAS to accurately locate the questionable cross sections, if any. EAS will implement these comments.

3. The expansion, contraction coefficients was used as 0.1, 0.3 in all the cross sections. This needs to be explained.

Response: Per HEC-RAS Hydraulic Reference Manual (dated Mar 2008), Chapter 2, the expansion and contraction coefficients were defined in Table 3-3, as shown below. "*Where the change in river cross* *section is small, and the flow is subcritical, coefficients of contraction and expansion are typically on the order of 0.1 and 0.3, respectively; and when the change in effective cross section area is abrupt such as bridges, contraction and expansion coefficients of 0.3 and 0.5 are often used."* In the Withlacoochee River HEC-RAS modeling, the subcritical flow regime is used for steady state flow simulation. For most of the river segments, the change in effective cross section area is not abrupt; therefore the expansion and contraction coefficients of 0.1 and 0.3 are appropriate values for this project, except for cross sections at bridges, where 0.3 and 0.5 were used per HEC-RAS Hydraulic Reference Manual.

4. Nonlinear relations could be used instead of looking at the break points. I tried to use nonlinear relationship (e.g., power of exponential) and it improved R square but not too much. Therefore, the rating curves can be considered acceptable.

Response: Acknowledged.

5. The relationship between flow of With @ Inverness and flow of With @ Holder: the first equation can work for any flow and no need for the break point in this case while it may be important in the case of the relation between the flow of Gum Spring and the flow @ Holder. For example, if flow of With @ Holder = 1250, from the first equation, With flow @ Inverness = 1037, and from second equation, flow of With @ Inverness = 0.837 (1250) - 9 = 1037. Note that an average flow of Gum Spring @ Holder = 172. However, if the flow @ Holder is greater than 1250, say 2000 cfs, then from the second equation the flow @ Inverness will be 1665 cfs, adding 172 cfs from Gum Springs, then the flow @ Holder could be 1837 cfs which shows some discrepancy. In this case if the first equation is used, then if gives 1873 cfs (1071 + 172), which is better than the second equation (closer to 2000 cfs).

Response: As mentioned in the draft report, the Gum Spring is defined as a spring-feed creek, by evaluating the historical flow data, a linear regression analysis with one break point was used to describe the relationship between flow of With @ Gum Spring and flow of With @ Holder as shown in Figure 2.4 of the report, and the reviewer also supports this methodology.

The Gum Spring joins the main channel of the Withlacoochee River just downstream of USGS With @ Inverness, as shown in Figure 2.1 of the report, and contributes about 10% flow to the main channel. It is assumed that the flow from the Gum Spring also impacts the relationship between flow of With @ Inverness and flow of With @ Holder. To verify this assumption, EAS performed two different regression approaches to establish the relationship between flow of With @ Inverness and flow of With @ Holder: 1) linear regression with break point at 1,250 cfs (flow of With @ Holder), see Figure C.1, and the R^2 value is 0.992732912; and 2) linear regression without break point, see Figure C.2, and the R^2 value is 0.992486361. The linear regression with break point resulted in improved R^2 value, and therefore it was selected for the HEC-RAS modeling.

In the reviewer's comment above, additional effort was taken to minimize the discrepancy between flow @ Holder and the summation of flow @ Gum Spring and flow @ Inverness, by only utilizing the "first equation" or "Y = a*x + b" for all flow conditions (below or above 1,250 cfs). However, we would not use reviewer's alternative in this project for the following reasons:

1) The discrepancy is reasonable and acceptable given the distance between With @ Holder and With @ Inverness (about 8.4 miles), where additional surface rainfall runoff and several small tributaries join the Withlacoochee River. Smaller flow discrepancy is not necessarily better than the larger one, unless more evidence or data is provided to support the reviewer's assumption;

2) The "first equation" and "second equation" in the linear regression should be only applied to their designated conditions (below 1,250 cfs or above 1,250 cfs); therefore using the "first equation" in the high flow condition is not allowed. Of course, we can use the linear regression without breakpoint, as shown in Figure C.2; however, we already discarded this option due to its smaller R^2 value as mentioned above. The discrepancy analysis is summarized in Table C.1 and Table C.2, for linear regression with break point and linear regression without break point, respectively. It is noted that smaller discrepancies are observed in high flow conditions for the linear regression with break point.

