January 7, 2022

PARTIAL DRAFT #1 - Supplemental analyses, data presentations, and clarifications related to the minimum flows report for the Little Manatee River and ongoing technical peer review

Submitted by Sid Flannery, Retired, formerly Chief Environmental Scientist with the SWFWMD minimum flows program

This document presents a series of new analyses and presentations of existing information related to the evaluation of minimum flows for the Little Manatee River by the Southwest Florida Water Management District, which is now in progress. The document also provides clarification or elaboration of statements made in either the draft minimum flows report or the initial report prepared by the independent scientific panel that is reviewing the District report. The purpose of this document is to present findings that enhance the evaluation of minimum flows for the Little Manatee River.

The material I present is based in part on my knowledge of the Little Manatee River as I worked extensively on the ecological flow relationships of the river for many years and was the project manager for many of the consultant, agency, and university reports cited in the draft District report. I also present material related to several topics that have been raised by the peer review panel. In most cases, I have made suggestions on how additional material can be considered or incorporated in the District report to address topics that either I or the panel have identified.

In 2011, the District published a minimum flows report for the upper freshwater section of the river (Hood et al. 2011) that underwent peer review and is included as Appendix A to the current draft minimum flows report. In 2018, the District published a reevaluation of the minimum flows for the upper river prepared by the primary consultant on the current project, Janicki Environmental Incorporated (JEI 2018a), which is included as Appendix C to the current draft report. A draft minimum flows report for the lower river that was also prepared by JEI in 2018 is provided as Appendix E (JEI 2018b). That draft report for the lower river took some technical approaches that have since changed, but it presented a great deal of very useful material that I describe and reprint in some cases.

It seems that when the District decided to prepare a combined minimum flows report for the upper and lower river, there was a desire to consolidate the material to keep the report from being too lengthy, and in my opinion, some important material got dropped. Minimum flows reports serve as important technical documents that are frequently referenced to cite important physical, hydrologic, and ecological information for a particular river. Accordingly, minimum flows reports should be thorough and accurate in how they present important information for a river. As described in this document, I have suggested some revisions to the minimum flows report and identify some material presented in the previous reports for the upper and lower river that should be updated and incorporated in the current minimum flows report.

The topics that are described in this following document are below:

1. Recent point source discharges from the Mosaic Company Four Corners mine and the status of phosphate mining in the Little Manatee River watershed

2. Clarification and analysis of the flow duration characteristics of the 72 cfs threshold to switch from medium flow to high flow blocks to change the allowable percent flow reductions

3. Need to show additional bathymetric and morphological information for the lower river

4. Additional salinity data for the lower river and upstream extent of estuarine conditions

5. Additional dissolved oxygen data for the lower river

5. Nitrogen enrichment of the lower river

6. Additional statistics for ichthyoplankton and nekton catch in the lower river

8. Other clarifications

   - Previous method for baseline flow calculation

   - Comparison of current baseline flow method to the MIKESHE output for the Myakka River

   - Florida Power and Light withdrawals

I anticipate submitting two more documents to the District. The next will include discussions of: factors that should be evaluated to determine low, medium, and high flow blocks for the lower river; modeling changes in low salinity shoreline habitats; and revisiting some of the regression analyses of nekton abundance with flow which were presented in the previous minimum report for the lower river (JEI, 2018b).

Toward the end of the process, I will also submit to the District a review of the report discussing findings or terminology used in specific sentences of paragraphs, some of which I have already identified in previous correspondence.

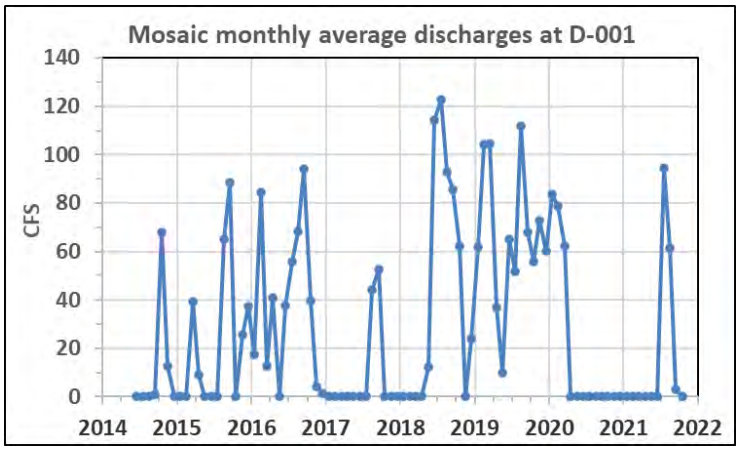
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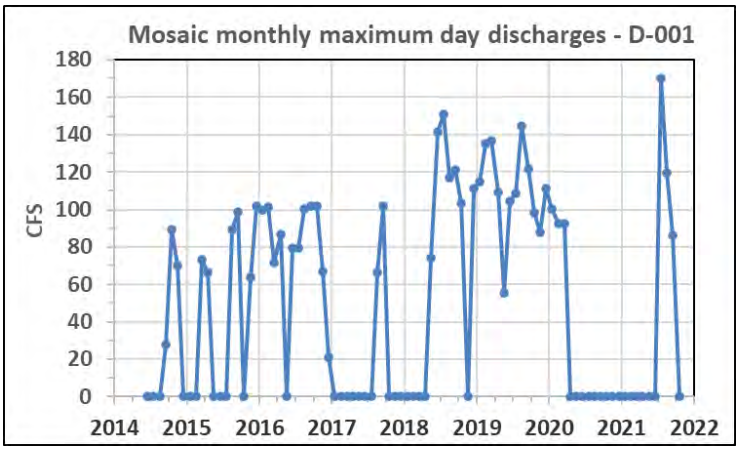
1. Recent point source discharges from the Mosaic Company Four Corners mine and status of phosphate mining in the Little Manatee River watershed.

The Mosaic Company mines phosphate ore in the upper reaches of the Little Manatee River watershed. Associated with this mining is point source discharge site D-001 located on the upper reaches of Aldermans Creek, which flows to the Little Manatee. This discharge is part of the Four Corners Mine, and includes discharges that originate outside the Little Manatee River watershed.

On page 44 the draft minimum flows report cites a study from 2012 (FDEP 2012) that concluded that discharge from site D-001 has been limited for several years, so the District did not present any discharge values for that site nor account for it in developing the baseline flow record for the river. Both previous minimum flows reports (Hood et al. 2011, JEI 2018b) and the reevaluation of the minimum flows for the upper river (JEI 2018a) showed hydrographs for discharges from site D-001, but similarly concluded that adjusting the baseline for record for these discharges would be complex, so it was not incorporated in the baseline flow record. I agree that the baseline flow record for the river does not need to be adjusted for the discharges from D-001, but a greater discussion of those discharges needs to be in the draft minimum flows report for they have a significant effect on the river's flow regime.

I contacted the Florida DEP and made retrievals from their OCULUS data base and found that discharge records for Site D-001 are very sparse from 2010 through 2012, but a continuous record of monthly discharges exists from June 2014 to recent, with six other monthly values recorded between August 2013 to April 2014. During this period, discharges from site D-001 have been fairly frequent and of considerable magnitude. Monthly values for average monthly discharges and maximum day discharges within months for the continuous record from June 2014 to October 2021 are shown in Figures 1 and 2. Discharges from Site D-001 occurred during 53 percent of the 89 months during that period. Average monthly discharges at D-001 exceeded 60 cfs in 24 of those months (Figure 1), while maximum daily flows exceeded 100 cfs in 25 of those months (Figure 2).





Figures 1 and 2. Average monthly and maximum day per month discharges from Site D-001 for the period June 2014 to October 2021.

These discharges have comprised a significant proportion of the flow of the Little Manatee River in recent years. From June 2014 to October 2021, the average discharge from Site D-001 was 29.2 cfs, equal to 16.1 percent of the average flow of the river at the USGS gage at US 301 gage near Wimauma (181.8 cfs) for this same period. For the seven full years of complete record from June 2014 to May 2021, the average flow from D-001 (29.0 cfs) was 16.4 percent of the average flow at the USGS gage (176.3 cfs). In the 47 of the total 89 months when discharges from D-001 were occurring, they comprised 21.2 percent of the gaged flow of the river.

During some months the discharges from Site D-001 comprised large proportions of the flows at the USGS gage (Figure 3). Based on a percentage of flow there are some months where the results seem unusually high, but large one-day discharges at D-001 could have played a role. I do not know the accuracy of the flow rating measurements used by Mosaic, but FDEP staff have confirmed that the average monthly flow values are for all days in the month, not just for the days that the discharges were occurring.

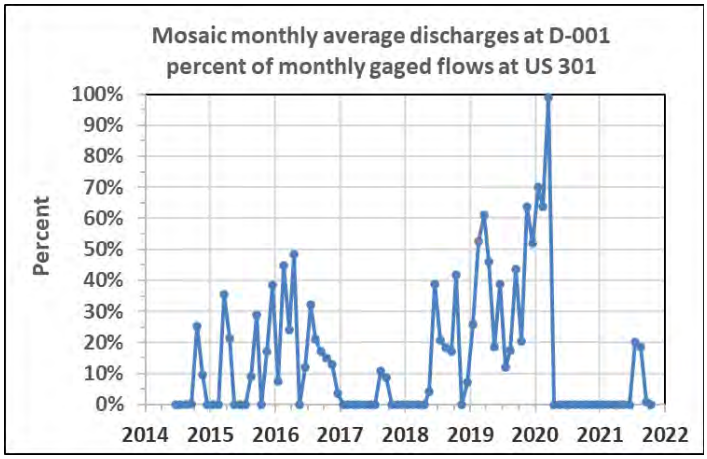


Figure 3. Percentage of average monthly gaged flows at the Little Manatee River at Wimauma at US 301 comprised of average monthly discharges at Mosaic Site D-001

In their initial report, the review panel identified the effects of phosphate mining on the hydrology of the Little Manatee River as an issue of concern, including a statement on page 2-33 that reads "Report needs more discussion regarding the impacts of mining on the recent streamflow record." I concur with that statement and recommend that the discharge record for site-2001 be updated and presented and discussed in the minimum flow report. In that regard, I have provided to the District the discharge data for site D-001 that I obtained from the Florida DEP.

Given the changing status of mined and reclaimed lands in the Little Manatee watershed, I agree with the District that the baseline flow record for the river should not be corrected to account for the effects of mining or discharges from Site D-001. However, the discharges from site D-001 and have been fairly frequent of considerable magnitude in recent years. Because it includes water that originates outside the Little Manatee watershed, I wonder if discharges from site D-001 could be masking any potential flow reductions resulting from mining within the Little Manatee River basin.

The review panel also questioned if mining in the upperpart of the watershed could affect the degree of confinement between surficial features and the Upper Floridan aquifer.

I do not know the answer to these questions, but believe the discussion of the status of previous, ongoing, and future mining in the Little Manatee River and its possible effects on the river's flow regime needs more emphasis in the minimum flows report. I also think the evaluation of minimum flows for the Little Manatee River needs to be conservative in how much water can be withdrawn from the river, because the flows of the river are in a state of flux due to mining in the watershed.

With regard to geographical data presentation, the previous minimum flows reports for the upper (Hood et al. 2011, Appendix A), the reevaluation of those minimum flows (JEI 2018a, Appendix C), and the previous draft minimum flows report for the lower river (JEI 2018b, Appendix E) all presented land cover/use maps that were much more informative than the map presented in the current draft minimum flows report. To illustrate this point, the map that was published in 2018 for both the reevaluation of the minimum flows for the upper river and the draft report for the lower river previous is shown in Figure 4. This map, which is for the year 2011, shows separate coverages for active mining (mines) and reclaimed land.

Although not reprinted here, the map presented in the first minimum flows report for the upper river (Hood et al. 2011, Appendix A) showed a very informative map specific to the Mosaic Company's land holdings in 2011 that showed separate coverages for preserved floodplain lands, reclaimed lands, and active mining along with the location of the D-001 discharge point.

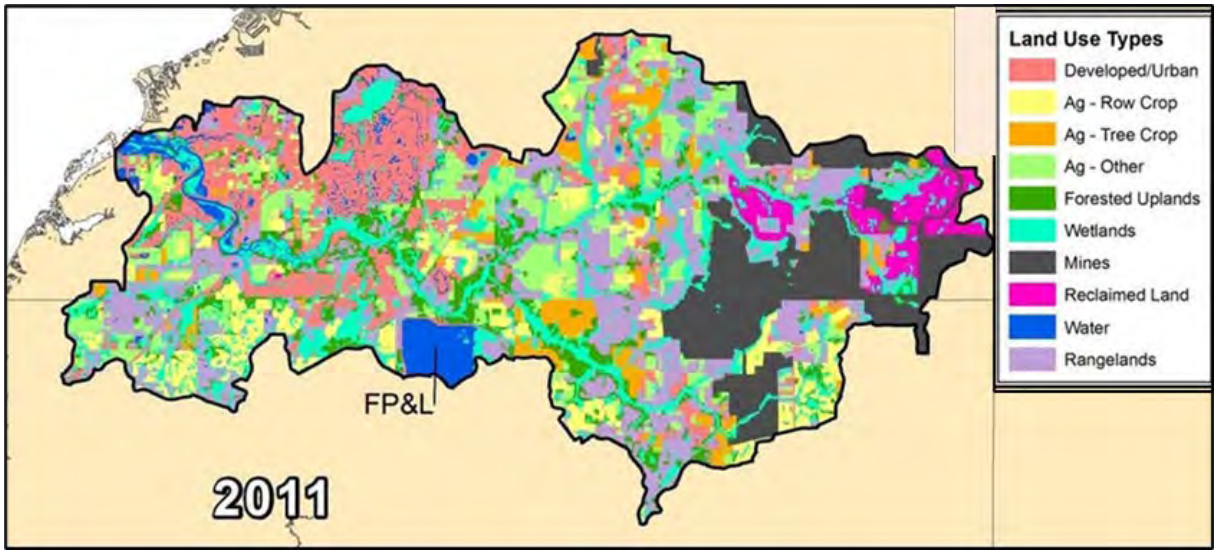


Figure 4. Land/Use cover map in the Little Manatee River Watershed for 2011, adapted from Figure 2-5 in JEI (2018a, Appendix C) and Figure 2-6 in JEI (2018b, Appendix E).

All three of these previous reports presented tables listing the amounts of reclaimed land and lands currently being mined, with the first minimum flows report for the upper river identifying other categories such as preserved floodplains, Mosaic land holdings not to be mined, and the percentages these various categories comprised of the total Mosaic lands.

The current minimum flows report shows land use/cover maps for the Little Manatee River for six different years ranging from 1974 to 2017, with the map for 2017 shown below (Figure 5). Possibly for consistency, these maps are for Level 1 classifications using the FLUCCS system. Both mined and reclaimed lands are included in the Urban and Built-Up category, making it impossible to visually separate out the mined or reclaimed lands from urban and built-up lands in other parts of the watershed. The current minimum flows report does include a table (Table 2-1 on page 27) that lists the acreages of land covers for these same six years, with extractive (mining) land cover quantified using FLUCCS Level 4 classification. However, the quantity of reclaimed land is not identified.

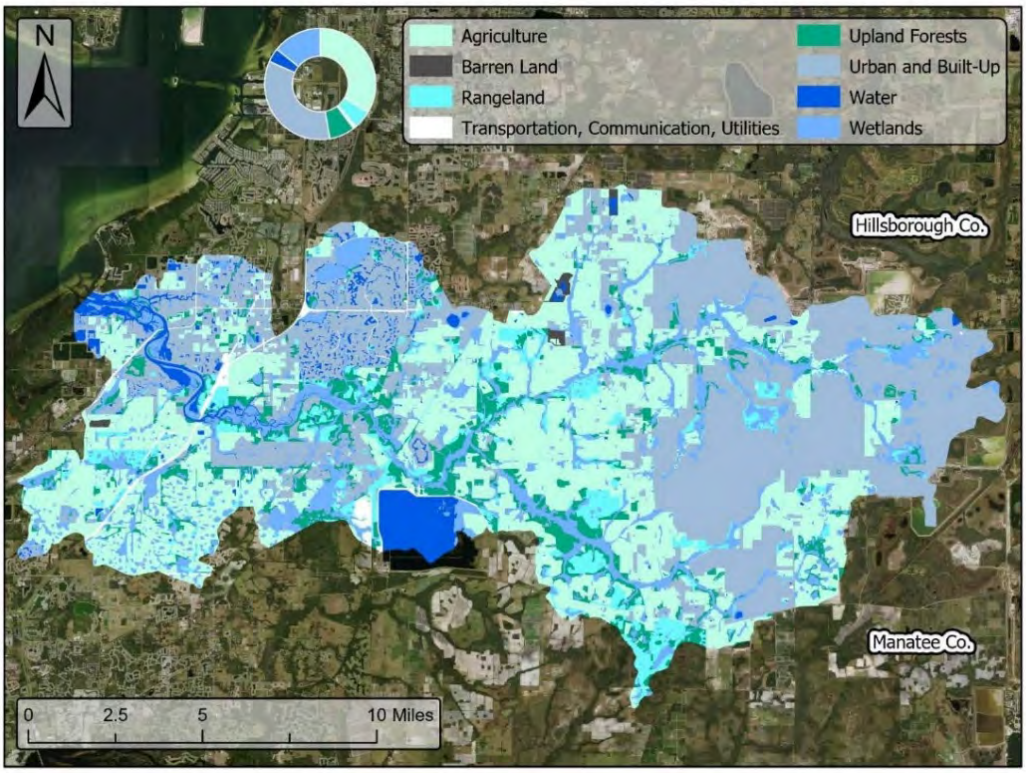


Figure 5. The 2017 Florida Land Use, Cover and Forms Classification System (Level 1) of the Little Manatee River watershed (SWFWMD 2019). Reprinted from 2021 draft minimum flows report.

Hood et al. (2011) states that the Mosaic Company owns approximately 26% of the Little Manatee River watershed. Given the frequent large discharges from site D-001 and the extent of current and projected future mining in the watershed, it would significantly improve the minimum flows report to include a more detailed land use/cover map for the watershed. Although the report could refer to maps in the Appendices, it is much better to improve the map in the primary report.

The District should also present updated discharge records for site D-001 and discuss the potential impacts of current and additional mining in the watershed and the future discontinuation of discharges from site D-001 on the hydrology of the river. Again, based on uncertainties in the effects of current and future mining and discharges from site D-001, I think a conservative approach needs to be taken to establishing minimum flows for the Little Manatee River.

2. Additional flow duration analysis of the 72 cfs threshold to switch from medium to high flow blocks to change allowable flow reduction rates

The proposed minimum flows for both the upper and lower sections of the Little Manatee River both include a threshold of 72 cfs to switch from the medium to high flow blocks to change the percentage flow reductions that comply with the minimum flows. In that regard, it is important to examine how often a flow of 72 cfs is exceeded and the percent withdrawals for the high flow blocks will be in effect. First, though, it is helpful to examine how the 72 cfs threshold for switching blocks was determined for the Little Manatee.

For many years the District employed a seasonal approach to minimum flows for freshwater rivers, in which three seasonal blocks were assigned to the spring dry season, the summer wet season, and the intermediate flow season from fall to early spring. The first minimum flows report for the Little Manatee River (Hood et al. 2011) employed this seasonal block approach, but the review panel for the first report suggested that a flow-based approach could be more straightforward and protective of the river system (Powell et al. 2012, Appendix B).

Accordingly, the reevaluation of the minimum flows for the upper river recommended that flow based approach, and recommended that flow-based blocks for low, medium, and high flows be applied with a low flow cutoff (JEI 2018a, Appendix A)**.** The current minimum flows report utilizes this approach, and established a flow rate of 72 cfs as the threshold to switch from the medium to the high flow block, with a second high flow block for the upper river at flows above 174 cfs. This is the first time the District has applied flow-based blocks to a freshwater river, and I strongly endorse that approach.

In contrast, the District has typically not applied seasonal blocks for the estuarine lower rivers, but instead has used either a single percentage withdrawal rate (e.g., Lower Alafia, Weeki Wachee, Homosassa) or included one or more flow thresholds to switch percentage withdrawal rates (e.g., lower reaches of the Myakka, Pithlachascotee and Peace Rivers and Shell Creek). The initial minimum flows that were adopted for the Lower Peace River aused a seasonal block approach, but included a flow-based threshold so that blocks for intermediate and high flow seasons could not go into effect until flows in the river exceeded a rate of 625 cfs (SWFWMD, 2010). The readoption of minimum flows for the Lower Peace River went to a straight flow-based approach with blocks for low, medium, and high flows in combination with a low flow threshold below which no surface water withdrawals are allowed (SWFWMD 2021).

For the Little Manatee, the District took a different approach and determined flow-based blocks based on relationships within the freshwater section of the river and then simply applied those same blocks to the proposed minimum flows rules estuarine lower river. This is the first time the District has done this, and I think this is a fundamental mistake that is unnecessary from a practical water management perspective, and more importantly, does not account for important relationships of flow with circulation, salinity, water quality and the biology of the lower river, which should be evaluated to establish flow blocks specific to the lower river. I have examined those relationships and think that 72 cfs is too low to serve as a high flow threshold for the lower river.

The first draft minimum flows report for the lower river (JEI, 2018b) included regression equations developed by Peebles (2008) and MacDonald et al. (2007) to predict the abundance of various species of ichthyoplankton and nekton (fishes and larger free-swimming invertebrates such as blue crabs) as a function of flow. The report also used Environmental Favorability Function (EFF) modeling to evaluate reductions favorable habitat for key fish species as a function of flow. Based on these analyses, the 2018 report concluded that the minimum flows proposed for the upper section of the Little Manatee were protective of the lower river, so the same flow-based blocks and percentage withdrawals were proposed for both the upper and lower river.

As previously discussed, the current minimum flows report combined the findings of the previous evaluations of the upper and lower river into one report. With some updates and modifications, much of the results for the upper river were carried over from the 2018 report to the current 2021 report, including the same proposed minimum flows. However, for the lower river the current report dropped the flow/abundance regressions presented in the 2018 report and instead relied solely on the Environmental Favorability Function modeling to evaluate impacts to fish species in the lower river. This greatly increased the flow reduction percentages allowed for the high flow block for the lower river, which I will address in another document.

The 72 cfs threshold that was first presented in the 2018 reevaluation of minimum flows for the upper river was then later applied to the lower river in the current minimum flows report. The only description of how often this threshold will be in effect in the current minimum flows report is on page 103, where it says "72 cfs is the 60th non-exceedance percentile. These blocks are defined using the flow record at the USGS Little Manatee River at US 301 near Wimauma FL (No. 02300500) gage. The period of record is April 1, 1939 through December 31, 2014." This sentence is based on findings presented in the 2018 reevaluation of the minimum flows for the upper river, in which some analyses were based on flows between those dates in 1939 and 2014.

The sentence taken above from the draft minimum flows report needs clarification, for this value was not taken from actual flow record at the USGS gage. I checked the historic flow records at the USGS gage and found that 72 cfs corresponded to the 56th percentile flow at this gage, rather than the 60th percentile reported for this same period. This is because the 2018 reevaluation of minimum flows for the upper river describes that 72 cfs is the 60th percentile value for the baseline flow record, which involved adjusting the flows after 1977 to account for excess flows the river has received due to changes in land and water use in the watershed (see Table 3-2 on page 3-19 in JEI 2018a).

This should be clarified in the current minimum flows report, for it is confusing that in a report that presents some data through 2020, the flow blocks are statistically described based on baseline flows that end in 2014. It is unclear in the minimum flows report though what year baseline flows have been calculated, but if it is past 2014, the percentile value for 72 cfs in the baseline flow record should be updated to include more recent years.

The percentile value of 72 cfs in the long-term baseline flow record is useful but, it is just as important to see how often 72 cfs has been exceed recent decades for that is the flow regime that the river system has adapted to, especially the lower river which is strongly influenced by salinity gradients that are dependent upon the rate of freshwater inflow. We do not know to what degree the river will return to a baseline flow condition, and if the resources of the lower river are to be protected, it is important to evaluate how often the different flow blocks will be applied in the current hydrologic setting.

To address this question, I have calculated the percentile values for 72 cfs for various time intervals using the gaged flow records for the river at the USGS gage at US 301 (Table 1). It is simple to correct the gaged flow record for withdrawals by Florida Power and Light, so values are listed for both the observed gaged flows and flows corrected for withdrawals by Florida Power and Light which began in December of 1976. However, it is reiterated the uncorrected gaged flow record is what the river below that intake receives, which includes the entire lower river.

Table 1. Percentile values for a flow rate of 72 cfs for the observed flows at the USGS Little Manatee River at US 301 near Wimauma gage and the gaged flows corrected for upstream withdrawals by the Florida Power and Light Corporation.

Time period	Percentile in gage flows	Percentile in corrected flows
1977 - 2020 (43 years)	47th	45th
1991 - 2020 (30 years)	48th	46th
2001 – 2020 (20 years)	48th	47th
2015 – 2019 (5 years)	42th	42th

For periods going back over 40 years, 72 cfs was actually slightly less than the median flow of the river. The review panel has identified the selection of flow blocks as a topic that needs further investigation, noting on page 2-29 that based on field observations by a panel member on October 15, 2021, flows were within the banks at several locations when flows were at 82 cfs, which "raises the question of whether the 60th percentile flow (72 cfs) is properly supported as a high-flow threshold."

The panel also questioned how changing the 72 cfs threshold could change the allowable flow reductions allowed for the lower river in the medium flow block 2, noting "72 cfs is not a significantly high flow value and represents the 60 percentile as outlined in the section above." This statement is even more profound when it is understood that 72 cfs has actually been slightly less than the median flow for the river for over four decades.

It is important to note that during 2015 to 2019, 72 cfs corresponded to the 42nd percentile for both the gaged and corrected flows. As described in Section 6.5 of the draft minimum flows report, the five-year period from 2015 to 2019 was the period that was ultimately applied in the EFF modeling to evaluate changes in fish habitat that would cause significant harm based on habitat reductions greater than 15 percent.

The section about fish estuarine fish habitat modeling in the draft minimum flows includes a table (Table 6-4) that lists flows rates corresponding to various percentiles in the gaged flow record for the river for four multi-year intervals. These values were taken from the report by Jacobs and JEI (2021b), which is included as Appendix D3 to the minimum flows report and is reprinted below.

Table 2. Distributional percentile values for observed discharge at the USGS Little Manatee River at US 301 near Wimauma (No. 02300500) gage for periods of record considered for environmental favorability analyses based on a LOESS regression for predicting salinity (from Jacobs and JEI 2021b). Reprinted from the draft minimum flows report (SWFWMD 2021)

Percentile	1940-2014	1940-2019	1996-2019	2000-2005
Min	0.92	0.92	3.8	3.8
5th	12	12	16	16
10th	18	18	24	21
25th	31	32	37	39
50th	61	62	75	81
75th	145	152	167	165
90th	379	387	375	380
Max	11100	11100	10400	10400

Percentile values were not listed in the table above for the period 2015 to 2019, which is the period for which changes in favorable fish habitat were reported in five other tables in that section of the 2021 draft minimum flows report. To address that omission, I have listed the flow values corresponding to the same percentiles for 2015 to 2019 period in Table 4 below. Percentile values are also listed for the long-term period for complete years from 1940 to 2020.

Table 3. Distributional percentile values for observed discharge at the USGS Little Manatee River at US 301 near Wimauma gage for the years 2015 to 2019 and 1940 to 2020.

Years	Minimum	5th	10th	25th	50th	75th	90th	Maximum
2015-2019	9	19	29	40	105	243	516	4,350
1940-2020	1	12	18	32	63	151	384	10,400

In comparing the values for 2015-2019 to the long-term values for 1940 – 2020, it is clear that 2015- it is clear that 2015 – 2019 was a wet period, with higher typically percentile values especially between the 50th (median) and 90th percentiles. In fact, the 5-year median flow for 2015-2019 was the highest in 81 years of records for complete years at the USGS gage.

The values for 2015-2019 are also considerably higher than for the periods shown in Table 3, which was reprinted from the minimum flows report. For example, the P10 (10th percentile) for 2015-2019 was 29 cfs compared to a range of 18 to 24 cfs for the year intervals in Table 3, the P50 for 2015-2019 is 105 cfs compared to range of 61 to 81 cfs in Table 3, the P75 for 2015-2019 is 243 cfs compared to a range of 145 to 167 cfs in Table 3, and the P90 for 2015 – 2019 below is 516 cfs compared to a range of 375 to 387 cfs in Table 3.

On page 150, the minimum flows report describes that the results for changes in favorable fish habitat were more conservative than results for the modeling of biologically important salinity zones using the EFDC hydrodynamic model for the river. Therefore, the proposed minimum flows for the Lower Little Manatee River were based on the Environmental Favorability Function (EFF) analyses. It was not clear why the 2015-2019 period was used for the final EFF analyses, but it was and the proposed minimum flows were ultimately based on EFF results for that period.

Keep in mind the 72 cfs threshold is supposed to represent a high flow block for the Little Manatee River. The fact that 72 cfs is actually less than the median flow for the river in recent decades does not pose an undue risk to the natural systems of the upper river, because the allowable flow reductions for the two high flow blocks (13% and 11%) for the upper river are less than the allowable flow reduction (20%) for the medium flow block that extends from 35 cfs to 72 cfs.

It is a very different situation in the lower river, where the allowable flow reduction for the medium flow block (20%) increases to a rate of 30% in the high flow block for all flows above 72 cfs. Based on flow data for the river for the last several decades, an allowable flow reduction rate of 30% will be in effect for slightly over half the year on average and considerably more often in some years. This is potentially problematic, as the selection of 72 cfs as the threshold between the medium and high flow blocks was not based on any relationships of flow with salinity, water quality, or biological variables in the lower river.

The fact that the allowable for reductions for the lower river was based on analyses of an unusually wet multi-year period is an important factor that warrants further investigation. The fish species that assessed with the EFF modeling are species that prefer low salinity habitats. It is reasonable to conclude that the amount of favorable habitat for these species increases with flow, which is also indicated by Figure 4-8 for the striped mojarra (*Eugerres plumieri*) in the first draft minimum flows report of the lower river (JEI 2018b).

What is important to consider is that the response of many variables or parameters in estuaries to in freshwater inflow is nonlinear, and the change in a particular parameter can be more sensitive to flow reductions at low flows and less sensitive at high flows. This concept was important to original development of the percent of flow method, with the Little Manatee River being one of the first three rivers (along with the Peace and Alafia) from which findings were used to support thepercent of flow method over twenty years ago (Flannery et al. 2002).

Two examples of a nonlinear response to freshwater inflow are shown in Figures 6 and 7 on the following page. The area and volume of various salinity zones typically show a steep rate of change at low flows, with an inflexion region at the medium flow range and more gradual response to freshwater flow at high flows. Similarly, residence time, which can strongly affect water quality in estuaries, has a strong nonlinear to freshwater inflow at different locations in the estuary, with rapid changes at lows, an inflexion region, and a more gradual change at high flows. It is worth noting that Figure 7 was taken from the first draft minimum flows report for the lower river (JEI 2018b) based on work by Huang and Liu (2006), while the current draft minimum flows report only mentions that residence time work was done without presenting any results

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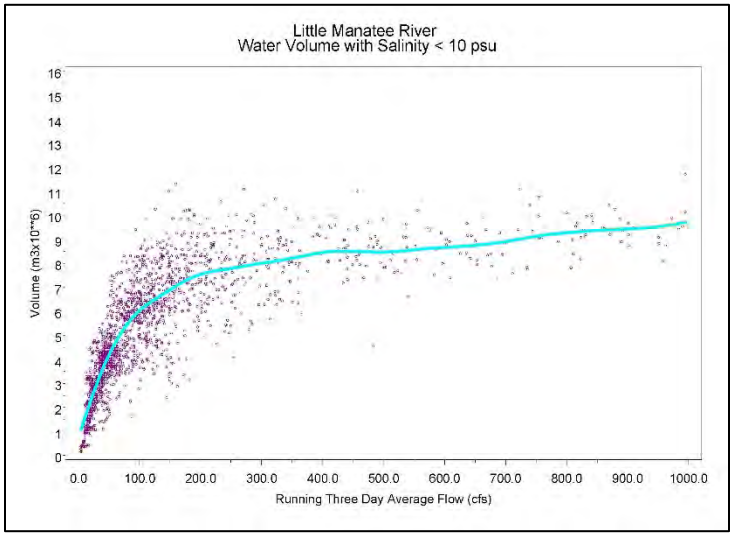


Figure 6. Water volume less than 10 psu salinity in the Lower Little Manatee River as a function of preceding three-day freshwater inflow as predicted by the EFDC model for the lower river.

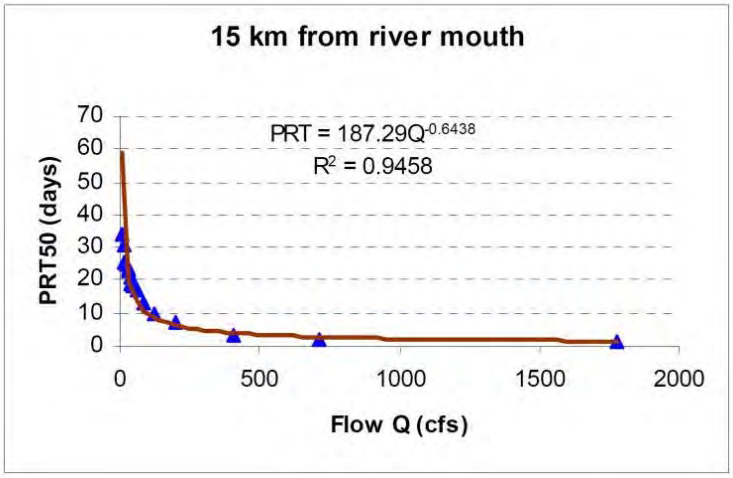


Figure 7. Pulse residence time versus freshwater inflow at a site 15 kilometers upstream from the mouth of the Little Manatee River, adapted from Figure 3-14 in JEI (2018b).

The nonlinear response of different variables in estuaries is important for revaluating flow-based blocks for which different percent allowable flow reductions can be determined. That was not done for the Little Manatee River, where flow blocks determined for the freshwater section of the river were applied to the estuarine section of the river. I will evaluate criteria for other possible flow blocks for the lower river in another document I will submit to the District.

For any flow blocks that are established, including those in the current draft minimum flows report, it is very important to evaluate the flow duration characteristics of the period that was used for the minimum flows analysis. Even when flow reductions are limited to a fixed percentage of daily flow, the resulting proportional (percentage) change for a parameter (e.g., volume of low salinity water)

can be greater at low flows and less at high flows. An example of this for the Lower Alafia River is show in Figure 8. When this occurs, the smaller proportional changes at high flows, when numerical values of that parameter (e.g., cubic meters of volume) are high, can override the results for many days at low flows if simple averages of quantities of that parameter are calculated for the baseline and flow reduction scenario.

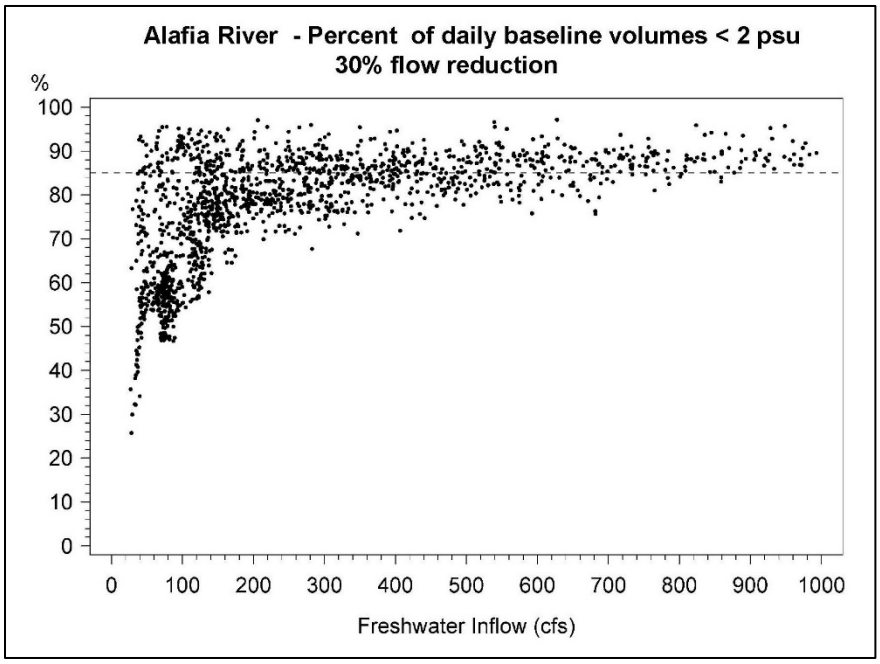


Figure 8. Percent of water volume less than 2 psu salinity relative to baseline for daily flow reductions of 30 percent vs. the rate of daily baseline flow for the Lower Alafia River with a reference line at 85 percent remaining habitat, equivalent to a 15% reduction in volume.

If the evaluation period is wet with flow duration characteristics that are markedly above average, the results of the minimum flows analysis can indicate that relatively high percent flow reductions are allowable because the findings have been influenced by the frequent occurrence of high flows when the proportional changes in the parameter are less, whereas their numerical values are high. Conversely, minimum flow analyses that are based on periods with unusually low flows can come up with more restrictive allowable flow reductions, as the numerical values of the parameter are low, but their proportional changes are greater.

The percentile values for flows shown in Tables 3 and 4 clearly show that the 2015 to 2019 period, on which the proposed minimum flows were based, was unusually wet. I realize that the EFF and salinity modeling analyses were conducted on baseline flows, but wet periods in the gaged records are also likely wet periods in the baseline record. Also, the District report claims that the effects of land and water use on excess flows in the river have declined in recent years. If that is the case, the difference between the baseline and gaged flows should be less in more recent years, making the 2015-2019 even more relatively wet within the baseline record.

To evaluate how prevailing hydrologic conditions could be affecting the results of a minimum analysis, the response of various parameter should be plotted as function of baseline flow to determine if the parameter responds to flow in generally a linear or nonlinear manner (e.g., Figures 6 and 7 on page 12). The percent changes in the parameters of interest should also should be plotted versus flow for the flow reduction scenarios being considered as shown in Figure 8.

These graphics, and associated statistical analyses, can show how the response of a specific parameter is influenced by flow rate. If there is no substantial change in the percent reduction in a parameter as a function of baseline flow, then the effects of prolonged wet and dry periods in the analysis may be not critical. However, if the percent reductions in a parameter are related to the rate of baseline flow, the flow duration characteristics during the entire period of analysis must be taken into account in the determination of minimum flows.

To address this topic, I have requested daily values of the area and volume of four salinity zones for baseline flows and five flow reduction scenarios that are predicted for the lower river using the EFDC model. The District has informed me they can provide those values when the new runs that incorporate revisions to the EFDC model runs are completed. I have also requested daily output of favorable habitat for nine species of fish predicted by the EFF model for baseline and four flow reduction scenarios, which I hope to receive in January. After I receive these files, I will perform analyses such as those described above to see how prevailing hydrologic conditions may have affected the minimum flow results.

- Text continues on next page -

Report end date	Parameter	Flow	Source	Unit	Type
August 31, 2013	Flow	29.7	Report	MGD	MK - Monthly Average
September 30, 2013	Flow	38.8	Report	MGD	MK - Monthly Average
October 31, 2013	Flow	42.2	Report	MGD	MK - Monthly Average
November 30, 2013	Flow	47.1	Report	MGD	MK - Monthly Average
December 31, 2013	Flow	5.5	Report	MGD	MK - Monthly Average
April 30, 2014	Flow	16.5	Report	MGD	MK - Monthly Average
June 30, 2014	Flow	NOD	Report	MGD	MK - Monthly Average
July 31, 2014	Flow	NOD	Report	MGD	MK - Monthly Average
August 31, 2014	Flow	NOD	Report	MGD	MK - Monthly Average
September 30, 2014	Flow	0.6	Report	MGD	MK - Monthly Average
October 31, 2014	Flow	43.8	Report	MGD	MK - Monthly Average
November 30, 2014	Flow	8.3	Report	MGD	MK - Monthly Average
December 31, 2014	Flow	NOD	Report	MGD	MK - Monthly Average
January 31, 2015	Flow	NOD	Report	MGD	MK - Monthly Average
February 28, 2015	Flow	NOD	Report	MGD	MK - Monthly Average
March 31, 2015	Flow	25.4	Report	MGD	MK - Monthly Average
April 30, 2015	Flow	5.9	Report	MGD	MK - Monthly Average
May 31, 2015	Flow	NOD	Report	MGD	MK - Monthly Average
June 30, 2015	Flow	NOD	Report	MGD	MK - Monthly Average
July 31, 2015	Flow	NOD	Report	MGD	MK - Monthly Average
August 31, 2015	Flow	42.1	Report	MGD	MK - Monthly Average
September 30, 2015	Flow	57.1	Report	MGD	MK - Monthly Average
October 31, 2015	Flow	NOD	Report	MGD	MK - Monthly Average
November 30, 2015	Flow	16.6	Report	MGD	MK - Monthly Average
December 31, 2015	Flow	24.1	Report	MGD	MK - Monthly Average
January 31, 2016	Flow	11.3	Report	MGD	MK - Monthly Average
February 29, 2016	Flow	54.5	Report	MGD	MK - Monthly Average
March 31, 2016	Flow	8.1	Report	MGD	MK - Monthly Average
April 30, 2016	Flow	26.4	Report	MGD	MK - Monthly Average
May 31, 2016	Flow	NOD	Report	MGD	MK - Monthly Average
June 30, 2016	Flow	24.3	Report	MGD	MK - Monthly Average
July 31, 2016	Flow	36.0	Report	MGD	MK - Monthly Average
August 31, 2016	Flow	44.0	Report	MGD	MK - Monthly Average
September 30, 2016	Flow	60.8	Report	MGD	MK - Monthly Average
October 31, 2016	Flow	25.6	Report	MGD	MK - Monthly Average
November 30, 2016	Flow	2.7	Report	MGD	MK - Monthly Average
December 31, 2016	Flow	0.8	Report	MGD	MK - Monthly Average
January 31, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
February 28, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
March 31, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
April 30, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
May 31, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
June 30, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
July 31, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
August 31, 2017	Flow	28.4	Report	MGD	MK - Monthly Average
September 30, 2017	Flow	34.1	Report	MGD	MK - Monthly Average
October 31, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
November 30, 2017	Flow	NOD	Report	MGD	MK - Monthly Average
December 31, 2017	Flow	NOD	Report	MGD	MK - Monthly Average

January 31, 2018	Flow	NOD	Report	MGD	MK - Monthly Average
February 28, 2018	Flow	NOD	Report	MGD	MK - Monthly Average
March 31, 2018	Flow	NOD	Report	MGD	MK - Monthly Average
April 30, 2018	Flow	NOD	Report	MGD	MK - Monthly Average
May 31, 2018	Flow	8.0	Report	MGD	MK - Monthly Average
June 30, 2018	Flow	73.9	Report	MGD	MK - Monthly Average
July 31, 2018	Flow	79.3	Report	MGD	MK - Monthly Average
August 31, 2018	Flow	60.0	Report	MGD	MK - Monthly Average
September 30, 2018	Flow	55.3	Report	MGD	MK - Monthly Average
October 31, 2018	Flow	40.1	Report	MGD	MK - Monthly Average
November 30, 2018	Flow	NOD	Report	MGD	MK - Monthly Average
December 31, 2018	Flow	15.5	Report	MGD	MK - Monthly Average
January 31, 2019	Flow	40.0	Report	MGD	MK - Monthly Average
February 28, 2019	Flow	67.4	Report	MGD	MK - Monthly Average
March 31, 2019	Flow	67.6	Report	MGD	MK - Monthly Average
April 30, 2019	Flow	23.7	Report	MGD	MK - Monthly Average
May 31, 2019	Flow	6.3	Report	MGD	MK - Monthly Average
June 30, 2019	Flow	42.0	Report	MGD	MK - Monthly Average
July 31, 2019	Flow	33.4	Report	MGD	MK - Monthly Average
August 31, 2019	Flow	72.1	Report	MGD	MK - Monthly Average
September 30, 2019	Flow	43.9	Report	MGD	MK - Monthly Average
October 31, 2019	Flow	36.0	Report	MGD	MK - Monthly Average
November 30, 2019	Flow	47.0	Report	MGD	MK - Monthly Average
December 31, 2019	Flow	38.8	Report	MGD	MK - Monthly Average
January 31, 2020	Flow	54.0	Report	MGD	MK - Monthly Average
February 29, 2020	Flow	50.8	Report	MGD	MK - Monthly Average
March 31, 2020	Flow	40.3	Report	MGD	MK - Monthly Average
April 30, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
May 31, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
June 30, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
July 31, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
August 31, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
September 30, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
October 31, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
November 30, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
December 31, 2020	Flow	NOD	Report	MGD	MK - Monthly Average
January 31, 2021		NOD	Individual Monthly report	MGD	MK - Monthly Average
February 28, 2021		NOD	Individual Monthly report	MGD	MK - Monthly Average
March 31, 2021		NOD	Individual Monthly report	MGD	MK - Monthly Average
April 30, 2021		NOD	Individual Monthly report	MGD	MK - Monthly Average
May 31, 2021		NOD	Individual Monthly report	MGD	MK - Monthly Average
June 30, 2021		NOD	Individual Monthly report	MGD	MK - Monthly Average
July 31, 2021		60.9	Individual Monthly report	MGD	MK - Monthly Average
August 31, 2021		39.8	Individual Monthly report	MGD	MK - Monthly Average
September 30, 2021		1.9	Individual Monthly report	MGD	MK - Monthly Average
October 31, 2021		NOD	Individual Monthly report	MGD	MK - Monthly Average

NOD = no discharge or 0.0 MGD

From:	Sid Flannery
To:	Doug Leeper; Kym Holzwart; Xinjian Chen; Lei Yang; Kristina Deak; Gabe I. Herrick; Chris Zajac; Randy Smith
Cc:	Jordan D. Miller; Danielle Rogers
Subject:	Email 1 - Discharge information for Mosaic outfall D-001
Date:	Friday, January 7, 2022 9:29:19 AM
Attachments:	FL0036412_D001data.xlsx Mosic D-001 small to the District.xls DepEzDMR-82aec81c-841f-4fe9-a289-3e23610b896c (2).pdf DepEzDMR-e12ae591-6d9a-4481-9f32-09895adc9d2a (5).pdf Little Manatee River Supplemental Analyses, Partial Draft #1, Jan. 7, 2021.pdf

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[EXTERNAL SENDER] Use caution before opening.

Hello Kym, Doug and minimum flows staff,

As I mentioned in a recent email to Doug and Kym, I will be submitting to the District a document that shows the results of supplementary data analyses and presentations I have prepared related to minimum flows for the Little Manatee River.

I am submitting today a partial draft of that document (attached) that covers the first two topics contained in it. I plan to submit a second partial draft on Monday which covers 2 or 3 more topics in advance of the Environmental Advisory Committee on Tuesday. I hope to have the complete document finished by the end of next week.

This email concerns the first topic covered in the document, which is point source discharges from the Mosaic Company's site D-001 that flows into Aldermans Creek in the headwaters of the Little Manatee River.
As the document describes, discharges from D-001 have been fairly frequent in recent years - just over half the time since the summer of 2014. In many months the discharges are substantial and have comprised 16.1 percent of the flow of the river for a recent 7-plus year period. I have also attached a file I requested from FDEP that contains data from August 2013 to December 2020. For months after that I made retrievals of monthly reports from the FDEP OCULUS database.

If you care to call up this database use the public access login. Then, in different windows to the left click Wastewater and in the other one Sampling. The facility you will search for is FL0036412, but that may come up automatically. You will then see the monthly reports where you can get data after the year 2020 (or further back if you desire). I have attached a report for one of those months that I downloaded.

https://depedms.dep.state.fl.us/Oculus/servlet/login

I have also attached an EXCEL file I created from the FDEP database and

my monthly retrievals. I think it is correct, but if the District wants to discuss these data in the minimum flows report, you might do your own retrievals and build the data set separately as a check, but that is up to you.

As my document says, I think the District should present data for recent discharges from D-001 and expand the discussion of phosphate mining in the watershed in the minimum flows report. The initial panel report wanted more discussion of phosphate mining as well. When I am finished with my document, I will submit it to the panel after the District has time to look it over and comment.

See email #2 for a discussion of the relevance of flow duration characteristics during the minimum flow analysis period and why I am asking for output from the EFDC salinity modeling and the Environmental Favorability Function fish habitat modeling.

Sid

From:	Sid Flannery
To:	Doug Leeper; Kym Holzwart; Gabe I. Herrick; Kristina Deak; Xinjian Chen; Lei Yang; Chris Zajac; Randy Smith
Cc:	Jordan D. Miller; Danielle Rogers
Subject:	Email 2 - Need to assess hydrologic condtions when intpreting minimum flow results
Date:	Friday, January 7, 2022 9:44:12 AM
Attachments:	Little Manatee River Supplemental Analyses, Partial Draft #1, Jan. 7, 2021.pdf Flannery, Peebles and Montgomery (2002) Percent of flow method.pdf

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[EXTERNAL SENDER] Use caution before opening.

Hello again Doug, Kym and other District staff,

This email (#2) pertains to a discussion in the same document in today's email #1, but I am attaching it again and drawing attention to topic #2 that starts on page 7.

That subject is the need to consider the hydrologic characteristics of a period that is used for minimum flows analysis. For some (not all) response variables, including model output, if the period of analysis was unusually wet or dry with flow duration characteristics that are well above or below normal, it can affect the findings of the minimum flows analysis and the proposed minimum flows rules.

There are some simple analyses that can be examined to evaluate the potential for this to happen, which I discuss in my document. As has been shown in District estuarine research, the response of some important estuarine variables to freshwater inflow can be strongly nonlinear. That is, a given flow reduction (e.g 20 cfs) can have a much greater effect on the response variable at low flows than at high flows. Even when flows are limited to a percentage of daily flow using the percent of flow method, this can still occur.

The types of diagnostic analyses I am suggesting are described in the attached document, and are very straightforward using relatively simple data sets and can be conducted fairly quickly. Basically, plot the daily quantity of the response variable vs. daily baseline flow. Then, for one or more flow reduction scenarios, plot the daily percent change of that variable from baseline vs. the corresponding rate of baseline flow. These tests help determine how much the variable and/or its percent change due to flow reductions respond to flow in a generally linear or nonlinear manner.

If the response of either of both of these parameters is nonlinear, the hydrologic characteristics of the study period can strongly affect the results and caution must be used in how the results are statistically analyzed, which in turn can affect the proposed minimum flows.

As described below, I am will to run some tests if the District will provide

to me daily values of model output for the EFDC salinity model of the lower river and favorable habitat values from the Environmental Favorability Function (EFF) modeling that was done for several fish species in the lower river. These should be fairly simple files with dates, corresponding daily values for flow and the variable of interest (e.g, bottom area < 2 psu salinity) for the baseline flow scenario or various percent flow reduction scenarios. If daily values of percent changes from baseline for the variables of interest have been calculated that can be sent as well, but I can calculate that if I have the numerical results for baseline and flow reduction scenarios.

I have described the files I need in previous emails I have sent to the District (Nov 9th, 19th, and Dec. 13th). The District has responded saying it can provide the EFDC model output and we agreed that would be fine after the revisions to the model are completed. I also requested output from the EFF fish habitat modeling analysis, for which revisions are not expected. Again, the existing files should be straightforward and I would think relatively easy for the consultant to locate and separate them out. In that regard, I hope they can be provided free of charge without a public records request fee.