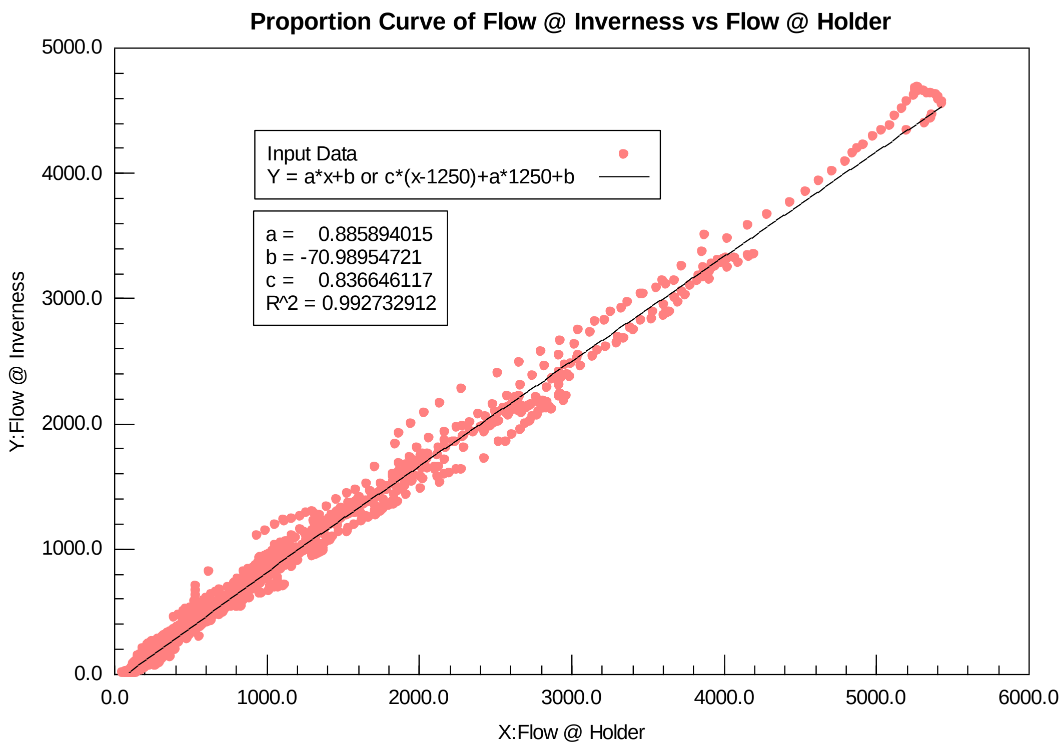


Figure C.1. Proportion Curve Analysis of Flow @ Inverness vs. Flow @ Holder (with break point)