Happy New Year and Go Dawgs!
Sid

From:	Sid Flannery
To:	Doug Leeper; Kym Holzwart; Xinjian Chen; Gabe I. Herrick; Lei Yang; Randy Smith; Chris Zajac; Kristina Deak
Cc:	Danielle Rogers; Jordan D. Miller
Subject:	Follow-up factoids
Date:	Friday, January 7, 2022 12:29:10 PM

[EXTERNAL SENDER] Use caution before opening.

Hello District staff,

While eating lunch, I realized I left out a couple of quick tidbits in my emails this morning that might be of interest to those who don't have time to read the documents that were attached.

In the email #2, I attached the journal article from 2002 to show that the management of nonlinear relationships in estuaries has been a focus of District work for over 20 years (see the abstract).

Also, the proposed minimum flows for the Lower Little Manatee River were ultimately based on EFF fish habitat modeling for a five-year period from 2015 to 2019. Based on 81 years of record at the long-term USGS gage on the Little Manatee, the median flow for the 2015-2019 period was the highest for any five-year period on record.

Have a fine weekend and Go Bucs!

Sid

From: Sid Flannery
To: Kym Holzwart
Cc: Doug Leeper; Xinjian Chen; Gabe I. Herrick; Lei Yang; Randy Smith; Chris Zajac; Kristina Deak; Danielle Rogers; Jordan D. Miller
Subject: Re: Follow-up factoids
Date: Monday, January 10, 2022 8:24:50 AM

[EXTERNAL SENDER] Use caution before opening.

Hello Kym,

I am contemplating wanting to show 3 or 4 graphics at tomorrow's Environmental Advisory Committee meeting. Can I do so?
If yes, I will send them to the District today so you can call them up during the discussion period after the Little Manatee River minimum flows presentation.
Please advise.

Thanks,
Sid

On Mon, Jan 10, 2022 at 7:32 AM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

> Good Morning Sid,
> Thanks for the comments and information.
> Best regards,
> Kym
>
> ---
>
> **From:** Sid Flannery <sidflannery22@gmail.com>
> **Sent:** Friday, January 7, 2022 12:28 PM
> **To:** Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Lei Yang <Lei.Yang@swfwmd.state.fl.us>; Randy Smith <Randy.Smith@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>
> **Cc:** Danielle Rogers <Danielle.Rogers@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>
> **Subject:** Follow-up factoids
>
> [EXTERNAL SENDER] Use caution before opening.
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> Hello District staff,
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Also, the proposed minimum flows for the Lower Little Manatee River were ultimately based on EFF fish habitat modeling for a five-year period from 2015 to 2019. Based on 81 years of record at the long-term USGS gage on the Little Manatee, the median flow for the 2015-2019 period was the highest for any five-year period on record.

Have a fine weekend and Go Bucs!

Sid

From:	Sid Flannery
To:	Virginia Singer
Cc:	Kym Holzwart; Doug Leeper; Xinjian Chen; Lei Yang; Kristina Deak; Danielle Rogers; Chris Zajac; Randy Smith; Jordan D. Miller; Gabe I. Herrick
Subject:	Re: Slides for tomorrow"s EAC meeting
Date:	Monday, January 10, 2022 2:14:41 PM
Attachments:	image001.png image002.png image003.png image004.png image005.png image006.png Sid"s slides for EAC meeting.pdf

---

[EXTERNAL SENDER] Use caution before opening.

Hello Virginia,
Here is a pdf of my slides. It turned out to be five pages, but they are fairly brief in their content.
See y'all virtually at the EAC meeting tomorrow.

Go Dawgs!
Sid

On Mon, Jan 10, 2022 at 9:30 AM Sid Flannery <sidflannery22@gmail.com> wrote:

> Thanks Virginia,
> I will combine my slides into a single pdf file and send it to you this afternoon.
> Sid
>
> On Mon, Jan 10, 2022 at 9:03 AM Virginia Singer <Virginia.Singer@swfwmd.state.fl.us> wrote:
>
> > Hi Sid,
> >
> > Yes, the meeting is remote via Teams. You can send me your files and we can display them following Kym's presentation, but can you send me one four-page PDF instead of four one-page PDFs. It will be much easier to screen share one file rather than opening and closing four. If needed, you can send me the four separate files and I can combine them into one PDF.
> >
> > **Virginia Singer**
> >
> > Southwest Florida Water Management District
> >
> > Board and Executive Services Manager
> >
> > 2379 Broad St.
> >
> > Brooksville, FL 34604

Mobile: (352) 410-5388

Office: (352) 796-7211, ext. 4662

Virginia.Singer@WaterMatters.org



From: Sid Flannery <sidflannery22@gmail.com>
Sent: Monday, January 10, 2022 8:48 AM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Cc: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Virginia Singer <Virginia.Singer@swfwmd.state.fl.us>
Subject: Slides for tomorrow's EAC meeting

[EXTERNAL SENDER] Use caution before opening.

Hello Virginia,

Could I send you four one-page pdf files today that could be shown in the discussion after the presentation of the Little Manatee River minimum flows at tomorrow's EAC meeting. I think it would be easiest for the District to call them up rather than me trying to do it from my computer.

I am assuming the meeting tomorrow is remote via Microsoft Teams, is that correct?

Thanks

Sid

On Mon, Jan 10, 2022 at 8:37 AM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

> Good Morning Sid,
>
> I suggest checking with Virginia to find out the best way to include your presentation during the EAC meeting.
>
> Kym
>
> ---
>
> **From:** Sid Flannery <sidflannery22@gmail.com>
> **Sent:** Monday, January 10, 2022 8:25 AM
> **To:** Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
> **Cc:** Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Lei Yang <Lei.Yang@swfwmd.state.fl.us>; Randy Smith <Randy.Smith@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Danielle Rogers <Danielle.Rogers@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>
> **Subject:** Re: Follow-up factoids
>
> [EXTERNAL SENDER] Use caution before opening.
>
> Hello Kym,
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> I am contemplating wanting to show 3 or 4 graphics at tomorrow's Environmental Advisory Committee meeting. Can I do so?
>
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> Please advise.
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> Good Morning Sid,
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> Thanks for the comments and information.
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> Best regards,
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> Kym
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> **From:** Sid Flannery <sidflannery22@gmail.com>
> **Sent:** Friday, January 7, 2022 12:28 PM
> **To:** Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Lei Yang <Lei.Yang@swfwmd.state.fl.us>; Randy Smith <Randy.Smith@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>
> **Cc:** Danielle Rogers <Danielle.Rogers@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>
> **Subject:** Follow-up factoids
>
> [EXTERNAL SENDER] Use caution before opening.
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> Hello District staff,
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> While eating lunch, I realized I left out a couple of quick tidbits in my emails this morning that might be of interest to those who don't have time to read the documents that were attached.
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> In the email #2, I attached the journal article from 2002 to show that the management of nonlinear relationships in estuaries has been a focus of District work for over 20 years (see the abstract).
>
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Have a fine weekend and Go Bucs!

Sid

Table 6-9. Proposed minimum flows for the Little Manatee River.

	Block 1 (≤ 35 cfs)	Block 2 (> 35 cfs and ≤ 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	**87%** of the flow on the previous day when the previous day's flow was > 72 cfs and ≤ 174 cfs, or **89%** of the flow on the previous day when the previous day's flow was > 174 cfs
Lower Little Manatee River (Highway 301 to Tampa Bay)	90% of the flow on the previous day	80% of the flow on the previous day	**70%** of the flow on the previous day
Upper and Lower Little Manatee River	No surface water withdrawals are permitted when flows are ≤ 35 cfs		

Table 1. Percentile values for a flow rate of 72 cfs for the observed flows at the USGS Little Manatee River at US 301 near Wimauma gage and the gaged flows corrected for upstream withdrawals by the Florida Power and Light Corporation.

Time period	Percentile in gage flows	Percentile in corrected flows
1977 - 2020 (43 years)	47th	45th
1991 - 2020 (30 years)	48th	46th
2001 – 2020 (20 years)	48th	47th
2015 – 2019 (5 years)	42th	42th

Estuaries Vol. 25, No. 6B, p. 1318–1332 December 2002

A Percent-of-flow Approach for Managing Reductions of Freshwater Inflows from Unimpounded Rivers to Southwest Florida Estuaries

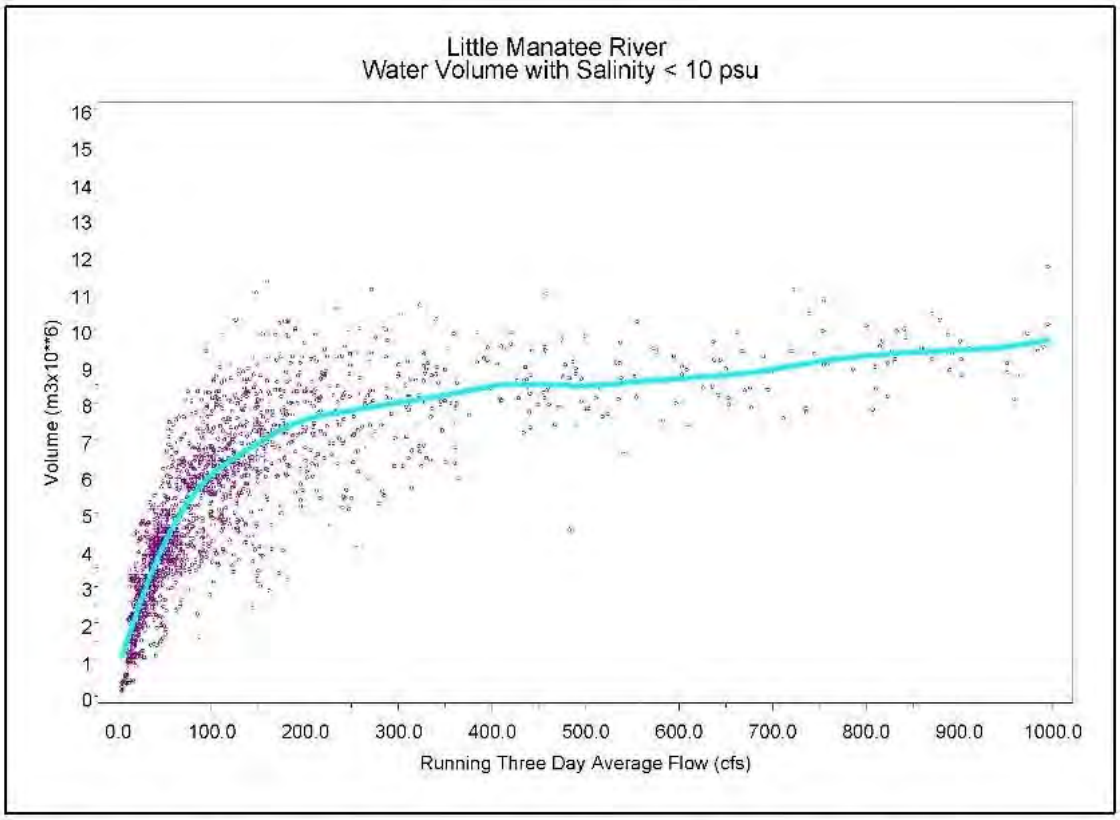
MICHAEL S. FLANNERY[1,*], ERNST B. PEEBLES[2], and RALPH T. MONTGOMERY[3]

[1] *Southwest Florida Water Management District, 2379 Broad Street, Brooksville, Florida 34604*
[2] *University of South Florida, College of Marine Science, 140 Seventh Avenue South, St. Petersburg, Florida 33701*
[3] *PBS&J, Inc., 5300 West Cypress Street, Suite 300, Tampa, Florida 33606*

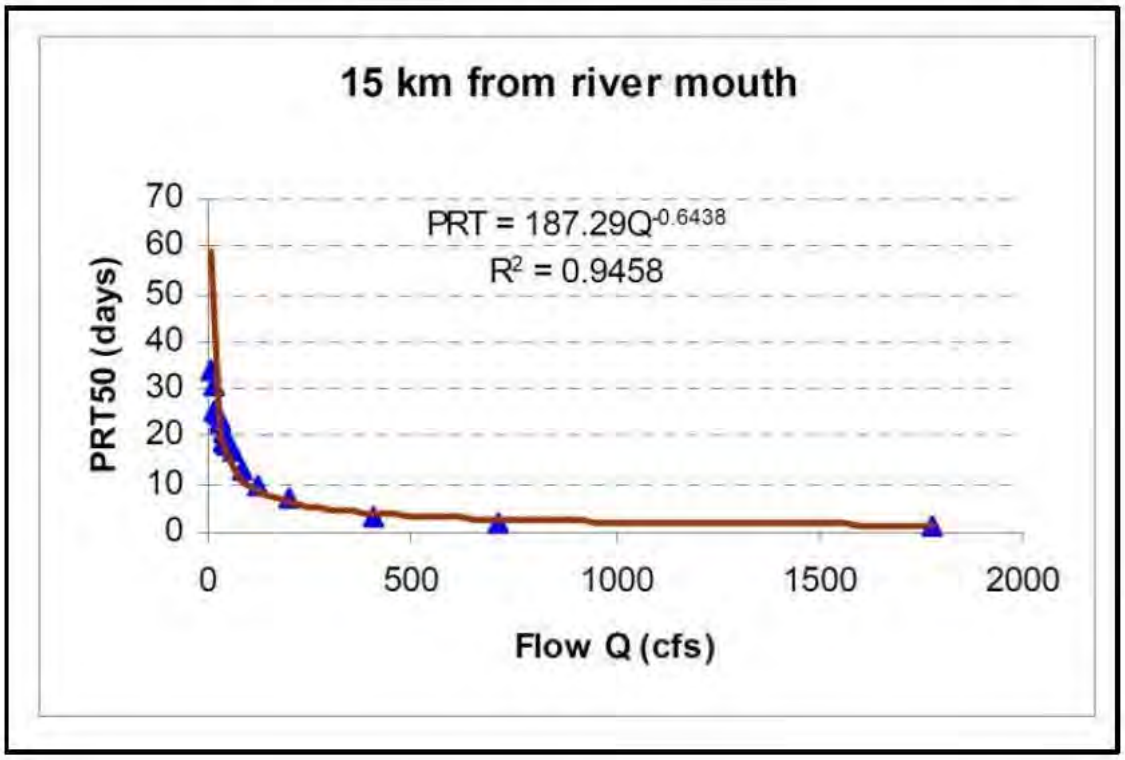
ABSTRACT: The Southwest Florida Water Management District has implemented a management approach for unimpounded rivers that limits withdrawals to a percentage of streamflow at the time of withdrawal. The natural flow regime of the contributing river is considered to be the baseline for assessing the effects of withdrawals. Development of the percent-of-flow approach has emphasized the interaction of freshwater inflow with the overlap of stationary and dynamic habitat components in tidal river zones of larger estuarine systems. Since the responses of key estuarine characteristics (e.g., isohaline locations, residence times) to freshwater inflow are frequently nonlinear, the approach is designed to prevent impacts to estuarine resources during sensitive low-inflow periods and to allow water supplies to become gradually more available as inflow increases. A high sensitivity to variation at low inflow extends to many invertebrates and fishes that move upstream and downstream in synchrony with inflow. Total numbers of estuarine-resident and estuarine-dependent organisms have been found to decrease during low-inflow periods, including mysids, grass shrimp, and juveniles of the bay anchovy and sand seatrout. The interaction of freshwater inflow with seasonal processes, such as phytoplankton production and the recruitment of fishes to the tidal-river nursery, indicates that withdrawal percentages during the springtime should be most restrictive. Ongoing efforts are oriented toward refining percentage withdrawal limits among seasons and flow ranges to account for shifts in the responsiveness of estuarine processes to reductions in freshwater inflow.

Introduction

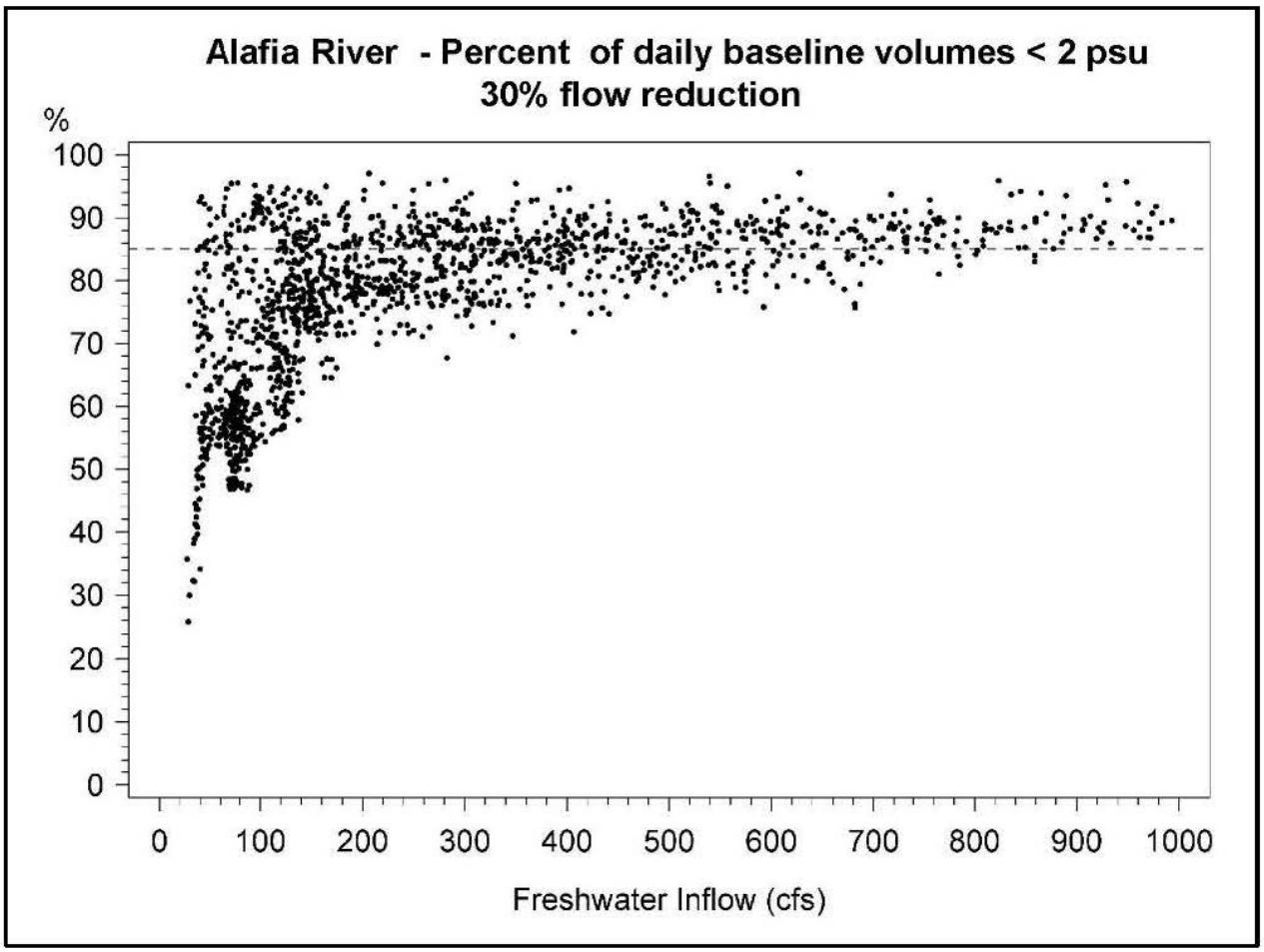
Stream ecologists have emphasized the importance of natural flow regimes for maintaining the ceding freshwater inflow terms calculated over 2-mo or 3-mo intervals, indicating that the seasonality of inflow can have a significant effect on fish



Volume of salinity < 10 psu vs flow in Lower Little Manatee River



Pulse residence time at kilometer 15 versus freshwater inflow



Percent of water volume less than 2 psu salinity relative to baseline for daily flow reductions of 30 percent vs. baseline flow for the Lower Alafia River

Distributional percentile values for observed discharge at the USGS Little Manatee River at US 301 near Wimauma gage for the years 2015 to 2019 and 1940 to 2020.

Years	Minimum	5th	10th	25th	50th	75th	90th	Maximum
2015-2019	9	19	29	40	105	243	516	4,350
1940-2020	1	12	18	32	63	151	384	10,400

Table A. Mean salinity at capture for fish species for which changes in favorable habitat was simulated using the Environmental Favorability Function model in the draft minimum flows report. Values listed for both seine and trawl samples from the 1996-2006 reported by MacDonald et al. (2007). All values as practical salinity units (psu)

Common Name	Scientific Name	Seine	Trawl
		Salinity (psu)	
Tidewater mojarra	*Eucinostomus harengulus*	12.9	10.8
Hogchoker	*Trinectes maculatus*	5.3	5.1
Clown goby	Microgobius gulosus	9.0	10.0
Rainwater killifish	*Lucania parva*	9.0	15.7
Striped mojarra	*Eugeres plumeri*	9.8	8.0
Naked goby	*Gobiosoma* bosc	8.8	7.7
Small gobies	*Gobiosoma* spp.	6.5	14.0
Common snook	*Centropus unidecimalis*	6.1	5.2
Sailfin molly	*Poecilia latipinna*	8.5	7.9
Sheepshead	*Archosargus probatocephalus*	11.0	15.1
Mosquitofish	*Gambusia holbrooki*	2.0	Not caught

Table B. Supplement to Table 4-10 in the draft minimum flows report. Life stages of taxa caught in 480 plankton tows in the Little Manatee River from January 1998 – January 1990 (from Peebles 2008). Peak locations represent the kilometer of the station where the taxon/stage was most abundant based on density weighted interpolation between fixed stations with Bay listed for taxon/stages most abundant at the station in Tampa Bay. Ranks are listed for where they would appear if added to Table 4-10 in the draft minimum flows report, which is ranked by mean catch per unit effort as density in number per thousand cubic meters. The percent contribution to total was calculated from a count of 216,916 total specimens listed on page 99 in the draft report. It is uncertain if that total count lists the taxa and stages listed below, but the values below can be compared to the percent contribution values in Table 4-10 in the draft report using a common factor.

Rank	Common name and stage	Scientific Name	Number collected (n)	Mean CPUE (No. per 1,000 m3)	Percent Contribution to total	Peak Location (KM)	Mean Salinity at capture (psu)
2	Bay anchovy juveniles	*Anchoa mitchilli*	40,838	874.7	18.8%	7.1	7.2
7	Anchovies flexion	*Anchoa* spp.	11,287	130.5	5.2%	Bay	25.7
9	Bay anchovy postflexion	*Anchoa mitchilli*	7,908	93.8	3.6%	0.3	22.1
10	Anchovies preflexion	*Anchoa* spp.	9,169	80.8	4.2%	Bay	24.4
14	Bay anchovy eggs	*Anchoa mitchilli*	9,868	26.8	4.5%	Bay	23.5
19	Menhaden postflexion	*Brevoortia* spp.	2,393	18.7	1.1%	7.5	2.8

Table C. The most common taxa/states in 480 plankton tows as shown on page 100 in Table 4-10 in the draft minimum flows report. However, the taxa/stages listed in Table B should to be added to the table. Mean salinity at capture and center abundance in kilometers taken from Peebles (2008)

Common Name	Scientific Name	Number Collected (n)	Mean CPUE (No./10^3 m^3)	% Contribution to Total	Salinity . (psu)	KmU (Kilometer)
Fish eggs (primarily drum)	*Percomorpha* eggs (primarily Sciaenid)	167,840	5829.41	77.38	26.1	Bay
Gobies, postflexion larvae	*Gobiosoma* spp.	10,599	303.35	4.89	14.8	6.0
Gobies, flexion larvae	*Gobiosoma* spp.	8,052	234.09	3.71	18.3	3.3
Gobies, postflexion larvae	*Microgobius* spp.	5,642	184.73	2.60	23.6	Bay
Gobies, preflexion larvae	Gobiid	5,493	162.68	2.53	18.8	2.4
Gobies, flexion larvae	*Microgobius* spp.	3,093	95.29	1.43	21.5	4.3
Skilletfish, flexion larvae	*Gobiesox strumosus*	2,128	60.54	0.98	15.7	4.5
Skilletfish, preflexion larvae	*Gobiesox strumosus*	1,951	56.3	0.90	17.6	2.7
Blennies, preflexion larvae	Blenniid	1,159	35.1	0.53	21.5	0.1
Skilletfish, postflexion larvae	*Gobiesox strumosus*	787	21.43	0.33	11.8	7.3
Frillfin goby, preflexion larvae	*Bathygobius soporator*	779	23.55	0.36	22.0	0.6
Sand seatrout, preflexion larvae	*Cynoscion arenarius*	716	27.35	0.29	25.2	Bay
Silver perch, flexion larvae	*Bairdiella chrysoura*	629	22.46	0.36	23.5	Bay
Sand seatrout, postflexion larvae	*Cynoscion arenarius*	444	13.93	0.20	18.8	Bay
Hogchoker, postflexion larvae	*Trinectes maculatus*	433	12.12	0.18	10.4	5.8
Florida blenny, flexion larvae	*Chasmodes saburrae*	381	12.42	0.20	23.4	23.4
Frillfin goby, flexion larvae	*Bathygobius soporator*	334	10.42	0.14	21.6	21.6
Gobies, juveniles	*Giobiosoma* spp.	317	8.81	0.15	9.9	10.0
Kingfishes, preflexion larvae	*Menticirrhus* spp.	314	11.51	0.13	24.2	Bay
Silver perch, preflexion larvae	*Bairdiella chrysoura*	275	10.25	0.11	24.8	Bay
Gobies, flexion larvae	Gobiid	240	6.98	0.15	16.6	4.3
Kingfishes, flexion larvae	*Menticirrhus* spp.	238	8.94	0.10	25.0	Bay
Hogchoker, juveniles	*Trinectes maculatus*	233	6.18	0.09	1.6	9.7
Chain pipefish, juveniles	*Sygnathus louisianae*	225	7.5	0.11	22.4	Bay
Silver perch, postflexion larvae	*Bairdiella chrysoura*	216	6.62	0.10	16.4	2.9
Hogchoker, preflexion larvae	*Trinectes maculatus*	210	6.36	0.10	19.3	19.3

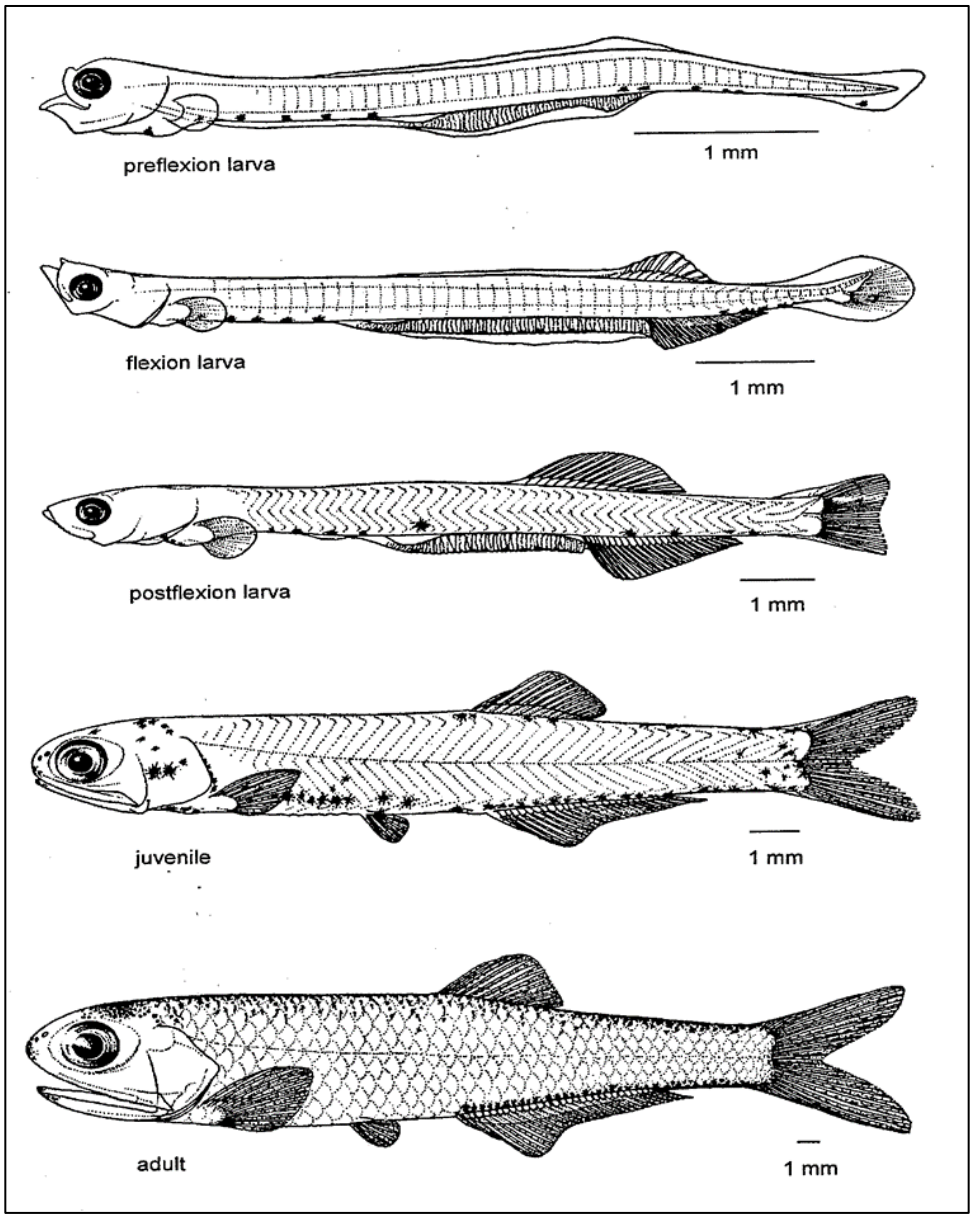


Figure I. Development stages of the bay anchovy (*Anchoa mitchilli*) collected from the Lower Little Manatee River and Tampa Bay, measuring 4.6, 7.0, 10,5, 16 and 31 mm standard length.

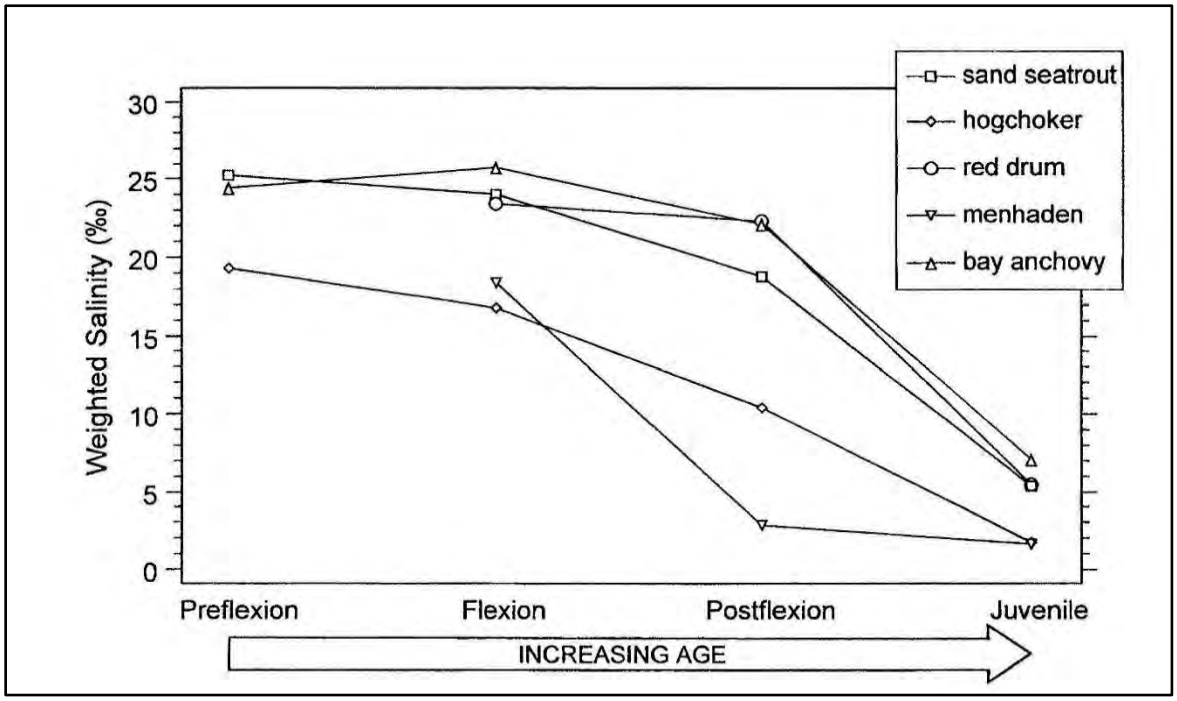


Figure J. Examples of decreasing mean salinity at capture with fish development. See Figure I for illustrations of these stages for the bay anchovy (*Anchoa mitchilli*).

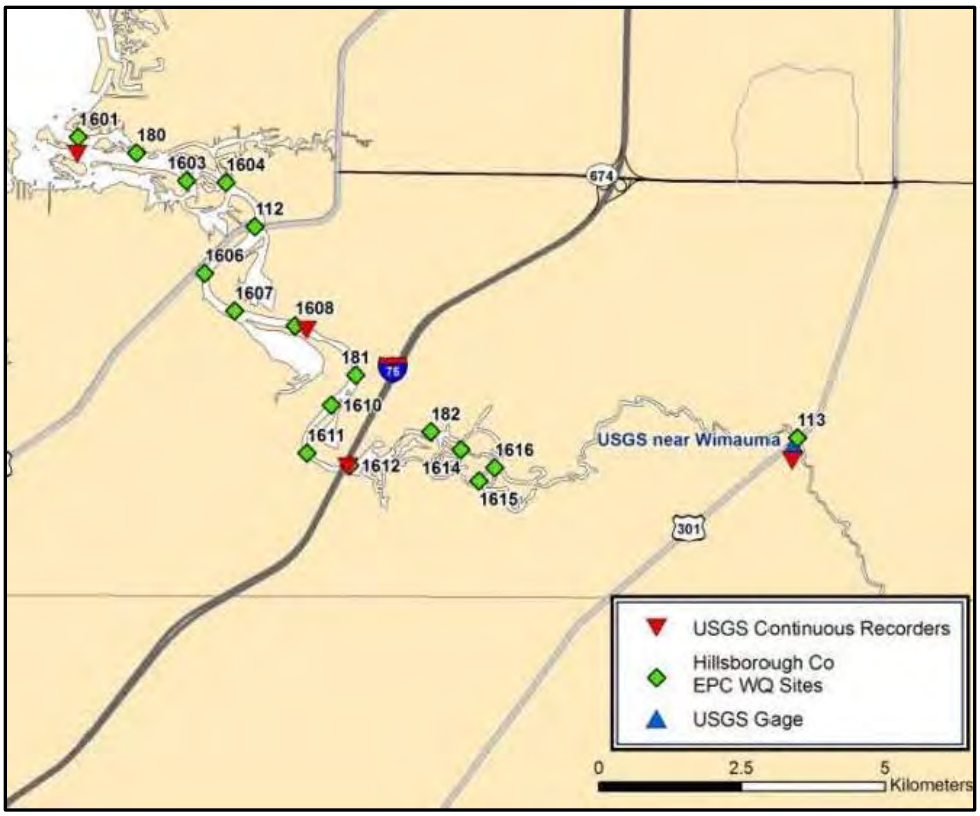


Figure A. USGS salinity recorders and EPCHC vertical profile stations in the lower river.

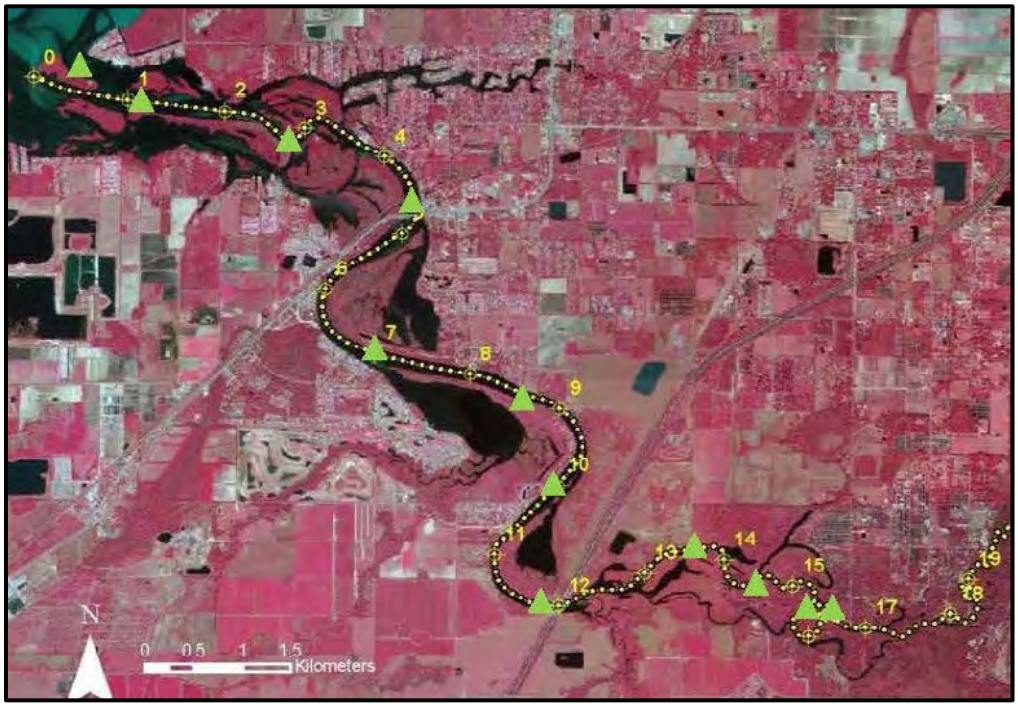


Figure B. Location SWFWMD vertical profile stations in the lower river, 1988 and 1989

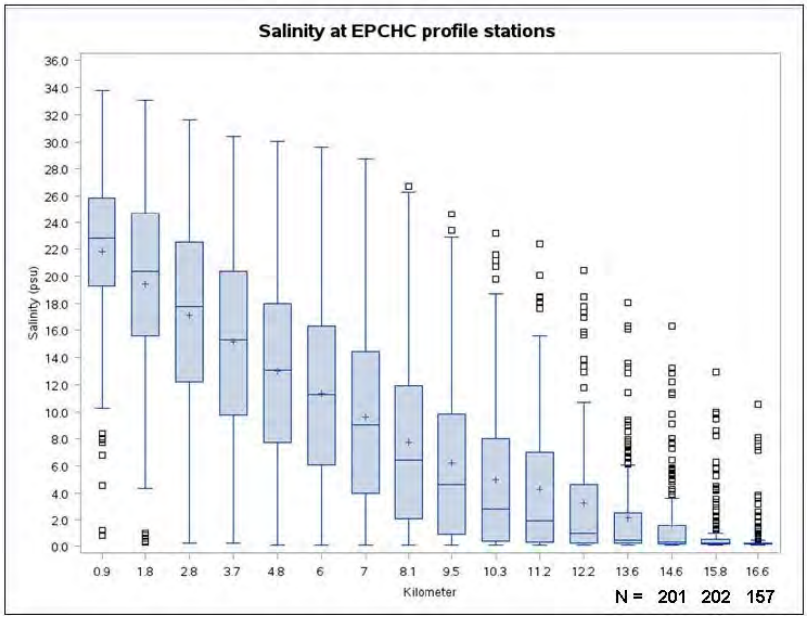


Figure C. Box plot of mean water column salinity values for vertical profiles measured in the lower river by the EPCHC from 12/14/2000 to 10/2/2006 and 01/26/2009 to 08/17/2001. N values for three upstream stations are the number of dates each station was sampled.

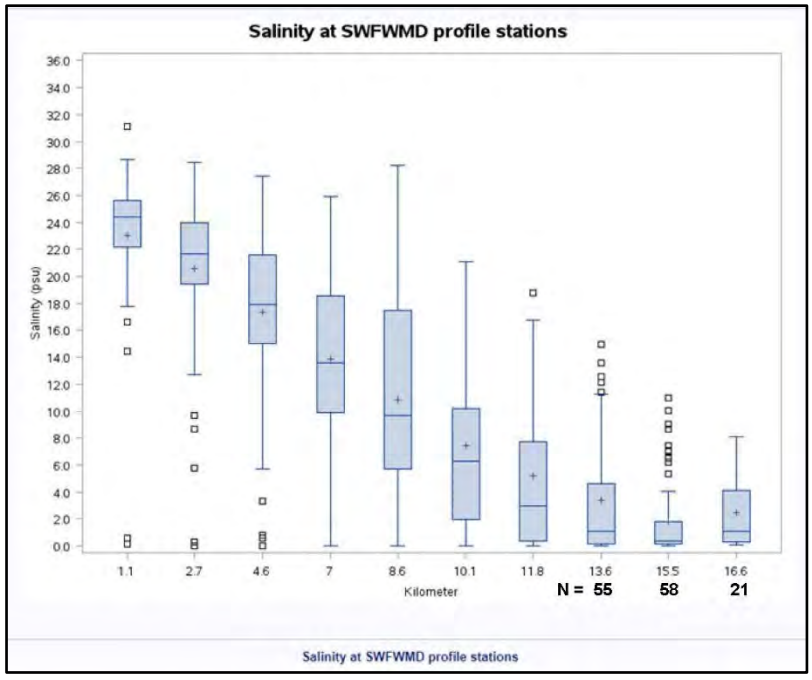


Figure D. Box plot of mean water column salinity values for vertical profiles measured in the lower river by the SWFWMD from 1985 to 1989. N values for three upstream stations are the number of dates each station was sampled.

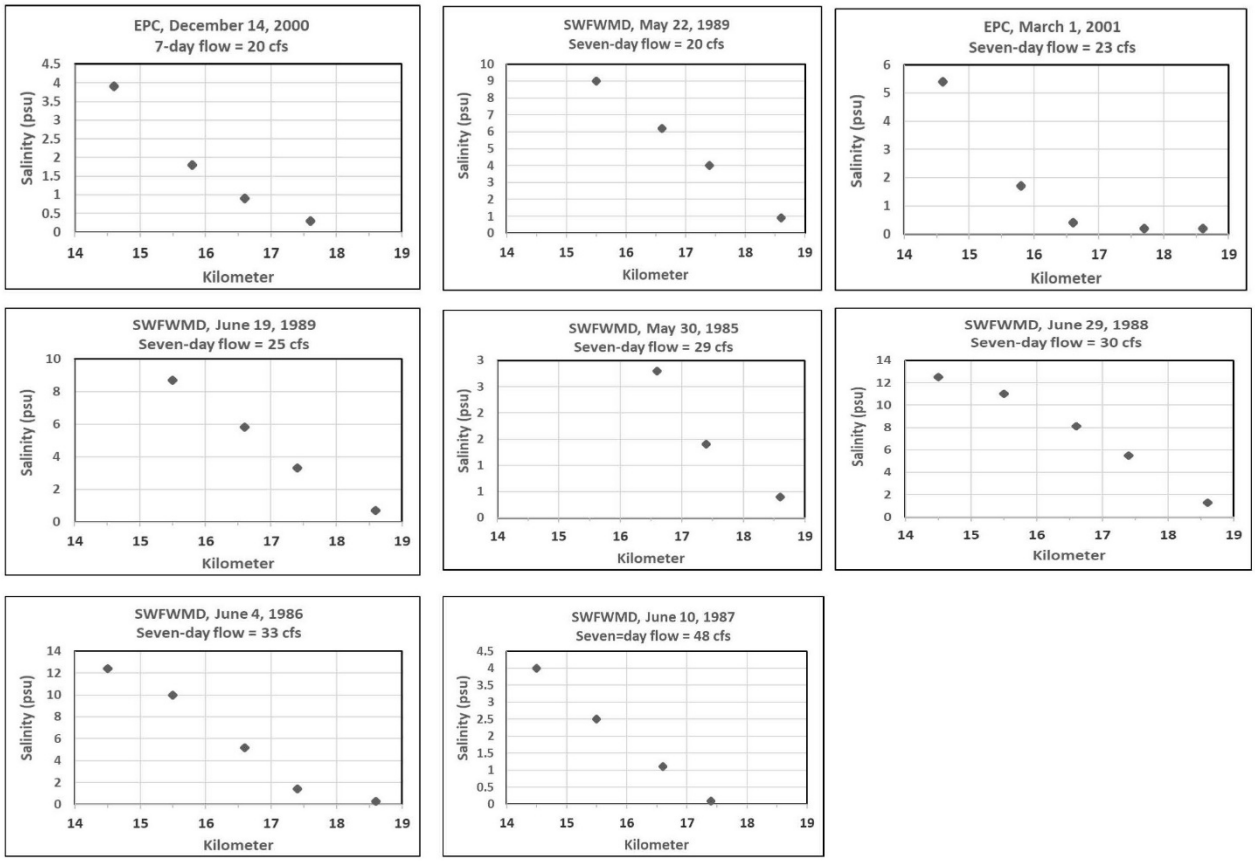


Figure E. Mean salinity values at stations in the upper reaches of the lower river on days when sampling by the EPCHC or the SWFWMD extended upstream of kilometer 16.6

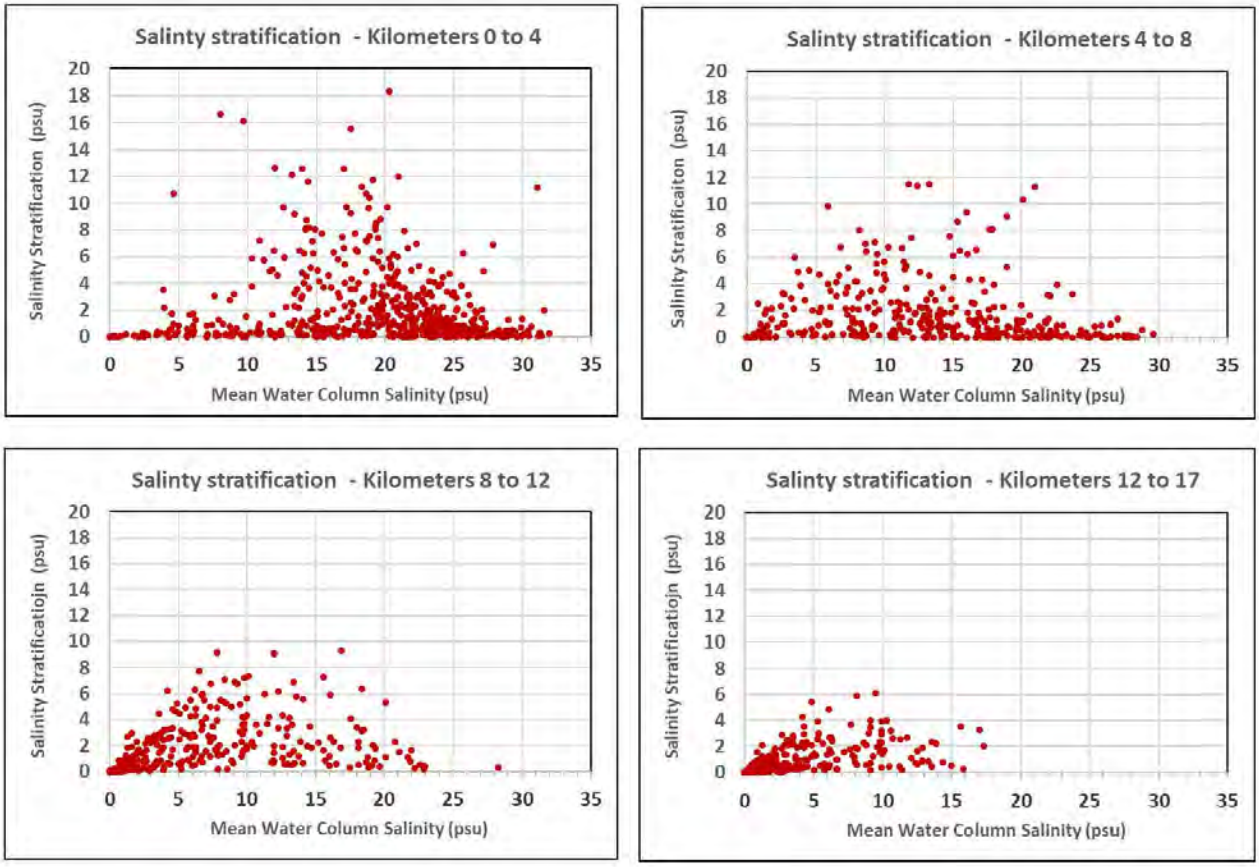


Figure F. Salinity stratification in four reaches of the lower river vs. mean water column salinity for stations that were two meters deep or greater. Stratification was calculated by subtracting the surface salinity value from the bottom salinity value.

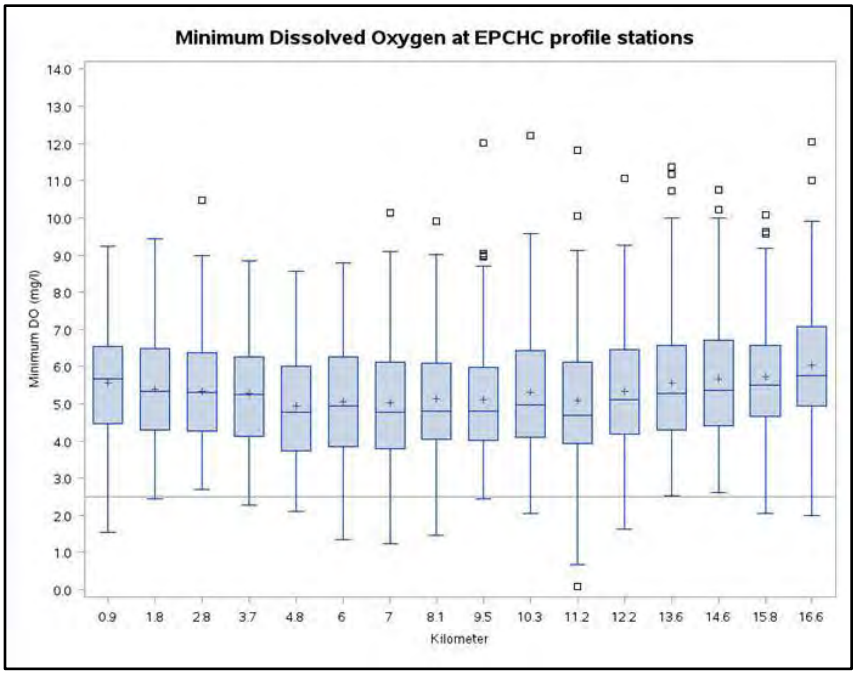


Figure G. Box plot of minimum dissolved oxygen concentrations a stations in the lower river monitored by the EPCHC. Whiskers are 1.5 times sssssssss.