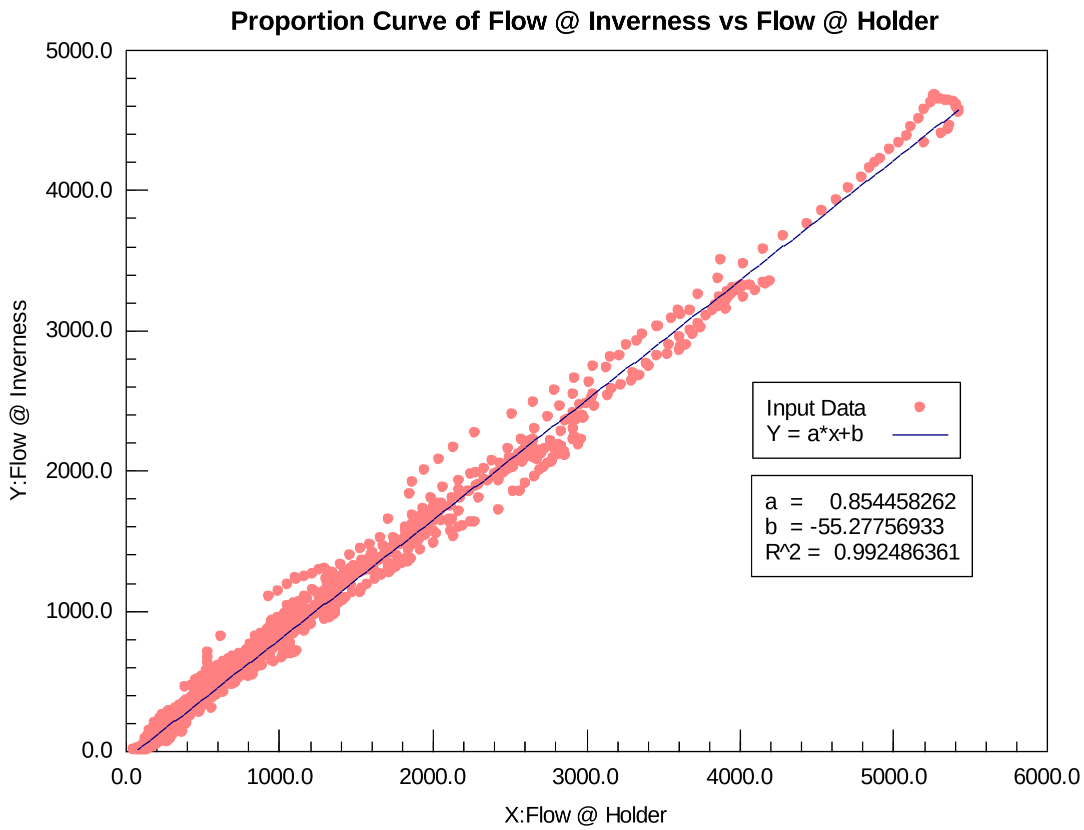


Figure C.2. Proportion Curve Analysis of Flow @ Inverness vs. Flow @ Holder (without break point)

Table C.1. Discrepancy Analysis for Linear Regression with Break Point

With @ Holder (cfs)	With @ Inverness (cfs)	Gum Spring (cfs)	Total (cfs)	Diff (cfs)
115	30.88826	61.53312	92.42139	22.58
150	61.89455	64.96063	126.8552	23.14
200	106.1893	69.85706	176.0463	23.95
300	194.7787	79.64993	274.4286	25.57
500	371.9575	99.23566	471.1931	28.81
700	549.1363	118.8214	667.9577	32.04
900	726.3151	138.4071	864.7222	35.28
1050	859.1992	153.0964	1012.296	37.70
1250	1036.378	172.6822	1209.06	40.94
1500	1245.54	172.6822	1418.222	81.78
1700	1412.869	172.6822	1585.551	114.45
1900	1580.198	172.6822	1752.88	147.12
2000	1663.863	172.6822	1836.545	163.46
2100	1747.527	172.6822	1920.209	179.79
2250	1873.024	172.6822	2045.706	204.29
2500	2082.186	172.6822	2254.868	245.13

Table C.2. Discrepancy Analysis for Linear Regression without Break Point

With @ Holder	With @ Inverness	Gum Spring	Total	Diff

(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
115	42.98513	61.53312	104.5183	10.48
150	72.89117	64.96063	137.8518	12.15
200	115.6141	69.85706	185.4711	14.53
300	201.0599	79.64993	280.7098	19.29
500	371.9516	99.23566	471.1872	28.81
700	542.8432	118.8214	661.6646	38.34
900	713.7349	138.4071	852.142	47.86
1050	841.9036	153.0964	995	55.00
1250	1012.795	172.6822	1185.477	64.52
1500	1226.41	172.6822	1399.092	100.91
1700	1397.301	172.6822	1569.984	130.02
1900	1568.193	172.6822	1740.875	159.12
2000	1653.639	172.6822	1826.321	173.68
2100	1739.085	172.6822	1911.767	188.23
2250	1867.254	172.6822	2039.936	210.06
2500	2080.868	172.6822	2253.55	246.45