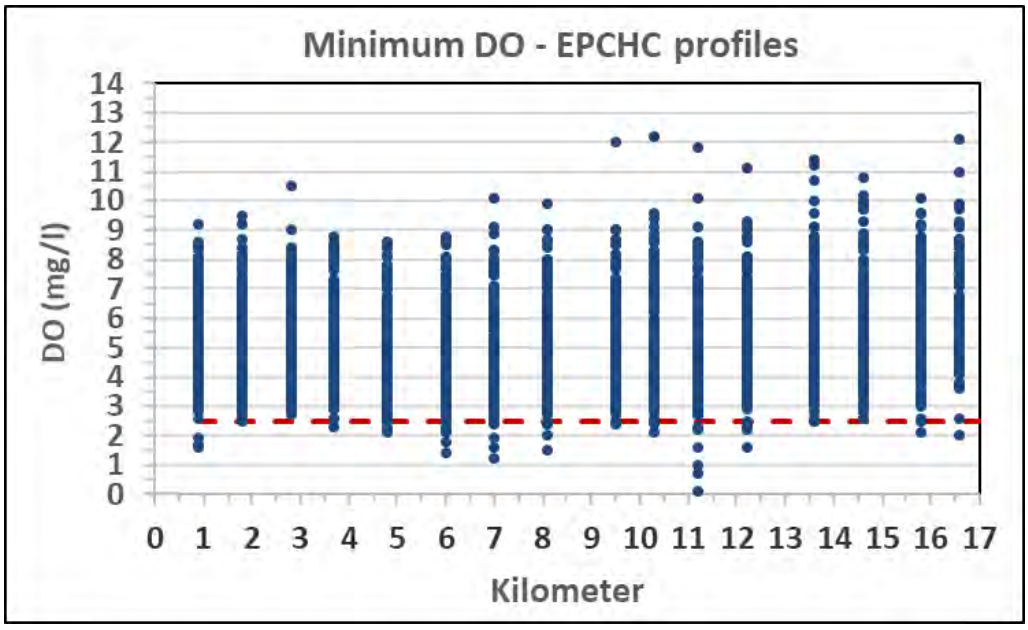


Figure G. Minimum dissolved oxygen concentrations at EPCHC vertical profile stations.

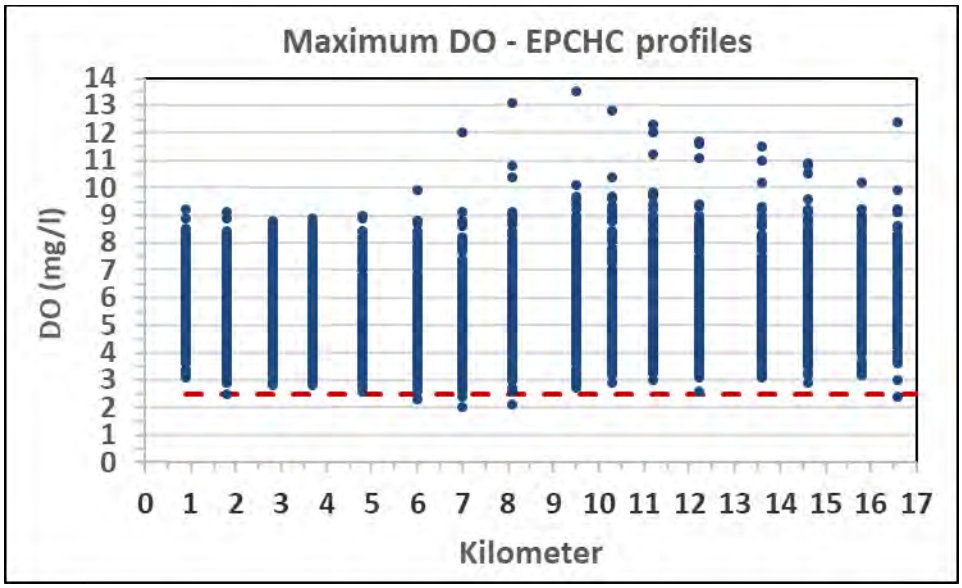


Figure H. Maximum dissolved oxygen concentrations at EPCHC vertical profile stations.

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper
Cc:	Chris Zajac; Xinjian Chen; Gabe I. Herrick; Jordan D. Miller; Randy Smith; Kristina Deak; Lei Yang; Danielle Rogers
Subject:	Tables and Figures for fish, salinity, and dissoved oxygen
Date:	Tuesday, January 11, 2022 7:34:51 AM
Attachments:	Salinity and DO Figures.pdf Fish Tables and Figures.pdf

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[EXTERNAL SENDER] Use caution before opening.

Hello District staff, particularly Environmental Scientists,

Attached are two pdf files that have figures and tables pertaining to the Little Manatee River minimum flows. Later this week I will put text and incorporate them in my broader comments to the District, but for now just wanted to give you a heads up - particularly for the biological information. Temporary letters (A, B, etc.) are given to the Table and Figure titles which I will later revise.

First - the Salinity DO Figures are pretty simple and self explanatory. They will be elaborated on another time.

I do provide some description below of the attached Fish Tables and Figures.

Regarding Table A. The species listed in this table are the species that were simulated using the Environmental Favorability Function modeling, which ultimately determined the minimum flows. The mean salinity at capture values were taken from the report that the FFWCC staff did for the District based on over 10 years of fish monitoring in the river at that time (MacDonald et al. 2007). The mean salinity of capture for many of these species are in the 8 to 10 psu range in the seine catch data, which comes from the shallower shoreline areas. The values for trawl catch data are higher for some but not all species, as these are deeper waters. Because the water less than 2 psu was the most conservative zone for salinity zone analysis, there might be a perception that it is the prime area for estuarine productivity. The < 2 psu is an important zone for protection, but the mesohaline zones are biologically very important as well.

Table B was prepared to supplement Table 4-10 in the minimum flows report, which concerned the ichthyoplankton catch data by USF in the late 1980s, when the District was involved in extensive studies of the Little Manatee. For whatever reason, Table 4-10 did not include the numerically dominant fish in the ichthyoplankton catch - the bay anchovy (*Anchoa mitchilli*). So, I prepared this table which included other species life stages that should go into Table 4-10 in the minimum flows report.

The Little Manatee River was the first river where ichthyoplankton was

studied by Dr. Peebles of USF and was an important precedent for the District's minimum flows work. As Figure J shows, as some fish species mature from egg through larval and juvenile stages, they migrate into low salinity waters in the river. As I said at the fist peer review meeting, Figure J probably best supports the District's minimum flows program and it should go into the report.

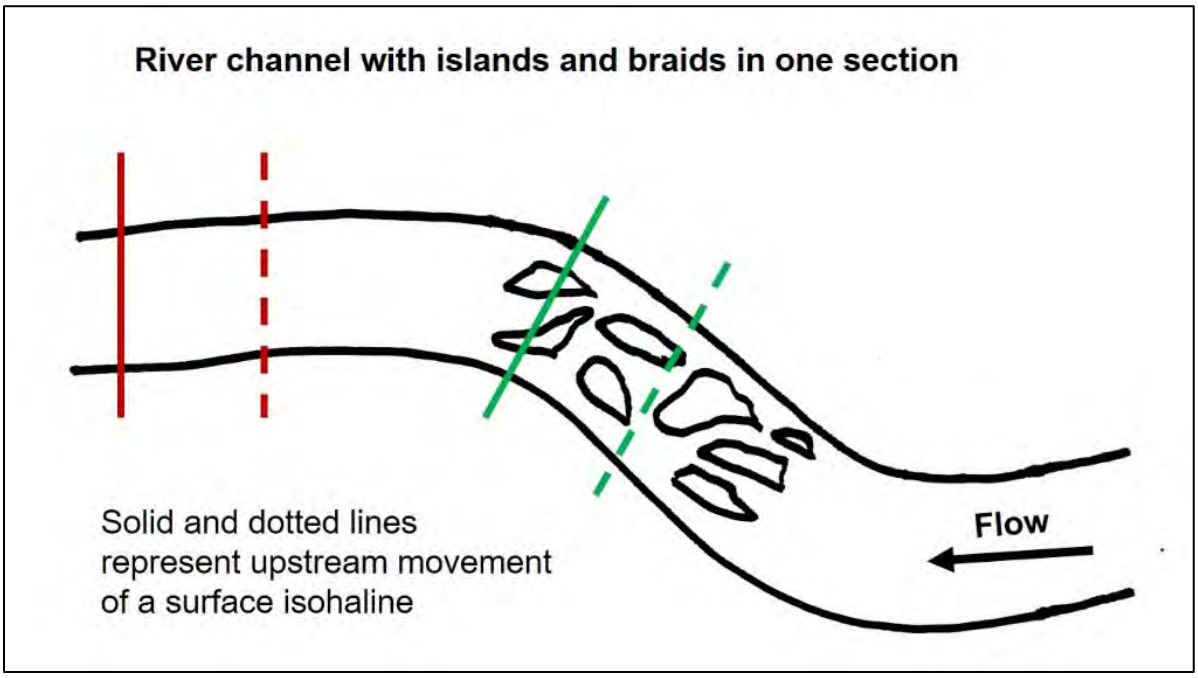
Also, Dr. Peeble's wife is a top notch biological illustrator and superb artist, and she did the illustration of the different life stages of the bay anchovy in Figure I, which appeared in the first ichthyoplankton report for the Little Manatee. It should also go into the minimum flows report as it helps illustrate the stronger swimming ability of the fish as they mature, thus supporting Figure J, plus it is a fine piece of work and the District should highlight it.

How bout them Dawgs! Congratulations to Doug and UGA.
Sid

Considerations for assessment of changes in shoreline length in given salinity zones in the Little Manatee River due to reductions in freshwater inflow Prepared by Sid Flannery, January 19, 2002

The conceptual graphic below represents the upstream movement of a surface isohaline (salinity concentration) of equal length along two sections of a river channel. Assuming the channel width is the same with in these two sections, there will be a much greater change in water area in the downstream reach denoted by the red lines than in the upstream reach denoted by the green lines, as the presence of islands reduces the total water area in the upstream reach of the river.

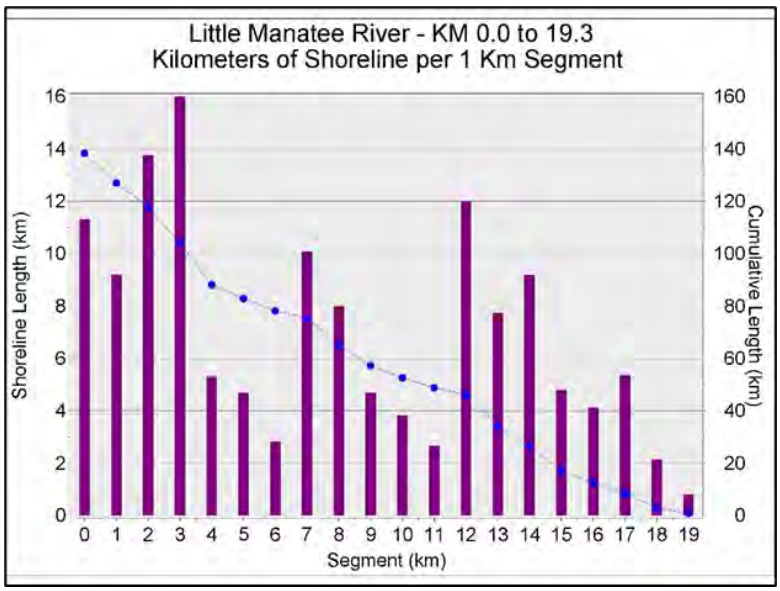
Conversely, there will be a much greater reduction in shoreline length associated with the green lines as there is a much greater quantity of shoreline length in that zone. The differences in these changes will also be reflected in percent reductions in total area and shoreline length upstream of these isohalines in the river.

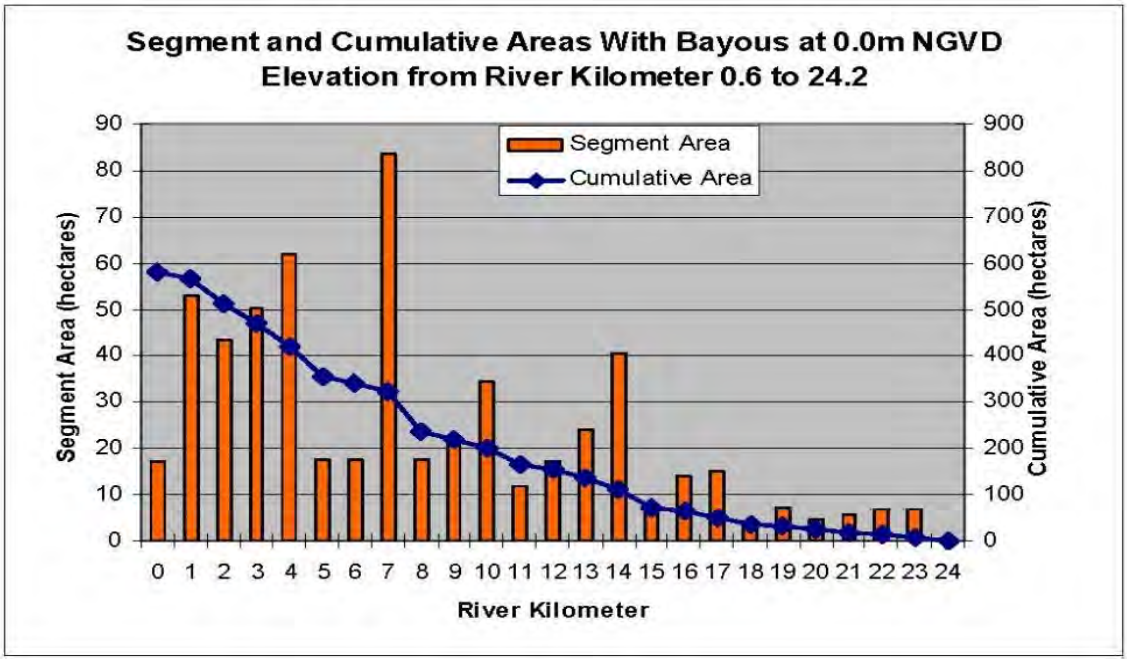


See next page for graphs from the Little Manatee

The amounts of shoreline and area can vary considerably within different river reaches. As shown below, the length of shoreline in one-kilometer segments in the Little Manatee River can vary greatly, ranging between approximately 2.4 kilometers per one kilometer of channel length to 12 to 16 kilometers of shoreline per one kilometer of channel length. Note the increase in shoreline length from river kilometer 11 to 12. The graph of river area per segment is also below. They are on different scales, but it is visually apparent there are considerable differences in the ratio of shoreline to area in different river segments.

The Little Manatee has extensive oligohaline and freshwater marshes in the braided zone upstream of Interstate 75 near kilometer 12 that are susceptible to the effects of increased salinity. As such, the quantification of changes in shoreline length below a given salinity concentration (2 or 4 psu) are much more meaningful than changes in area for assessing potential impacts to shoreline vegetation in the Little Manatee River that could result from flow reductions.





From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Xinjian Chen; Gabe I. Herrick; Jordan D. Miller; Randy Smith; Danielle Rogers; Chris Zajac
Cc:	MIke Wessel (MWessel@janickienvironmental.com)
Subject:	Shoreline length in the Little Manatee River and request for EFDC and EFF model output
Date:	Thursday, January 20, 2022 8:03:22 AM
Attachments:	Changes in area and shoreline length.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and Doug and District staff,

By Monday or Tuesday of next week, I will send you a complete document of some analyses I have conducted and presentations of existing results for the Little Manatee River. You have already seen some components that were sent with earlier emails.

Today, I want to again express my interest in running some simple graphs and statistics on model output for the Little Manatee River, both from the EFDC salinity model and the EFF fish habitat favorability modeling. These two requests are discussed sequentially below.

1. In earlier correspondence, I asked for output from the EFDC salinity model and Doug and I agreed it would be fine to wait until the revised model runs are completed - sounds good, thanks very much.
In other correspondence (Nov. 23), I discussed how shoreline length is also an important parameter that should be simulated for change using the EFDC model for the Little Manatee. The District has simulated changes in shoreline length in other rivers and it is listed as a parameter of interest to MFL determinations in the excellent presentation Gabe gave to the EAC last week.

The need to do shoreline simulations is especially pronounced on the Little Manatee. The river has an unusual morphology with the braided zone above Interstate 75 that has abundant oligohaline and freshwater marshes that would be susceptible to the effects of upstream salinity movement due to freshwater flow reductions. In this river in particular, changes in river area or volume are not always adequate predictors of changes in shoreline length. I have attached a simple document that has three graphs to make that point, especially for the Little Manatee.

So, along with my recommendation to include changes in shoreline length upstream of various salinity concentrations in the Little Manatee minimum flows analysis. I would like to receive model output values for shoreline length as well, in similar format as the area and volume. As discussed in previous emails, the format and content of these files can be pretty simple, with the date and daily values for rate of flow and the quantity of the parameter of interest (area, volume or shoreline length) for baseline

and a few flow reduction scenarios.

2. In an email dated Dec 13th and reiterated on January 7th, I would like to also receive model output from the EFF fish habitat modeling for several species and a few flow reduction scenarios. Like the salinity model output, these files can be in fairly simple format. Because it is not expected that the EFF model results will change, I hope the District can send this EFF output to me before too long.

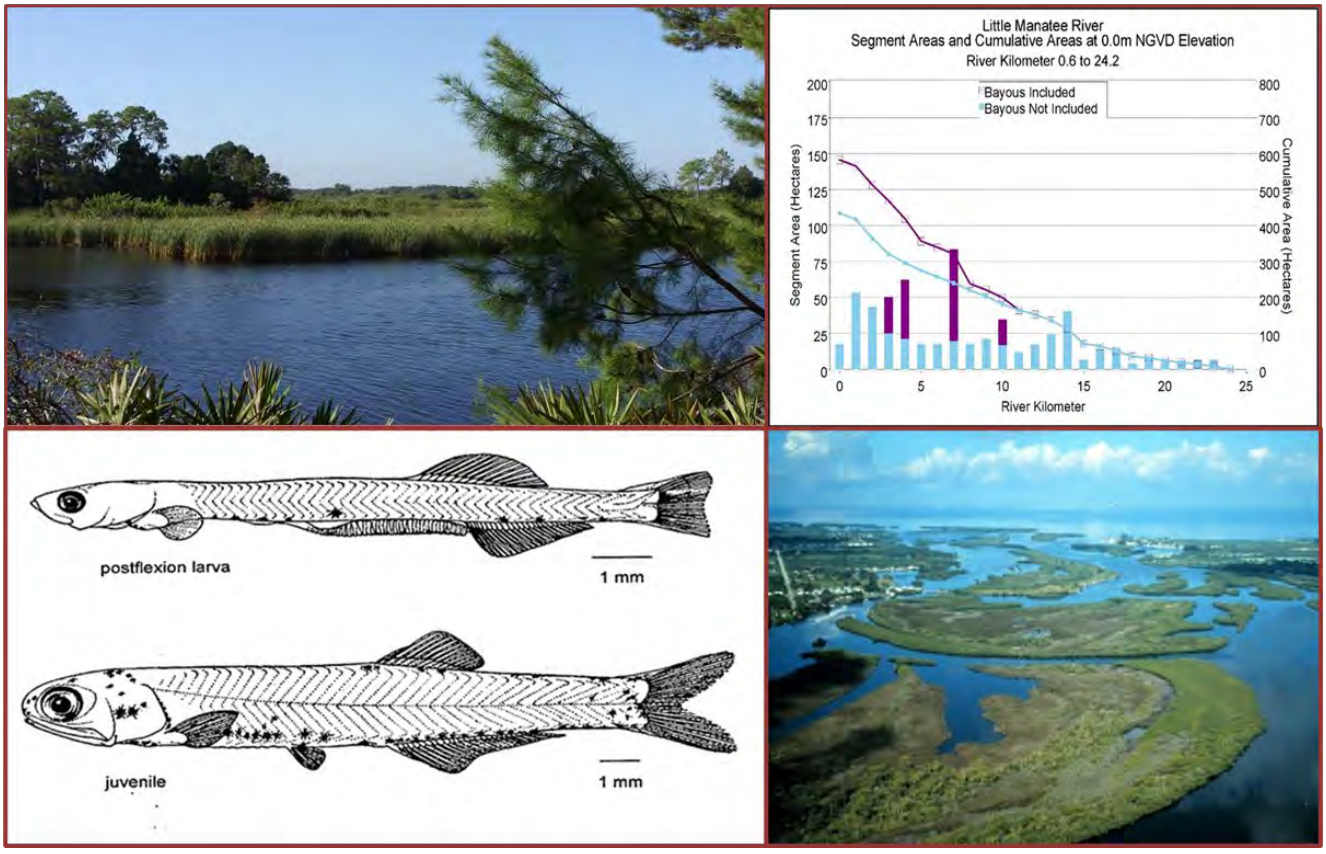
As I discussed at the EAC meeting and was in the partial draft document I sent on January 7th, I want to do some simple plots and tests on both types of model output to determine how each variable responds to freshwater inflow, which could be very helpful to the minimum flows analysis.

And - congratulations to the UGA Bulldogs on the national NCAA football championship!!

Sid

DRAFT

Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows for the Little Manatee River



January 24, 2022

Prepared by Sid Flannery - Retired, formerly Chief Environmental Scientist with the SWFWMD minimum flows program

Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows report for the Little Manatee River

Summary

This document presents a series of new analyses, presentation of existing information in District files, and technical clarifications related to the evaluation of minimum flows for the Little Manatee River by the Southwest Florida Water Management District. Summary points are below, with the text starting on page 3.

1. Discharges from the Mosaic company's point source discharge site D-001 have occurred during roughly half the months in recent years, comprising 16% of the average flow of the river. Due to uncertainties in the effects of phosphate mining in the watershed, including the future discontinuation of discharges from site D-001, a cautious approach should be taken to determining minimum flows for the Little Manatee River.

2. The 72 cfs threshold to identify the high flow block has been slightly below the median flow for the river for over four decades, including recent years. The flow-based blocks were based solely on ecological analyses of the upper river and 72 cfs is not an appropriate high flow threshold for the lower river. Many important variables in estuaries have a nonlinear relationship with flow, which needs to be accounted for when evaluating flow-based blocks for the lower river.

3. The flow duration characteristics of the period of minimum flows analysis must also be considered because they can affect the results of minimum flows analyses. The 2015-2019 period on which the fish EFF analysis was conducted was very wet, which needs to be examined to see how that may have affected the determination of the proposed minimum flows.

4. There is a bathymetric map of the river that should be included in the report and an area-volume file by kilometer and depth on file which might help in the assessment of the bathymetric accuracy and resolution of the EFDC model. There are existing graphs of the morphometric characteristics of the rive in one-kilometer intervals that should be included in the report as they are related to the overlap of stationary and dynamic components that is important for assessing freshwater inflow relationships in estuaries and evaluation of minimum flows.

5. There are extensive salinity and dissolved oxygen data along the length of the lower river collected by the EPCHC that should be presented in the minimum flows report. Field sampling has shown that brackish water (>1 psu salinity) rarely goes upstream of kilometer 17 and the report should clarify there is a tidal freshwater zone approximately 4 to 6 kilometers long below the US 301 bridge.

6. Values are presented for vertical salinity stratification in the river, which tends to be greatest in the middle flow range.

7. Although recent trends in water quality in the river have shown either no trend or improving conditions for many constituents, long-term data indicate the river continues to be enriched in nitrogen, which can affect freshwater flow relationships with phytoplankton and chlorophyll *a* in the estuary that can be related to the evaluation of minimum flows.

8. Possibly due to a misinterpretation of the plankton counting method in another report, the table of most abundant taxa for the ichthyoplankton data in the minimum flows report left out the numerically dominant fish species in the tidal river, the bay anchovy. Suggestions are made for three figures that should be added to the Ichthyoplankton section of the report.

9. Mean salinity at capture values reported in previous studies of ichthyoplankton and nekton by the University of South Florida and the Florida Marine Research Institute should be included in the minimum flows report. Although salinity modeling with the EFDC model indicates the < 2 psu zone was the most conservative for habitat protection, the mean salinity at capture values for the ten fish species that were simulated in the Environmental Favorability Function (EFF) modeling are primarily in the mesohaline zone.

10. The previous draft minimum flows report for the lower river published in 2018 applied a regression equation developed by the Florida Marine Research Institute to predict the abundance of blue crabs as a function of freshwater inflow based on data from 1996 to 2006. However, the most recent minimum flows report discontinued use of this regression, resulting in a large increase the percent allowable flow reduction in the high flow block. Given that there is now more than thirteen additional years of catch data available, it may be worth revising relationships of freshwater inflow with species abundance in the lower river.

11. There are a number of physical and ecological characteristics of the lower river that were described in more detail in the previous draft report for the lower river. The current report could benefit from greater elaboration on the findings of previous studies of the lower river. This has particular relevance to the trophic dynamics and ecological characteristics of low salinity areas that serve as nursery areas for estuarine dependent fishes.

12. In a separate document, I will present data for relationships of freshwater inflow with salinity, fish community characteristics, and chlorophyll *a* to evaluate flow-based blocks for the lower river.

13. I have requested from the District output for predictions of salinity zones from the EFDC model and favorable fish habitat from the EFF modeling effort to examine how the predicted values vary as a function of freshwater inflow in order to assess how flow duration characteristics during the evaluation periods may have affected the proposed minimum flows.

14. As a clarification, for the previous minimum flows analysis of the upper river published in 2011, the District assessed trends in various percentile flows within seasons to develop a baseline flow record, which were informative and described in the 2011 report. However, apparently due to a miscommunication, the subtraction of 15 cfs was applied to the gaged record for baseline simulations for the upper river using the HEC -RAS simulations in the previous minimum flows evaluation for the upper river. However, that is now water harmlessly under the bridge, as the method of baseline flow calculation used in the current minimum flows analysis is an improvement over the previously developed method.

Overview

This document presents a series of new analyses and presentations of existing information in District files that are related to the evaluation of minimum flows for the Little Manatee River by the Southwest Florida Water Management District (the District), for which a draft report was recently published (Holzwart et al. 2021). The document also provides clarification or elaboration on statements made in the draft report. The purpose of this document is to present findings that are relevant to and can benefit the evaluation of minimum flows for the Little Manatee River.

The material I present is based in part on my knowledge of the Little Manatee River, for I worked extensively on the ecological flow relationships of the river for many years and was the project manager for many of the consultant, agency, and university reports cited in the draft District report. This document presents suggestions on how additional material can be considered or incorporated in the District report to address topics that either I or the review panel have identified. This should not be viewed as not a complete review of the minimum flows project or report, for I have made other suggestions to the District in previous correspondence, some of which are generally referred in this document.

In 2011, the District published a minimum flows report for the upper freshwater section of the river (Hood et al. 2011) that underwent peer review and is included as Appendix A to the draft minimum flows report. In 2018, the District published a draft reevaluation of the minimum flows for the upper river (JEI 2018a) prepared by the primary consultant on the current project, Janicki Environmental Incorporated (JEI), which is included as Appendix C to the current draft report. A draft minimum flows report for the lower river also prepared by Janicki Environmental in 2018 is provided as Appendix E (JEI 2018b). That report for the lower river took some technical approaches that have since changed, but it presented a great deal of very useful material that I describe and reprint in some cases.

It seems that when the District decided to prepare a combined minimum flows report for the upper and lower river, there was a desire to consolidate the material to keep the report from being too lengthy, and in my opinion, some important material got dropped. Minimum flows reports serve as important technical documents that are frequently referenced to cite important physical, hydrologic, and ecological information for a particular river. Accordingly, minimum flows reports should be thorough and accurate in how they present important information for a river. As described in this document, I have suggested some revisions to the minimum flows report and identify some material presented in the previous reports for the upper and lower river that should be updated and incorporated in the current minimum flows report.

The topics that are described in this following document are:

1. Recent point source discharges from the Mosaic Company Four Corners mine and the status of phosphate mining in the Little Manatee River watershed
2. Clarification and analysis of the flow duration characteristics of the 72 cfs threshold to switch from medium flow to high flow blocks to change the allowable percent flow reductions

3. Additional bathymetric and morphometric information for the lower river

4. Additional salinity data for the lower river and the upstream extent of estuarine conditions

5. Additional dissolved oxygen data for the lower river

6. Nitrogen and groundwater enrichment of the lower river

7. Additional statistics and data presentations for ichthyoplankton in the lower river

8. Additional statistics and data presentations for nekton (fishes and larger free-swimming invertebrates) collected by seine and trawl in the lower river

9. Greater elaboration of the characteristics and functions of low salinity zones in the lower river related to favorable fish habitat and food web relationships

10. Previous District method for baseline flow calculation

11. Citation for the MIKE SHE integrated model output for the Myakka River presented in the report

I anticipate submitting two more documents to the District. The next will include discussions of: factors that should be evaluated to determine low, medium, and high flow blocks for the lower river; how the flow duration characteristics of the modeling periods may have influenced the results of the minimum flows analyses; and revisiting some of the relationships of nekton abundance with flow that were presented in the previous minimum report for the lower river (JEI 2018b).

Toward the end of the process, I will also submit a review of the report that provides edits, corrections, or clarifications of statements or terminology used in specific sentences of paragraphs, some of which I have already identified in previous correspondence to the District.

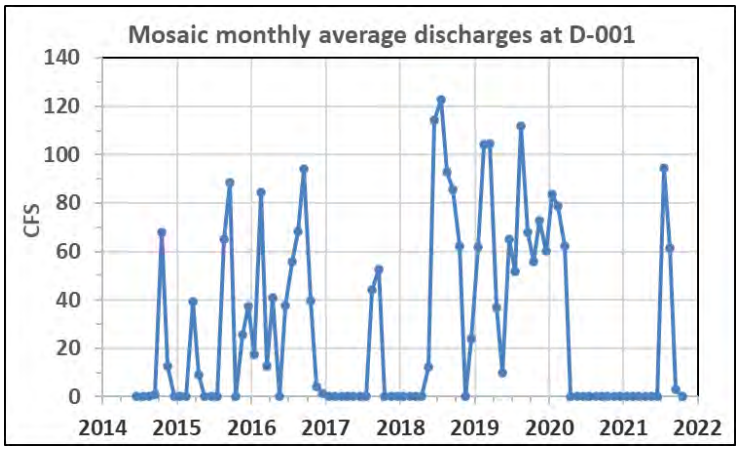
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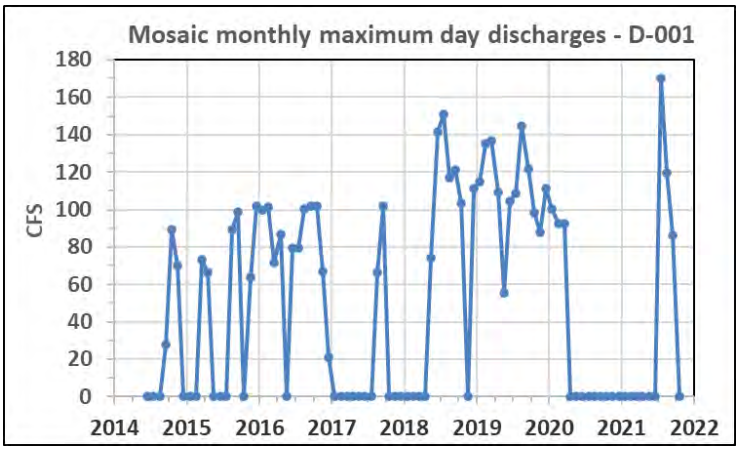
1. Recent point source discharges from the Mosaic Company Four Corners mine and status of phosphate mining in the Little Manatee River watershed.

The Mosaic Company mines phosphate ore in the upper reaches of the Little Manatee River watershed. Associated with this mining is point source discharge site D-001 located on the upper reaches of Aldermans Creek, which flows to the Little Manatee. This discharge is part of the Four Corners Mine and includes discharges that originate outside the Little Manatee River watershed.

On page 44 the draft minimum flows report cites a study from 2012 (FDEP 2012) that concluded that discharge from site D-001 has been limited for several years, so the District did not present any discharge values for that site. The previous minimum flows report for the upper river (Hood et al. 2011) showed a hydrograph for discharges at site D-001, but did not adjust the baseline flows for discharges from D-001 for it drained actively mined lands. The subsequent draft reports for the upper and lower river (JEI 2018a ,JEI 2018b) also showed graphs for discharges from site D-001, with the its net effect in the mined lands reflected in the rainfall streamflow regression used develop the baseline flow record for those reports. I don't think that the baseline flow record needs to be explicitly adjusted for the discharges from D-001, but a greater discussion of those discharges needs to be in the minimum flows report for they have a significant effect on the river's flow regime.

I contacted the Florida DEP and made retrievals from their OCULUS data base and found that discharge records for Site D-001 are very sparse from 2010 through 2012, but a continuous record of monthly discharges exists from June 2014 to recent, with six other monthly values recorded between August 2013 to April 2014. During this period, discharges from site D-001 were fairly frequent and of considerable magnitude. Monthly values for average monthly discharges and maximum day discharges within months for the continuous record from June 2014 to October 2021 are shown in Figures 1 and 2. Discharges from Site D-001 occurred during 53 percent of the 89 months during that period. Average monthly discharges at D-001 exceeded 60 cfs in 24 of those months (Figure 1), while maximum daily flows exceeded 100 cfs in 25 of those months (Figure 2).





Figures 1 and 2. Average monthly and maximum day per month discharges from Site D-001 for the period June 2014 to October 2021.

These discharges have comprised a significant proportion of the flow of the Little Manatee River in recent years. From June 2014 to October 2021, the average discharge from Site D-001 was 29.2 cfs, equal to 16.1 percent of the average flow of the river at the USGS gage at US 301 gage near Wimauma (181.8 cfs) for this same period. For the seven full years of complete record from June 2014 to May 2021, the average flow from D-001 (29.0 cfs) was 16.4 percent of the average flow at the USGS gage (176.3 cfs). During the 47 months when discharges from D-001 were occurring, they comprised 21.2 percent of the gaged flow of the river.

During some months the discharges from site D-001 comprised large proportions of the flows at the USGS gage (Figure 3). Based on a percentage of flow there are some months where the results seem unusually high, but large one-day discharges at D-001 could have played a role. I do not know the accuracy of the flow rating measurements used by Mosaic, but FDEP staff have confirmed that the average monthly flow values are for all days in the month, not just for the days that the discharges were occurring.

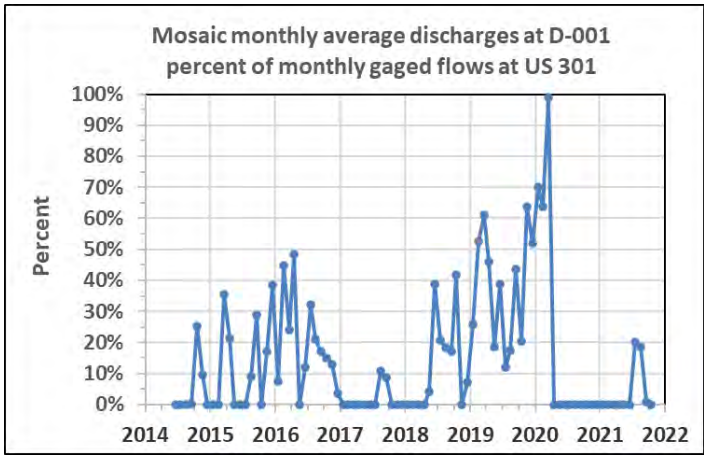


Figure 3. Percentage of average monthly gaged flows at the Little Manatee River at US 301 near Wimauma comprised of average monthly discharges at Mosaic Site D-001

In their initial report, the review panel identified the effects of phosphate mining on the hydrology of the Little Manatee River as an issue of concern, including a statement on page 2-33 that reads "Report needs more discussion regarding the impacts of mining on the recent streamflow record." I concur with that statement and recommend that the discharge record for site-2001 be updated and presented and discussed in the minimum flow report. In that regard, I have provided to the District the discharge data for site D-001 that I obtained from the Florida DEP.

Because it includes water that originates outside the Little Manatee watershed, I wonder if discharges from site D-001 could be masking any potential flow reductions resulting from mining within the Little Manatee River basin. The review panel also questioned if mining in the upperpart of the watershed could affect the degree of confinement between surficial features and the Upper Floridan aquifer.

I do not know the answer to these questions, but believe the discussion of the status of previous, ongoing, and future mining in the Little Manatee River and its possible effects on the river's flow

regime needs more emphasis in the minimum flows report. I also think the evaluation of minimum flows for the Little Manatee River needs to be conservative in how much water can be withdrawn from the river, because the flows of the river are in a state of flux due to mining in the watershed.

With regard to geographical data presentation, the previous minimum flows report for the upper (Hood et al. 2011, Appendix A), the reevaluation of those minimum flows (JEI 2018a, Appendix C), and the previous draft minimum flows report for the lower river (JEI 2018b, Appendix E) all presented land cover/use maps that were much more informative than the map presented in the current draft minimum flows report. To illustrate this point, the map that was published in 2018 for both the reevaluation of the minimum flows for the upper river and the draft report for the lower river previous is shown in Figure 4. This map, which is for the year 2011, shows separate coverages for active mines and reclaimed land.

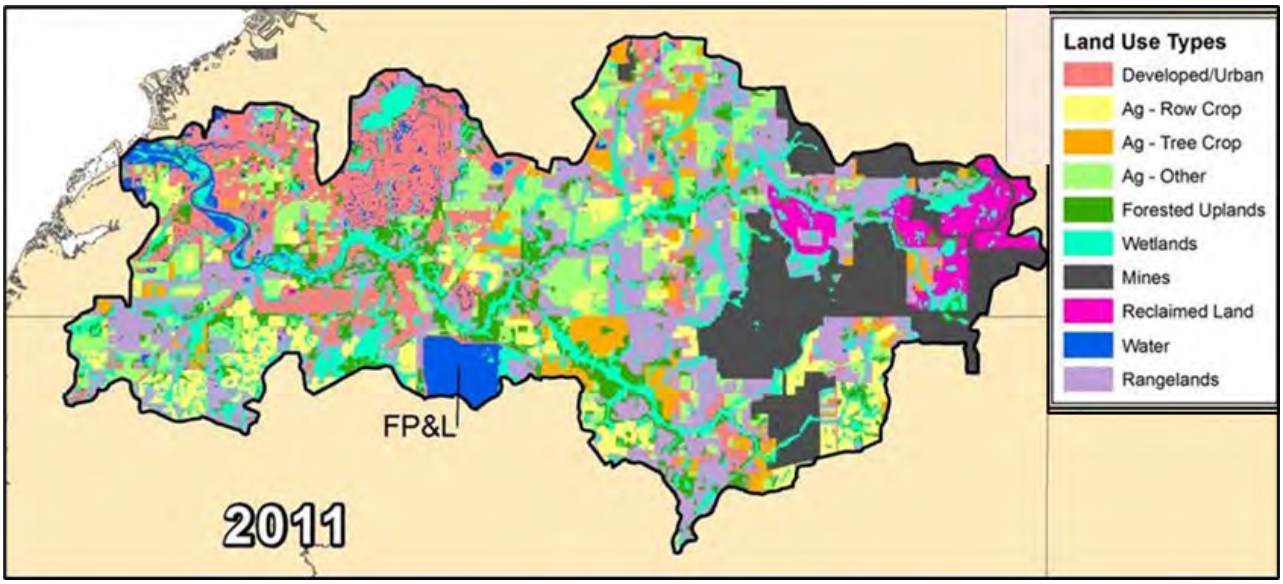


Figure 4. Land/Use cover map in the Little Manatee River Watershed for 2011, adapted from Figure 2-5 in JEI (2018a, Appendix C) and Figure 2-6 in JEI (2018b, Appendix E).

Although not reprinted here, the first minimum flows report for the upper river (Hood et al. 2011) included a very informative map specific to the Mosaic Company's land holdings in 2011 that showed separate coverages for preserved floodplain lands, reclaimed lands, and active mining along with the location of the D-001 discharge point.

All three of these previous reports presented tables listing the amounts of reclaimed land and lands currently being mined, with the first minimum flows report for the upper river identifying other categories such as preserved floodplains, Mosaic land holdings not to be mined, and the percentages these various categories comprised of the total Mosaic lands.

The current minimum flows report shows land use/cover maps for the Little Manatee River for six different years ranging from 1974 to 2017, with the map for 2017 shown below (Figure 5). Possibly for consistency, these maps are for Level 1 classifications using the FLUCCS system. Both mined and reclaimed lands are included in the Urban and Built-Up category, making it impossible to visually separate out the mined or reclaimed lands from urban and built-up lands in other parts of the watershed. The current minimum flows report does include a table (Table 2-1 on page 27) that lists the acreages of land covers for these same six years, with extractive (mining) land cover quantified using FLUCCS Level 4 classification. However, the quantity of reclaimed land is not identified.

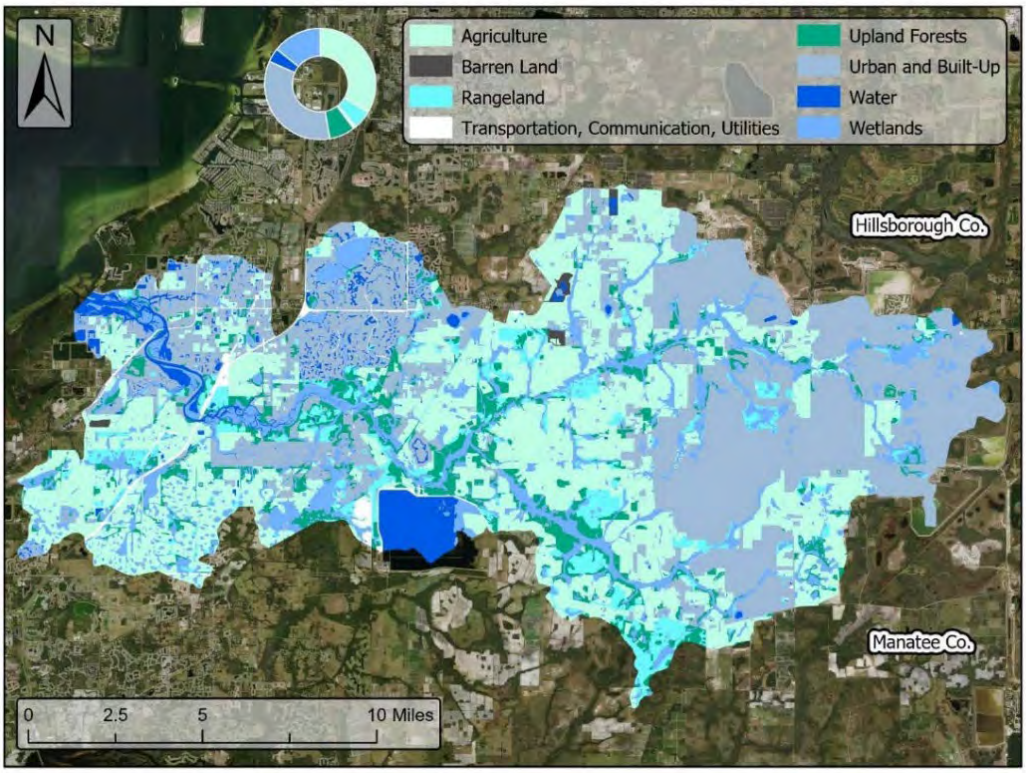


Figure 5. The 2017 Florida Land Use, Cover and Forms Classification System (Level 1) of the Little Manatee River watershed (SWFWMD 2019). Reprinted from 2021 draft minimum flows report.

Hood et al. (2011) states that the Mosaic Company owns approximately 26% of the Little Manatee River watershed. Given the frequent large discharges from site D-001 and the extent of current and projected future mining in the watershed, it would significantly improve the minimum flows report to include a more detailed land use/cover map for the watershed. Although the report could refer to maps in the Appendices, it is much better to improve the map in the primary report.

The District should also present updated discharge records for site D-001 and discuss the potential impacts of current and additional mining in the Little Manatee River watershed, including the future discontinuation of discharges from site D-001 on the hydrology of the river. Again, based on uncertainties in the effects of current and future mining and discharges from site D-001, I think a cautious, conservative approach needs to be taken to establishing minimum flows for the Little Manatee River.

2. Additional flow duration analysis of the 72 cfs threshold to switch from medium to high flow blocks to change allowable percent flow reduction rates

The proposed minimum flows for both the upper and lower sections of the Little Manatee River both include a threshold of 72 cfs to switch from the medium to high flow blocks to change the percent flow reductions that comply with the minimum flows. In that regard, it is important to examine how often a flow of 72 cfs is exceeded and the percent withdrawals for the high flow blocks will be in effect. First, though, it is helpful to examine how the 72 cfs threshold for switching blocks was determined for the Little Manatee.

For many years the District employed a seasonal calendar-based approach to minimum flows for freshwater rivers, in which three seasonal blocks were assigned to the spring dry season, the summer wet season, and the intermediate flow season from fall to early spring. The first minimum flows report for the Little Manatee River (Hood et al. 2011) employed this seasonal block approach, but the review panel for the first report suggested that a flow-based approach could be more straightforward and protective of the river system (Powell et al. 2012, Appendix B).

Accordingly, the reevaluation of the minimum flows for the upper river recommended that a flow-based approach be applied using flow rates to identify blocks for low, medium, and high flows in combination with a 35 cfs low flow cutoff (JEI 2018a). The current minimum flows report utilizes this approach, and established a flow rate of 72 cfs as the threshold to switch from the medium to the high flow block, with a second high flow block for the upper river at flows above 174 cfs. This is the first time the District has applied flow-based blocks to a freshwater river and I strongly endorse that approach.

In contrast, the District has typically not applied seasonal calendar-based blocks for the estuarine rivers, but instead has used either a single percentage withdrawal rate (e.g., Lower Alafia, Weeki Wachee, Homosassa) or included one or more flow-based thresholds to switch percentage withdrawal rates (lower reaches of the Myakka, Pithlachascotee and Peace Rivers and Shell Creek). The initial minimum flows that were adopted for the Lower Peace River used a calendar-based approach, but included a flow-based threshold so that blocks for intermediate and high flow seasons could not go into effect until flows in the river exceeded a rate of 625 cfs (SWFWMD, 2010). The readoption of minimum flows for the Lower Peace River went to a straight flow-based approach with blocks for low, medium, and high flows used in combination with a low flow threshold below which no surface water withdrawals are allowed (Ghile et al. 2021).

For the Little Manatee, the District took a different approach and determined flow-based blocks based on relationships in the freshwater section of the river and then simply applied those same blocks to the proposed minimum flows rules for the estuarine lower river. This is the first time the District has done this, and I think this is a fundamental mistake that is unnecessary from a practical water management perspective, and more importantly, does not account for important relationships of flow with circulation, salinity, water quality and the biology of the lower river. I have examined some of these relationships and 72 is not a appropriate high flow threshold for the

lower river. As has been done on other tidal rivers, relationships with flow should be examined within the estuarine section of the Little Manatee to develop flow-based blocks that protect those valuable resources.

There has been some revision in the methods used to determine minimum flows for the lower river since they were first proposed in the draft 2018 report (JEI 2018b). That report utilized regression equations developed by Peebles (2008) and MacDonald et al. (2007) to predict the abundance of various species of ichthyoplankton or nekton (fishes and larger free-swimming invertebrates such as blue crabs) as a function of flow. The report also used Environmental Favorability Function (EFF) modeling to evaluate reductions favorable habitat for key fish species as a function of flow. Based on these analyses, the 2018 report concluded that the minimum flows proposed for the upper section of the Little Manatee (JEI 2018a) were protective of the lower river.

As previously discussed, the current minimum flows report combined the findings of the previous evaluations of the upper and lower river into one report. With some updates and modifications, much of the results for the upper river were carried over from the 2018 report to the current report, including the same flow-based blocks with a slight revision to the allowable percent withdrawals for the upper river. However, for the lower river the current report dropped the regressions to predict fish or blue crab abundance as function of flow that were presented in the 2018 report, and instead, relied solely on the Environmental Favorability Function modeling to evaluate impacts to favorable fish habitats in the lower river. This greatly increased the flow reduction percentages allowed for the high flow block for the lower river from 16 to 30 percent.

The 72 cfs threshold to identify the high flow block that was first presented in the 2018 reevaluation of minimum flows for the upper river remains in effect for lower river in the current draft minimum flows report. The only description of how often this threshold will be in effect in the report is on page 103, where it says "72 cfs is the 60th non-exceedance percentile. These blocks are defined using the flow record at the USGS Little Manatee River at US 301 near Wimauma FL (No. 02300500) gage. The period of record is April 1, 1939 through December 31, 2014."

The sentence above from the draft minimum flows report needs clarification, for this value was not taken from actual flow record at the USGS gage. I checked the flow records at the USGS gage and found that 72 cfs corresponded to the 56th percentile flow at this gage, rather than the 60th percentile reported for that same period. This is because the 2018 reevaluation of minimum flows for the upper river describes that 72 cfs is the 60th percentile value for the baseline flow record from April 1, 1939 to December 31, 2014, which included adjusting the flows from 1977 forward to account for excess flows the river has received due to changes in land and water use in the watershed (see Table 3-2 in JEI 2018a). This should be clarified in the current minimum flows report, for it is confusing that in a report that presents some data through 2020, the flow blocks are statistically described in terms of baseline flows that end in 2014.

The percentile value of 72 cfs in the long-term baseline flow record is useful but, it is just as important to see how often 72 cfs has been exceed in recent decades for that is the flow regime that the river system has adapted to, especially the lower river which is strongly influenced by

salinity gradients that are dependent upon the rate of freshwater inflow. We do not know to what degree the river will return to a baseline flow condition, and if the resources of the lower river are to be protected, it is important to evaluate how often the different flow blocks will be applied in the current hydrologic setting.

To address this question, I have calculated the percentile values for 72 cfs for various time intervals using the gaged flow records for the river at the USGS gage at US 301 near Wimauma (Table 1). It is simple to correct the gaged flow record for withdrawals by Florida Power and Light (FP&L), so values are listed for both the observed gaged flows and flows corrected for FP&L withdrawals which began in December of 1976. However, it is reiterated the uncorrected gaged flow record is what the river below that intake receives, which includes the entire lower river.

Table 1. Percentile values for a flow rate of 72 cfs for the observed flows at the USGS Little Manatee River at US 301 near Wimauma gage and the gaged flows corrected for upstream withdrawals by the Florida Power and Light Corporation.

Time period	Percentile in gage flows	Percentile in corrected flows
1977 - 2020 (43 years)	47th	45th
1991 - 2020 (30 years)	48th	46th
2001 – 2020 (20 years)	48th	47th
2015 – 2019 (5 years)	42th	42th

For periods going back over 40 years, 72 cfs was actually slightly less than the median gaged flow of the river. The review panel has identified the selection of flow blocks as a topic that needs further investigation, noting on page 2-29 that based on field observations by a panel member on October 15, 2021, flows were within the banks at several locations when flows were at 82 cfs, which "raises the question of whether the 60th percentile flow (72 cfs) is properly supported as a high-flow threshold."

The panel also questioned how changing the 72 cfs threshold could change the allowable flow reductions allowed for the lower river in the medium flow block 2, noting "72 cfs is not a significantly high flow value and represents the 60 percentile as outlined in the section above." This statement is even more profound when it is understood that 72 cfs has actually been slightly less than the median flow for the river for over four decades.

It is important to note that during 2015 to 2019, 72 cfs corresponded to the 42nd percentile for both the gaged and corrected flows. As described in Section 6.5 of the draft minimum flows report, the five-year period from 2015 to 2019 was the period that was ultimately applied in the EFF modeling to evaluate changes in favorable fish habitat that would cause significant harm based on habitat reductions greater than 15 percent.

The section about fish estuarine fish habitat modeling in the draft minimum flows includes a table (Table 6-4) reprinted below that lists flows rates corresponding to various percentiles in the gaged flow record for the river for four multi-year intervals. These values were taken from the report by Jacobs and JEI (2021b), which is included as Appendix D3 to the minimum flows report.

Table 2. Distributional percentile values for observed discharge at the USGS Little Manatee River at US 301 near Wimauma (No. 02300500) gage for periods of record considered for environmental favorability analyses based on a LOESS regression for predicting salinity (from Jacobs and JEI 2021b). Reprinted from the current draft minimum flows report

Percentile	1940-2014	1940-2019	1996-2019	2000-2005
Min	0.92	0.92	3.8	3.8
5th	12	12	16	16
10th	18	18	24	21
25th	31	32	37	39
50th	61	62	75	81
75th	145	152	167	165
90th	379	387	375	380
Max	11100	11100	10400	10400

Percentile values were not listed in the table above for the period from 2015 to 2019, which is the period for which changes in favorable fish habitat were reported in four subsequent tables in that section of the 2021 draft minimum flows report. To address that omission, I have listed the flow values corresponding to the same percentiles for 2015 to 2019 at the USGS gage in Table 4 below. Percentile values are also listed for the long-term period for complete years from 1940 to 2020.