Table 3-1 Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
3. **Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged**			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070

Table 3-1 (Continued) Manning's 'n' Values

Table 3-1 (Continued) Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
C. *Excavated or Dredged Channels*			
1. **Earth, straight and uniform**			
a. Clean, recently completed	0.016	0.018	0.020
b. Clean, after weathering	0.018	0.022	0.025
c. Gravel, uniform section, clean	0.022	0.025	0.030
d. With short grass, few weeds	0.022	0.027	0.033
2. **Earth, winding and sluggish**			
a. No vegetation	0.023	0.025	0.030
b. Grass, some weeds	0.025	0.030	0.033
c. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
d. Earth bottom and rubble side	0.028	0.030	0.035
e. Stony bottom and weedy banks	0.025	0.035	0.040
f. Cobble bottom and clean sides	0.030	0.040	0.050
3. **Dragline-excavated or dredged**			
a. No vegetation	0.025	0.028	0.033
b. Light brush on banks	0.035	0.050	0.060
4. **Rock cuts**			
a. Smooth and uniform	0.025	0.035	0.040
b. Jagged and irregular	0.035	0.040	0.050
5. **Channels not maintained, weeds and brush**			
a. Clean bottom, brush on sides	0.040	0.050	0.080
b. Same as above, highest stage of flow	0.045	0.070	0.110
c. Dense weeds, high as flow depth	0.050	0.080	0.120
d. Dense brush, high stage	0.080	0.100	0.140
6. **Asp**			
a.		0.013	
b.		0.016	
7. **Veg**			0.500

Table 3-3

Subcritical Flow Contraction and Expansion Coefficients

	Contraction	Expansion
No transition loss computed	0.0	0.0
Gradual transitions	0.1	0.3
Typical Bridge sections	0.3	0.5
Abrupt transitions	0.6	0.8

SWFWMD internal review of the HEC-RAS model.

Jason,

I completed the review of the Withlacoochee River MFL project. I read the report and I run the HEC-RAS model with the input files and I checked the profiles and the outputs. I didn't see any major errors. However, there are few things that make the report more comprehensive and inclusive. These can be summarized in the following points:

1. The values of the Manning's "n" values used and explanation for why they were chosen must be provided. Also since the calibration of the model used Manual (trial & error) adjustment of Manning's n coefficients, the values before and after needs to be documented and if there is a big differences, the changes needs to be explained and interpreted.
2. The determination of bank stations is widely different from cross section to cross section. In some cross sections, the bank stations are chosen to be very wide and others are chosen very tight even though, the cross section can be much wider. See
3. The expansion, contraction coefficients was used as 0.1, 0.3 in all the cross sections. This needs to be explained.
4. Nonlinear relations could be used instead of looking at the break points. I tried to use nonlinear relationship (e.g., power of exponential) and it improved R square but not too much. Therefore, the rating curves can be considered acceptable.
5. The relationship between flow of With @ Inverness and flow of With @ Holder: the first equation can work for any flow and no need for the break point in this case while it may be important in the case of the relation between the flow of Gum Spring and the flow @ Holder. For example, if flow of With @ Holder = 1250, from the first equation, With flow @ Inverness = 1037, and from second equation, flow of With @ Inverness = 0.837 (1250) - 9 = 1037. Note that an average flow of Gum Spring @ Holder = 172. However, if the flow @ Holder is greater than 1250, say 2000 cfs, then from the second equation the flow @ Inverness will be 1665 cfs, adding 172 cfs from Gum Springs, then the flow @ Holder could be 1837 cfs which shows some discrepancy. In this case if the first equation is used, then if gives 1873 cfs (1071 + 172), which is better than the second equation (closer to 2000 cfs).

In conclusion, the report is well written and informative. While the calcification of the mentioned points will not change the report it will answer some question that a technical reader may have.

Thank you for giving me this opportunity. I am ready to answer any questions you may have and also I can write more details or provide examples and suggestions if needed.

Ahmed Said, Ph.D, P.E.