Table 3. Distributional percentile values for observed discharge at the USGS Little Manatee River at US 301 near Wimauma gage for the years 2015 to 2019 and 1940 to 2020.

Years	Minimum	5th	10th	25th	50th	75th	90th	Maximum
2015-2019	9	19	29	40	105	243	516	4,350
1940-2020	1	12	18	32	63	151	384	10,400

In comparing the values for 2015-2019 to the long-term values for 1940 – 2020, it is clear that 2015 – 2019 was a wet period, with higher typically percentile values especially between the 50th (median) and 90th percentiles. In fact, the 5-year median flow for 2015-2019 was the highest in 81 years of records for complete years at the USGS gage.

The values for 2015-2019 are also considerably higher than for the periods shown in Table 3, which was reprinted from the minimum flows report. For example, the P10 (10th percentile) for 2015-2019 was 29 cfs compared to a range of 18 to 24 cfs for the year intervals in Table 3, the P50 for 2015-2019 was 105 cfs compared to range of 61 to 81 cfs in Table 3, the P75 for 2015-2019 was 243 cfs compared to a range of 145 to 167 cfs in Table 3, and the P90 for 2015 – 2019 below was 516 cfs compared to a range of 375 to 387 cfs in Table 3.

On page 150, the minimum flows report describes that the results for changes in favorable fish habitat were more conservative than results for the modeling of biologically important salinity zones using the EFDC hydrodynamic model for the river. Therefore, the proposed minimum flows for the Lower Little Manatee River were based on the Environmental Favorability Function (EFF) analysis. It was not clear why the 2015-2019 period was used for the final EFF analyses, but it was and the proposed minimum flows were ultimately based on EFF results for that period.

Keep in mind the 72 cfs threshold is supposed to represent a high flow block for the Little Manatee River. The fact that 72 cfs is actually less than the median flow for the river in recent decades does not pose an undue risk to the natural systems of the upper river, because the allowable flow reductions for the two high flow blocks (13% and 11%) for the upper river are less than the allowable flow reduction (20%) for the medium flow block that extends from 35 cfs to 72 cfs.

It is a very different situation in the lower river, where the allowable flow reduction for the medium flow block (20%) increases to a rate of 30% in the high flow block for all flows above 72 cfs. Based on flow data for the river for the last several decades, an allowable flow reduction rate of 30% will be in effect for slightly over half the year on average and considerably more often in some years. This is potentially problematic, as the selection of 72 cfs as the threshold between the medium and high flow blocks was not based on analyses of relationships of flow with salinity, water quality, fish or invertebrate species or ecological parameters within the lower river.

Relation of flow duration characteristics to the assessment of nonlinear relationships in estuaries

The fact that the allowable for reductions for the lower river was based on analyses of an unusually wet multi-year period is an important factor that warrants further investigation. The fish species that were assessed with the EFF modeling are species that prefer low salinity habitats, so the amounts of favorable habitat for these species should increase with flow. However, the report does not show the shapes of the response curves of favorable habitats for these species as a function of freshwater inflow.

It is important to consider is that the response of many variables or parameters in estuaries to in freshwater inflow is nonlinear, and the change in a particular parameter can be more sensitive to flow reductions at low flows and less sensitive at high flows. This concept was important to original development of the percent-of-flow method, with the Little Manatee River being one of the first three rivers (along with the Peace and Alafia) from which findings were used to support the percent-of-flow-method over twenty years ago (see abstract in Flannery et al. 2002).

Two examples of a nonlinear response to freshwater inflow are shown in Figures 6 and 7 on the following page. The area and volume of various salinity zones typically show a steep rate of change at low flows, with an inflexion region in the medium flow range, and more a gradual response to freshwater flow at high flows. Similarly, residence time, which can strongly affect water quality in estuaries, has a strong nonlinear response to freshwater inflow at different locations in the estuary, with rapid changes at lows, an inflexion region, and a more gradual change at high flows. It is

worth noting that Figure 7 was taken from the first draft minimum flows report for the lower river (JEI 2018b) based on work by Huang and Liu (2006), while the current draft minimum flows report only mentions that residence time work was done without presenting any results.

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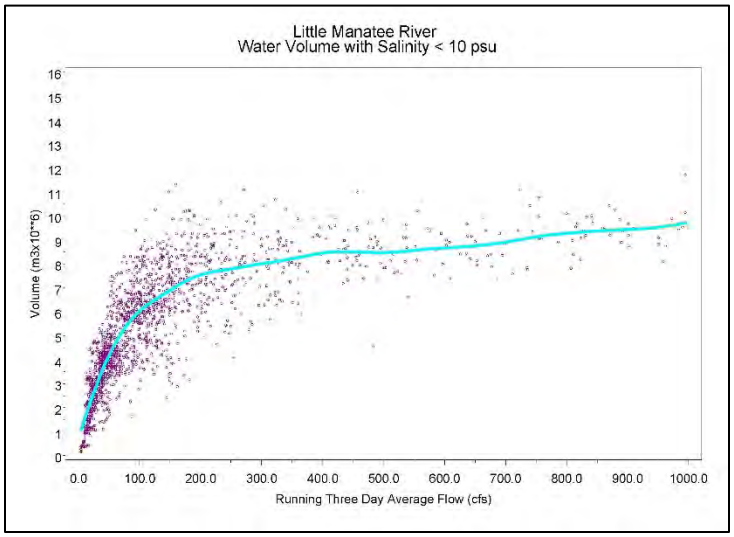


Figure 6. Water volume less than 10 psu salinity in the Lower Little Manatee River as a function of preceding three-day freshwater inflow as predicted by the EFDC model for the lower river.

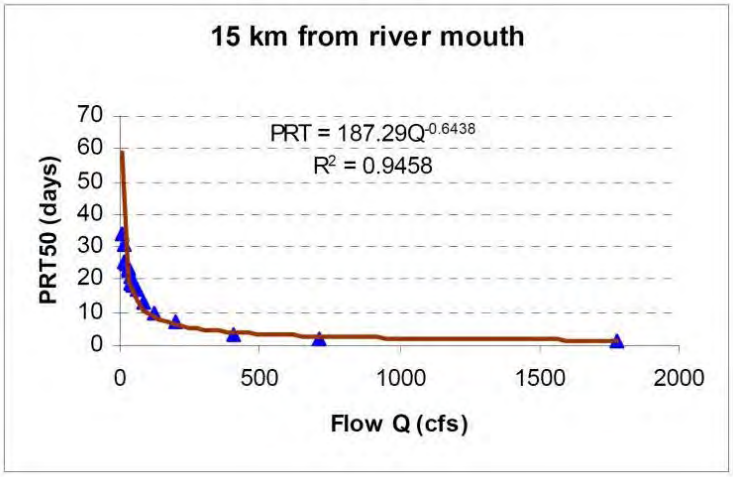


Figure 7. Pulse residence time versus freshwater inflow at a site 15 kilometers upstream from the mouth of the Little Manatee River, adapted from Figure 3-14 in JEI (2018b).

The nonlinear response of different variables in estuaries is important for evaluating flow-based blocks for which different percent allowable flow reductions can be determined. That was not done for the Little Manatee River, where flow blocks determined for the freshwater section of the river were applied to the estuarine section of the river. I will evaluate criteria for other possible flow blocks for the lower river in another document I will submit to the District.

For any flow-based blocks that are established, including those in the current draft minimum flows report, it is very important to evaluate the flow duration characteristics of the period that was used for the minimum flows analysis. Even when flow reductions are limited to a fixed percentage of daily flow, the resulting proportional (percentage) change for a parameter (e.g., volume of low salinity water) can be greater at low flows and less at high flows. An example of this for the Lower Alafia River is show in Figure 8. When this occurs, the smaller proportional changes at high flows, when numerical values of that parameter (e.g., cubic meters of volume) are high, can override the results for many days at low flows if simple averages of quantities of that parameter are calculated for the baseline and flow reduction scenario.

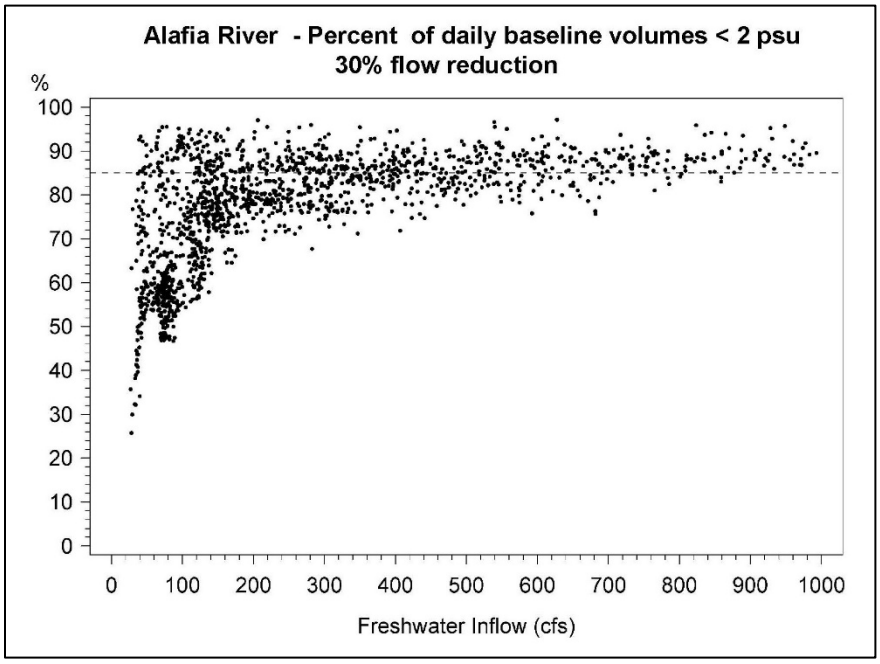


Figure 8. Percent of water volume less than 2 psu salinity relative to baseline for daily flow reductions of 30 percent vs. the rate of daily baseline flow for the Lower Alafia River with a reference line at 85 percent remaining habitat, equivalent to a 15% reduction in volume.

If the evaluation period is wet with flow duration characteristics that are markedly above average, the results of the minimum flows analysis can indicate that relatively high percent flow reductions are allowable because the findings have been influenced by the frequent occurrence of high flows, when the proportional changes in the parameter are less, but their numerical values are high. Conversely, minimum flow analyses that are based on periods with unusually low flows can come up with more restrictive allowable flow reductions, as the numerical values of the parameter are low, but their proportional changes are high.

The percentile values for flows shown in Tables 2 and 3 clearly show that the 2015 to 2019 period, on which the proposed minimum flows were based, was unusually wet. I realize that the EFF and salinity modeling analyses were conducted on baseline flows, but wet periods in the gaged records are also likely wet periods in the baseline record. Also, the baseline adjustment presented in the District report indicates the effects of land and water use on excess flows in the river have declined

in recent years. If that is the case, the difference between the baseline and gaged flows should be less in more recent years, making the 2015-2019 even more relatively wet within the baseline record.

To evaluate how prevailing hydrologic conditions could be affecting the results of a minimum analysis, the response of various parameters should be plotted as function of baseline flow to determine if the parameter responds to flow in generally a linear or nonlinear manner (e.g., Figures 6 and 7 on page 14). The percent changes in the parameters of interest should also should be plotted versus flow for the flow reduction scenarios being considered as shown in Figure 8 on page 15.

These graphics, and associated statistical analyses, can show how the response of a specific parameter is influenced by flow rate. If there is no substantial change in the percent reduction in a parameter as a function of baseline flow, then the effects of prolonged wet and dry periods in the analysis may be not critical. However, if the percent reductions in a parameter are related to the rate of baseline flow, the flow duration characteristics during the entire period of minimum flows analysis must be taken into account in the determination of minimum flows.

To address this topic, I have requested daily values of the area, volume and shoreline length of four salinity zones for baseline flows and five flow reduction scenarios that are predicted for the lower river using the EFDC model. The District has informed me they can provide output values when the new runs that incorporate revisions to the EFDC model runs are completed. I have also requested daily output of favorable habitat for nine fish species predicted by the EFF model for baseline and four flow reduction scenarios, which I hope to receive before too long. After I receive these files, I will perform analyses such as those described above to see how prevailing hydrologic conditions may have affected the minimum flow results.

- Text continues on next page -

3. Need to present bathymetric and morphometric information for the lower river

District minimum flows reports for estuarine rivers typically show a bathymetric map of the river and present graphs of morphometric information such as the area, volume, and various shoreline features as a function of distance along the river channel. Although such maps and graphics were readily available, they were not included in the draft minimum flows report for the Little Manatee and it would improve the report and enhance the interpretation and justification of the proposed minimum flows to include them in it. As such, maps and graphics that could be included in the minimum flows report are presented and discussed below.

Bathymetric information for the lower river was generated by staff from the Geology Department at the University of South Florida (Wang 2006), who have collected similar bathymetric data on other rivers for the District. The report that generated the bathymetric data was not cited in the draft minimum flows report, but has since been provided to the review panel. That project also generated jpg files of maps showing the shoreline of lower river and the bathymetric cross sections that were measured, which the District may have provided to the panel as well.

Bathymetric maps generated from the USF project have been generated twice. The files I have show a bathymetric map that I believe was generated by USF. Also, the previous draft report that proposed minimum flows for the lower river (JEI 2018b) included a bathymetric map of the lower river that appears to have been generated separately. Both of these maps are shown on the following page. Readers can zoom in to examine the maps at greater resolution or these maps can be requested from the District. The maps show similar patterns, but apparently were generated using different software programs.

Bathymetric maps are important for understanding how deep and shallow areas affect the circulation, water quality, and biological characteristics of an estuary. The review panel has also raised questions regarding the accuracy and resolution of the bathymetry that is incorporated in the EFDC hydrodynamic model for the river. The bathymetric data from the USF project was provided to the researchers from FSU who constructed the EFDC model, but I do not know how exactly it incorporated in the EFDC model. Possibly the bathymetric maps may assist the panel in assessment of the bathymetric accuracy and resolution of the EFDC model.

As part of the scope of work to develop the EFDC model, the staff from FSU also constructed a spreadsheet of the area and volume of the lower river at different depths in one-tenth kilometer intervals. A portion of that spreadsheet is shown on page 19. Though not shown, the file contained values down to a maximum depth of between 15 and 16.5 feet below NGVD 1929, which occurred in a deep area near kilometer 13.8. This file was based on the bathymetric data provided by Wang (2006), but I do not know how these correspond with the bathymetry and area and volume incorporated in the EFDC model. Regardless, this area and volume EXCEL file could be of use to the review panel and the District could provide it if it already has not.

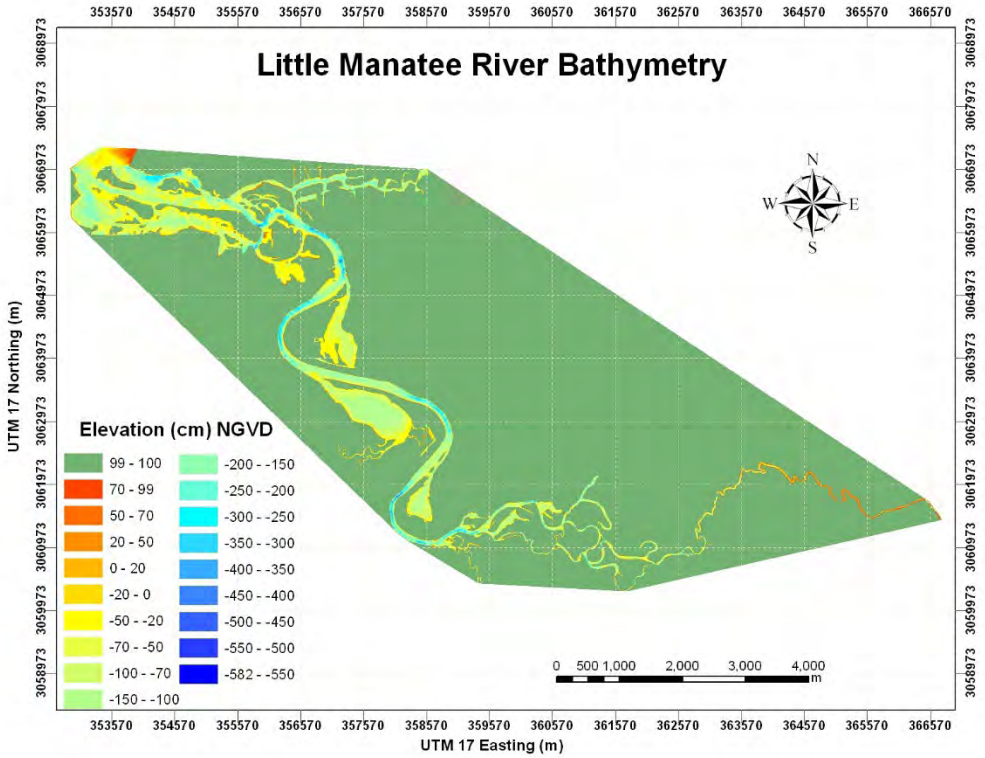
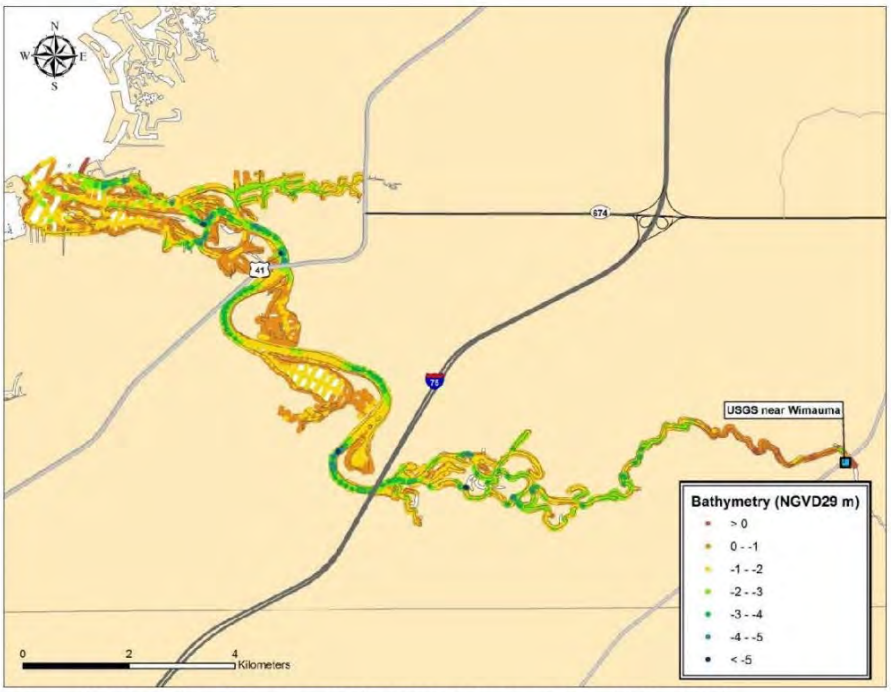


Figure 9. Bathymetric map of Little Manatee River generated from data from Wang (2006)



3-5. Bathymetry elevations of the Little Manatee River (USF, 2006).

Figure 10. Bathymetric map reprinted from the first draft minimum flows report for the lower river (JEI 2018b)

Table 4. Partial clip from EXCEL spreadsheet of area and volume values in one-tenth kilometer increments for the Little Manatee River developed by Huang and Liu (2007) from bathymetric data generated by Wang (2006). Downstream limit of file is 0.6 km on river centerline and the upstream limit is at kilometer 24.0. Depths (Z) are from NGVD 1929, with values extending down to depths between 15 and 16.5 feet at upriver locations. The description of this file is on page 17.

Little Manatee Area-Volume File																				
					A=Area	V=Volume														
				Centerline	Z<-0.0 feet		Z<-1.5 feet		Z<- 3 feet		Z<- 4.5 feet		Z<- 6 feet		Z<- 7.5 feet		Z<- 9 feet		Z<- 10.5 feet	
Cell	Long*	Lat*	Dx (m)	(Kilometer)	A (m^2)*	V(m^3)*	A(m^2)*	V(m^3)*	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)
2	-82.4817	27.7165	93.21	0.60	46471	70659	46386	49512	46301	28366	26655	11380	16711	2171	0	0	0	0	0	0
3	-82.4808	27.71627	87.65	0.70	43528	61062	43448	41267	34614	21953	17584	12048	17545	4031	0	0	0	0	0	0
4	-82.4799	27.71604	83.79	0.80	41446	62310	41369	43464	32960	25993	16739	15145	16701	7510	7838	2684	0	0	0	0
5	-82.4791	27.71583	81.49	0.90	40192	63121	40118	44862	31972	26724	23107	14560	16222	6628	8588	879	0	0	0	0
6	-82.4783	27.71562	80.61	1.00	39613	53005	39540	35004	30795	17741	8555	9712	8518	5840	8482	1968	0	0	0	0
7	-82.4776	27.71541	82.01	1.10	50362	43585	50286	20614	16925	2912	0	0	0	0	0	0	0	0	0	0
8	-82.4767	27.71521	83.84	1.10	51266	50797	51189	27428	42891	5826	0	0	0	0	0	0	0	0	0	0
9	-82.4759	27.71499	87.64	1.20	52154	52738	52073	28958	35281	7914	0	0	0	0	0	0	0	0	0	0
10	-82.475	27.71477	90.45	1.30	53480	53637	53398	29231	37482	7727	9742	268	0	0	0	0	0	0	0	0
11	-82.4741	27.71455	92.66	1.40	64307	65192	64223	35831	27822	15682	18926	6802	0	0	0	0	0	0	0	0
12	-82.4732	27.71431	94.21	1.50	46348	48452	46262	27325	37458	8076	9152	1624	0	0	0	0	0	0	0	0
13	-82.4723	27.71409	94.44	1.60	46354	52062	46267	30937	46181	9812	7848	59	0	0	0	0	0	0	0	0
14	-82.4711	27.71464	94.53	1.70	46281	52364	46195	31303	46109	10242	8837	1830	0	0	0	0	0	0	0	0
15	-82.47	27.71516	93.05	1.80	45295	52005	45210	31399	45126	10793	8725	3194	0	0	0	0	0	0	0	0
16	-82.4691	27.71493	91.19	1.90	35443	43775	35360	27683	35278	11591	8591	4591	8549	683	0	0	0	0	0	0
17	-82.4682	27.71471	87.42	2.00	33792	41199	33714	25858	33635	10517	8270	5155	8230	1397	0	0	0	0	0	0
18	-82.4674	27.71449	83.99	2.10	32228	31346	32153	16690	16285	4235	0	0	0	0	0	0	0	0	0	0
19	-82.4666	27.71427	80.73	2.20	39728	38385	39655	20297	24502	6358	0	0	0	0	0	0	0	0	0	0
20	-82.4658	27.71406	76.76	2.20	54011	52995	53942	28373	38970	5452	6262	235	0	0	0	0	0	0	0	0
21	-82.4651	27.71385	74.63	2.30	52153	48066	52086	24264	19218	7668	7093	2394	0	0	0	0	0	0	0	0
22	-82.4644	27.71364	72.25	2.40	39386	46034	39322	28068	18399	13414	12826	7407	12826	1539	0	0	0	0	0	0
23	-82.4637	27.71342	69.5	2.50	32369	37746	32307	22988	24350	9536	12328	2435	0	0	0	0	0	0	0	0
24	-82.463	27.71321	68.74	2.50	31851	32547	31790	18030	23879	4732	6236	296	0	0	0	0	0	0	0	0
25	-82.4624	27.71299	66.58	2.60	30677	37904	30618	23932	24218	10244	5424	4868	5424	2387	0	0	0	0	0	0
26	-82.4618	27.71278	63.62	2.70	29152	39008	29097	25745	29041	12482	18539	2754	0	0	0	0	0	0	0	0
27	-82.4612	27.71255	63.23	2.80	28749	35058	28694	21974	28638	8890	0	0	0	0	0	0	0	0	0	0
28	-82.4606	27.71232	66.4	2.90	30031	64160	29973	50539	29915	36918	19339	25959	19308	17155	19277	8351	13924	1276	0	0
29	-82.4595	27.7129	72.04	3.00	50249	82685	50187	59824	43961	37178	25414	24335	25381	12758	13231	4961	5176	491	0	0
30	-82.4584	27.71332	78.83	3.20	56158	66142	56092	40551	30216	17505	9038	7787	5469	3774	5469	1272	0	0	0	0
31	-82.4577	27.71297	87.06	3.30	19465	35991	19386	27227	19307	18462	19227	9698	9899	3995	6000	435	0	0	0	0
32	-82.4569	27.71257	91.22	3.40	20195	39118	20117	30027	20038	20936	19959	11845	15880	4164	0	0	0	0	0	0
33	-82.4561	27.71215	84.24	3.50	18382	31132	18307	22836	18231	14539	14494	6325	0	0	0	0	0	0	0	0
34	-82.4554	27.71176	74.69	3.60	16069	23181	16001	15914	15933	8647	4980	2926	4980	647	0	0	0	0	0	0
35	-82.4548	27.71138	73.84	3.63	15692	19173	15625	12077	8061	5469	8027	1805	0	0	0	0	0	0	0	0
36	-82.4542	27.71097	75.87	3.70	15976	23673	15907	16479	15838	9285	15769	2091	3196	287	0	0	0	0	0	0
37	-82.4536	27.71054	80.32	3.80	16723	24886	16650	17380	8649	9915	8611	6037	3426	3961	3388	2438	3351	915	0	0
38	-82.4529	27.71005	88.82	3.90	18098	19554	18017	11389	9331	4734	3689	2600	3647	942	0	0	0	0	0	0
39	-82.4519	27.70986	86.64	4.00	15433	25031	15353	18107	10018	11578	6572	7615	6531	4656	6490	1698	0	0	0	0
40	-82.451	27.70961	73.41	4.05	12696	18305	12630	12622	5459	7685	5425	5255	5391	2825	2372	1402	2338	337	0	0
41	-82.4506	27.70915	65.86	4.10	7385	11257	7325	7974	7264	4692	4757	2405	2085	783	0	0	0	0	0	0
42	-82.4501	27.70867	79.04	4.20	11288	18556	11215	13529	11142	8503	5022	3492	2550	1427	2513	282	0	0	0	0

Morphometric and vegetation graphs from the lower river

The bathymetric and shoreline values created by USF (Wang 2006) were also used to created very informative graphs of area, volume, and shoreline in the lower river vs. distance from the river mouth. Although available in District files, they were not included in the minimum flows report for the river. Some of these graphs are presented in this section, but first it valuable to describe their utility to understanding the ecology of the lower river and the establishment of minimum flows.

A fundamental concept related to the District's approach to managing freshwater inflow to estuaries and development of the percent-of-flow method is the interaction of stationary and dynamic components of estuarine systems as described by Browder and Moore (1981). Stationary components are those features that do not move, such as deep and shallow areas in the river and shoreline habitats. Dynamic habitats are those components that move with changes in freshwater inflow, with salinity clearly affected, but also including factors such as dissolve oxygen concentrations, water clarity, phytoplankton and chlorophyll *a* concentrations.

Estuarine productivity is maximized when there is an optimal overlap of stationary and dynamic habitats, such as fish species that prefers low salinity habitat and a certain type of shoreline. The Environmental Favorability Function (EFF) modeling that was performed to determine the proposed minimum flows contained factors for both salinity and shoreline habitat. The first draft minimum flows report for the lower river (JEI 2018b) in which the EFF modeling was first presented, contained an informative paragraph on pages 4-2 and 4-3 that describes the approach taken for the Little Manatee in relation to the concepts of Browder and Moore (1981). That same article was also discussed in the foundational paper for the percent-of-flow method (Flannery et al. 2002), but it was not cited nor discussed in the current draft minimum flows report.

A series of graphs are shown on the following pages that are available in District files that I suggest should be incorporated in the minimum flow report for they help improve understanding how the physical structure of a river interacts with its dynamic components to affect productivity. The large shoreline lengths per kilometer in some sections of the river shown in Figure 13 on page 22 reflects the presence of braids and islands and three bayous (including Ruskin Inlet) that intersect the river channel (Figures 11 and 12 on page 21).

Figure 14 shows the lengths of four major wetland communities along one kilometer sections of the river. The Little Manatee is notable for the abundant oligohaline and freshwater marshes that extend in the braided zone upstream of Interstate 75 near kilometer 12. As I have discussed in previous correspondence to the District, the wetland vegetation communities along the lower river were mapped in a detailed study conducted for the District by the Florida Marine Research Institute (1997), which needs to be cited and briefly discussed in the minimum flows report. A map from that report showing the distribution of vegetation communities associated with the Lower Little Manatee River is shown in Figure 15, which is more detailed that the vegetation map shown in the draft minimum flows report. In another document, I will describe how the effects of flow reductions upstream movement of low salinity waters along these wetland shorelines warrants further investigation in the minimum flows analysis.

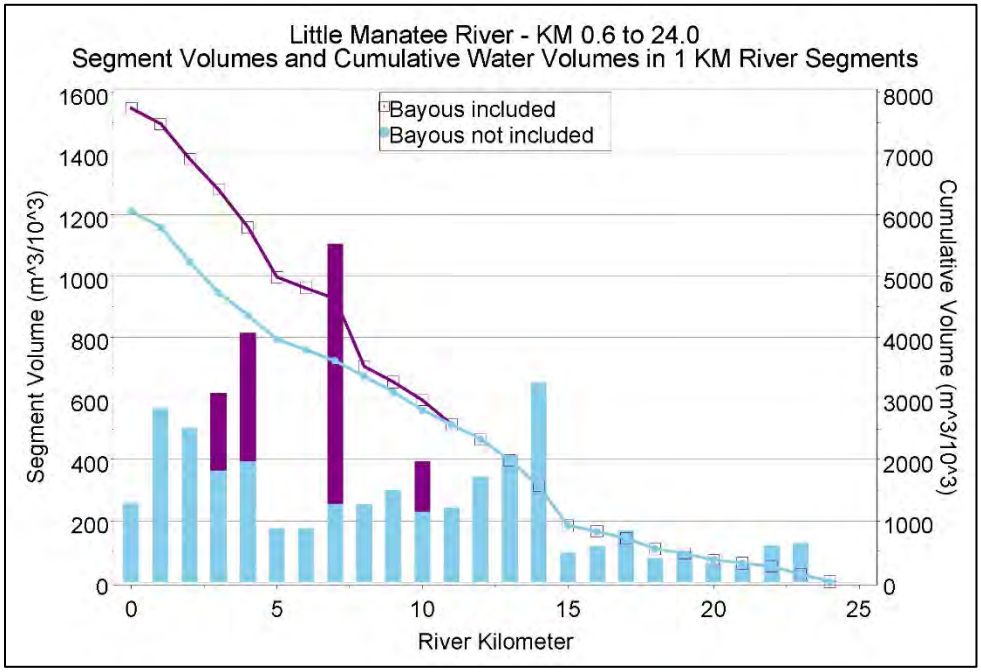


Figure 11. Volume of the Lower Little Manatee River in one-kilometer segments and cumulative volume increasing toward the river mouth from km 24 to km 0.6.

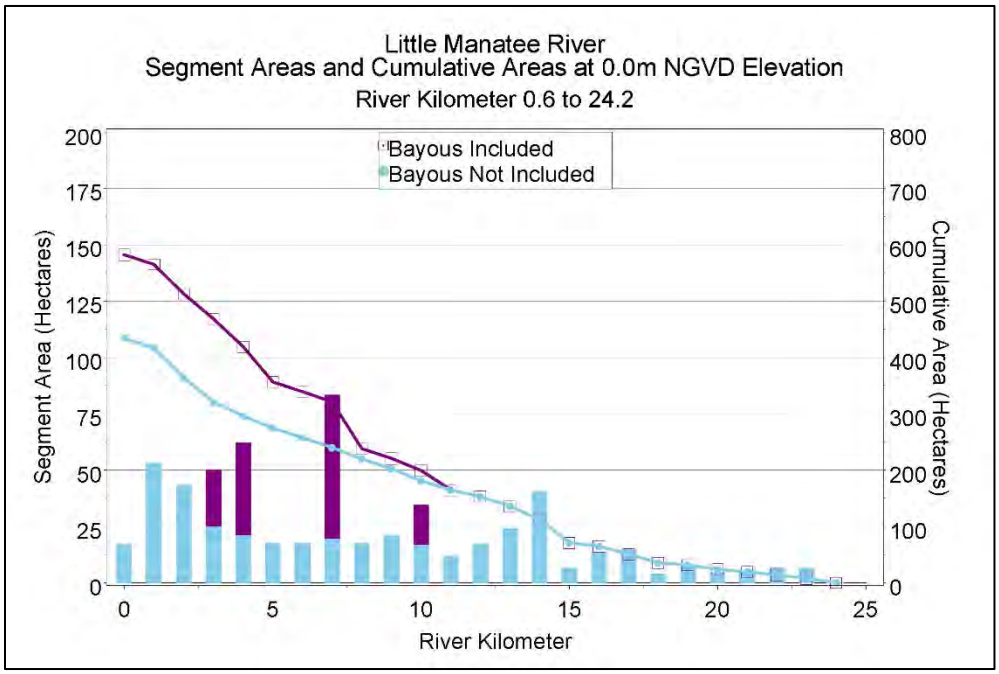


Figure 12. Area of the Lower Little Manatee River at an elevation of 0.0 meters NGVD1929 in one-kilometer segments and cumulative area increasing toward the river mouth from km 24 to km 0.6.

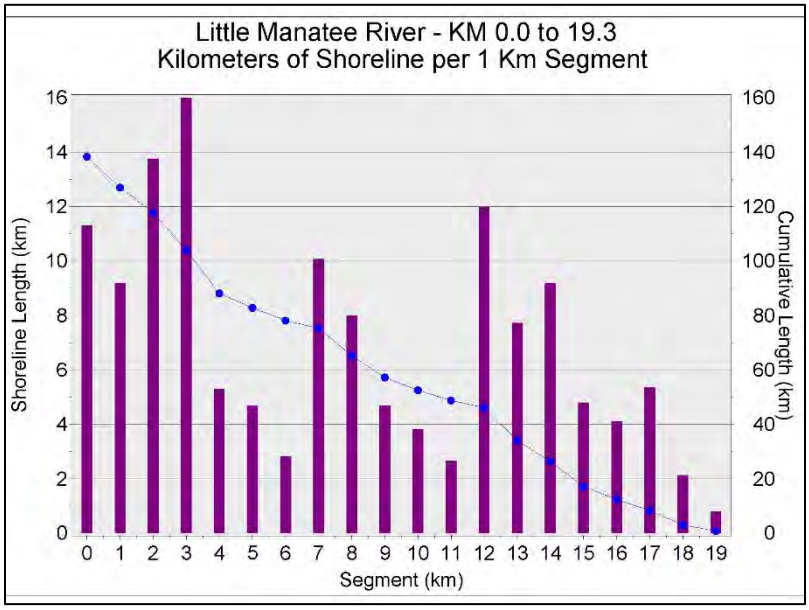


Figure 13. Shoreline lengths along the Lower Little Manatee River in one kilometer segments and cumulative shoreline length increasing toward the river mouth from km 19 to km 0.6

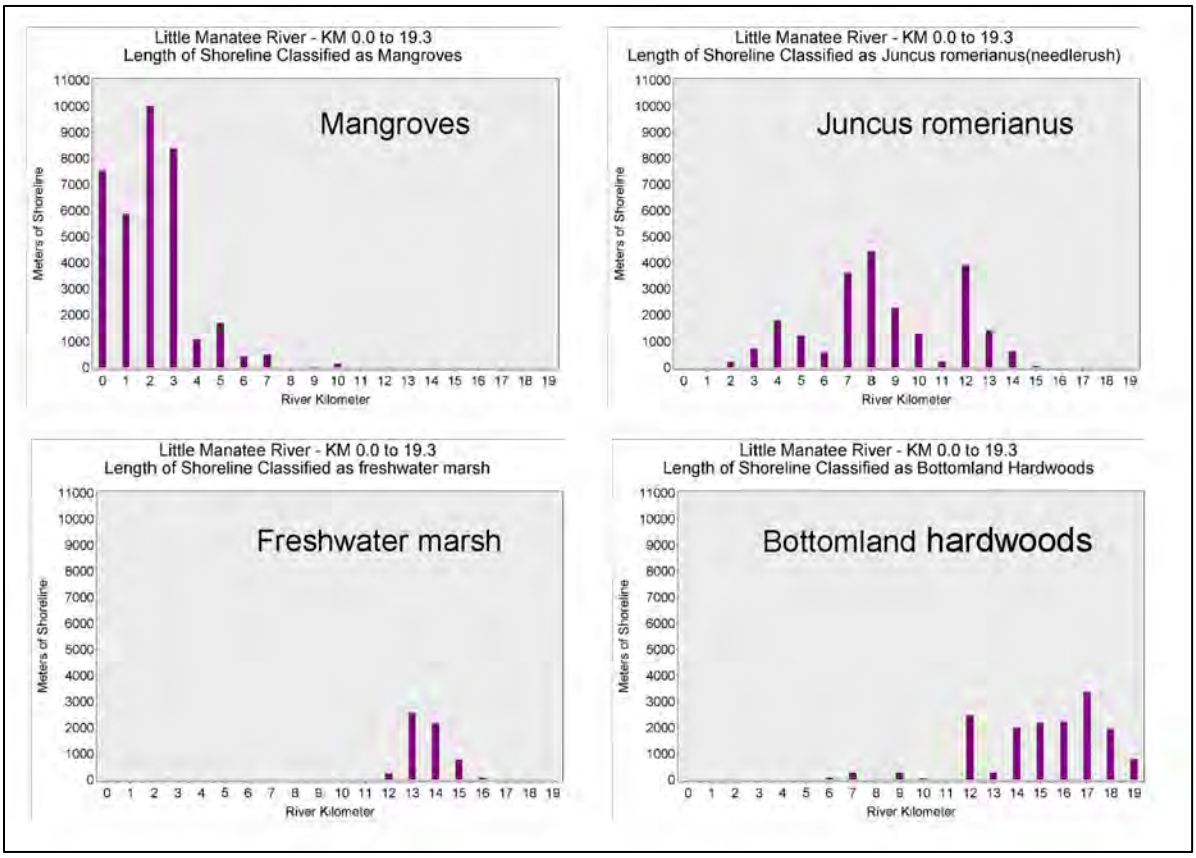


Figure 14. Shoreline lengths of mangroves, needle rush (*Juncus romerianus)*, freshwater marsh and bottomland hardwoods along the Little Manatee River from km 0.0 to km 19

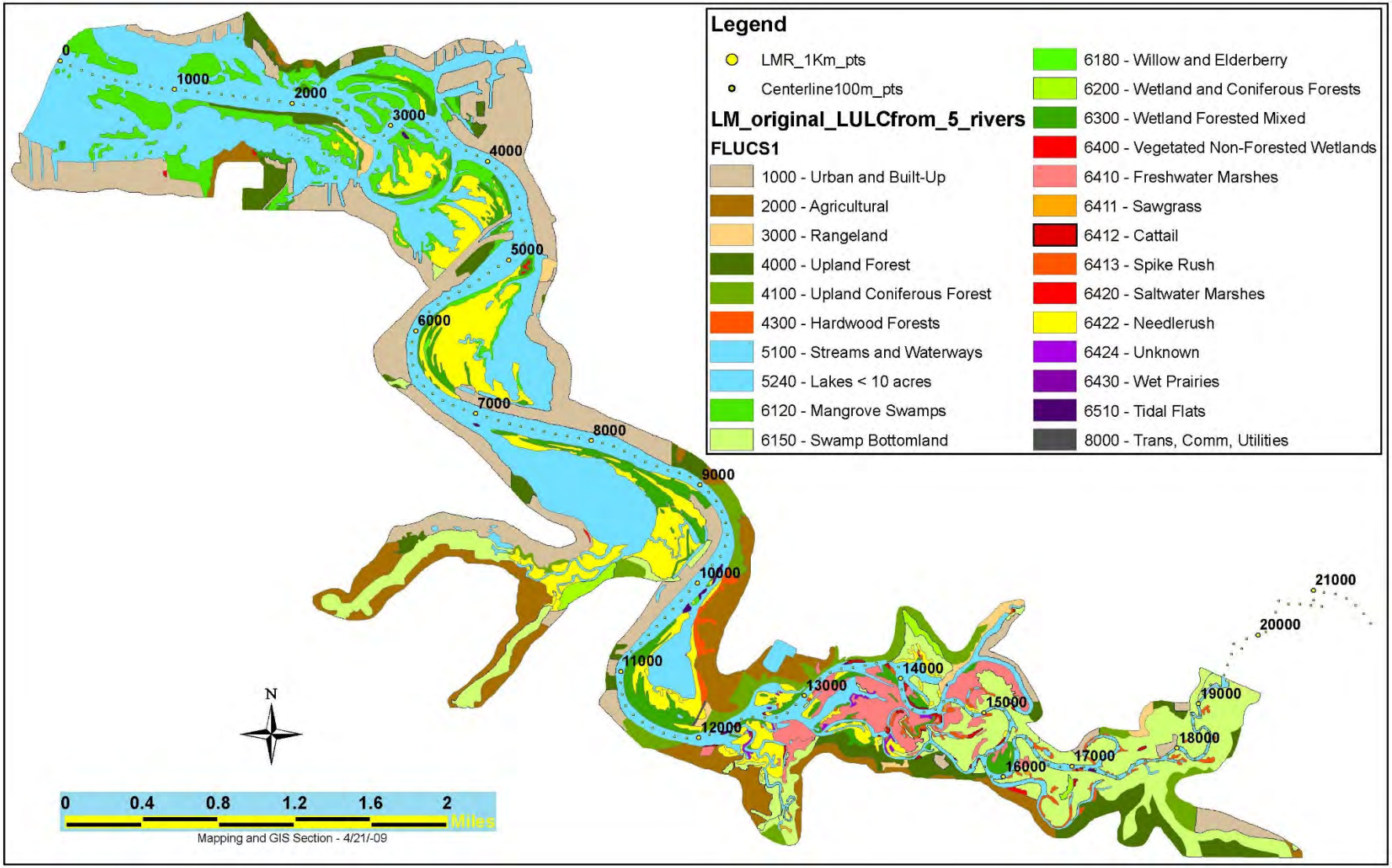


Figure 15. The distribution of major vegetation communities along the Lower Little Manatee River mapped by the Florida Marine Research Institute (1997).

4. Need to present additional salinity and dissolved oxygen data for the lower river.

The presentation of measured in situ salinity data for the Lower Little Manatee River in the draft minimum flows report is limited to a box plot for five long-term water quality stations monitored by the Environmental Protection Commission of Hillsborough County (EPCHC), the most upstream of which at US 301 has consistently recorded fresh water.* In order to present useful existing information for the river, there are considerably more salinity data that could be briefly presented to describe longitudinal and vertical salinity gradients in the lower river and the typical upstream extent of estuarine conditions.

Of particular note are the extensive vertical profile measurements of in situ water quality parameters (salinity, pH, temperature, dissolved oxygen) in the lower river collected by the Environmental Protection Commission of Hillsborough County (EPCHC). Sixteen stations are currently monitored on a monthly basis, which includes at the location four full water quality stations downstream of kilometer 14 shown in Figure 3-3 in the draft minimum flows report. A map of the sixteen vertical profile stations that was shown in the first draft report for the lower river (JEI 2018b) is reprinted in Figure 16 below. These vertical profile stations are among the several other physical, chemical, and biological characteristics of the lower river that were either mentioned solely, or discussed in more detail, in the previous draft minimum flows report for the lower river.

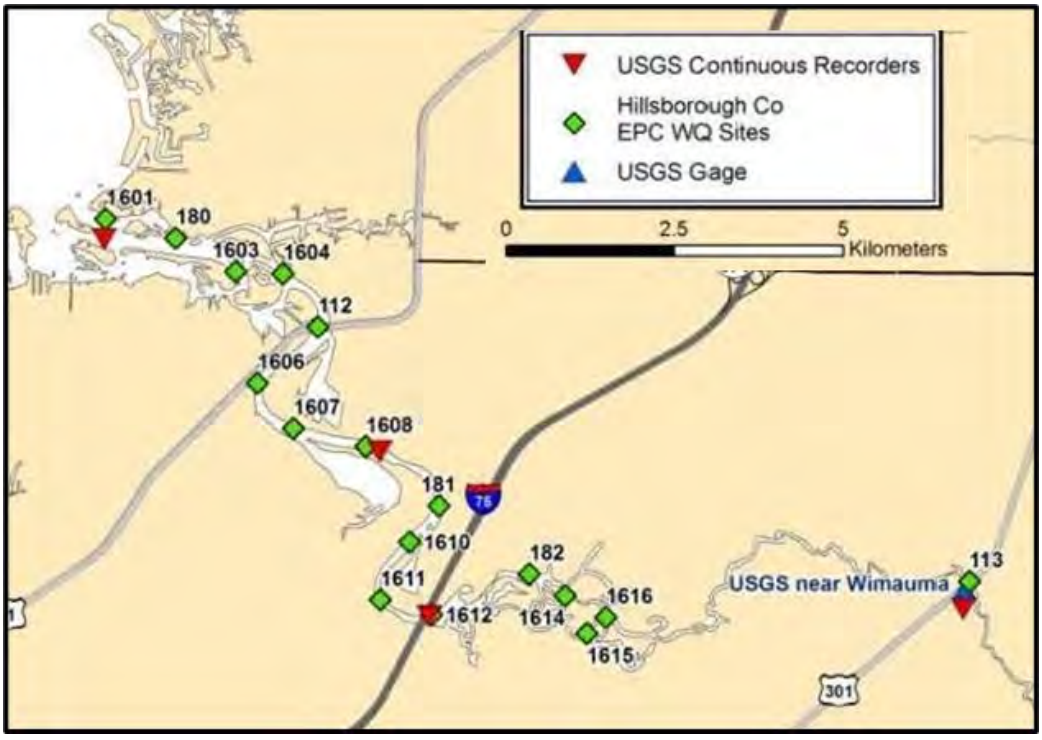


Figure 16. Location of vertical profile stations monitored in the lower river by the EPCHC, adapted from the first draft minimum flows report for the lower river (JEI 2018b).

*** three potentially anomalous non-fresh outliers from 1980 and 1988 are described in JEI (2018b).**

Data have been collected at mostly a monthly basis at these sixteen stations over two multi-year periods. The first period ran from December 2000 to October 2006 as part of the Hillsborough Independent Monitoring Program (HIMP), that was conducted to provide data in addition to that being collected by the Hydrobiological Monitoring Program being conducted in the lower reaches of the Alafia, Hillsborough River and the Tampa Bypass Canal by Tampa Bay Water as part of their water use permits to use those waterways for public water supply. The Little Manatee was to serve somewhat as control to examine temporal changes during the same years and climatic cycles.

The second set of years extends from June 2009 to current at these same stations, resulting in a very extensive data base of in situ water quality information in the lower river. A box plot of mean water column salinity at these stations in shown in Figure 17. The total number sampling trips (through August 2021) for the three uppermost stations is shown as N below those kilometer locations. The uppermost station was located at kilometer 16.4, and on some dates sampling did not extend that far upstream apparently because fresh water was encountered well below that station. Median values less than 1 psu salinity were found from kilometer 12.2 upstream (0.9 psu median at km 12.2), but much higher values occurred during prolonged dry periods.

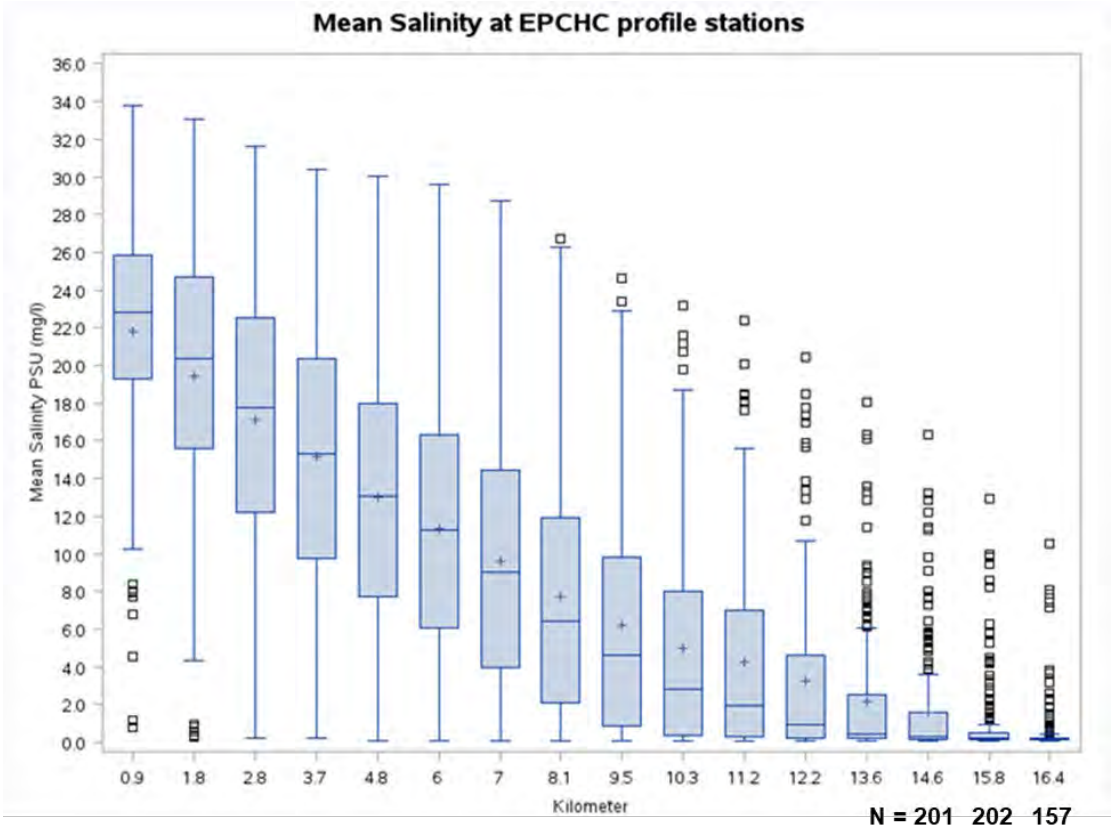


Figure 17. Box plot of mean water column salinity values at EPCHC vertical profile stations. The + symbols are means, the horizontal lines the medians, with the whiskers extending to 1.5 times the inter-quartile range. Outliers are shown for above the whiskers, but not below as freshwater outliers (<0.5 psu salinity) occurred at all stations upstream from kilometer 2.8 but are hidden by the X axis.

Another informative vertical profile data set for the lower river was collected by the District between 1985 and 1989, which was also identified in the previous draft report for the lower river (JEI 2018b). From 1985 to 1987, the District conducted 25 sampling trips on the river that measured vertical profiles for salinity. Then, in 1988 and 1989, vertical in situ profiles were measured 36 times as part of an extensive study of the Little Manatee River watershed (Flannery et al. 1991), with data collection for water quality, phytoplankton, zooplankton and ichthyoplankton collected in the lower river (Vargo 1989, 1990, Vargo el. 2004, Rast et al, 1991, Peebles and Flannery 1992, Peebles 2008). These studies have been described in other correspondence with the District.

In the 1988-1989 study, the District continued vertical profiles at ten fixed-location stations in the lower river and added data collection for full water quality at four moving salinity-based stations and two fixed location locations in the lower river. A box plot of mean water column salinity at the ten vertical profile stations is shown in Figure 18, using the same conventions for whiskers and outliers as shown for the EPCHC stations in Figure 17. As with the EPCHC stations, the total number of sampling trips at the three uppermost stations is shown as N.

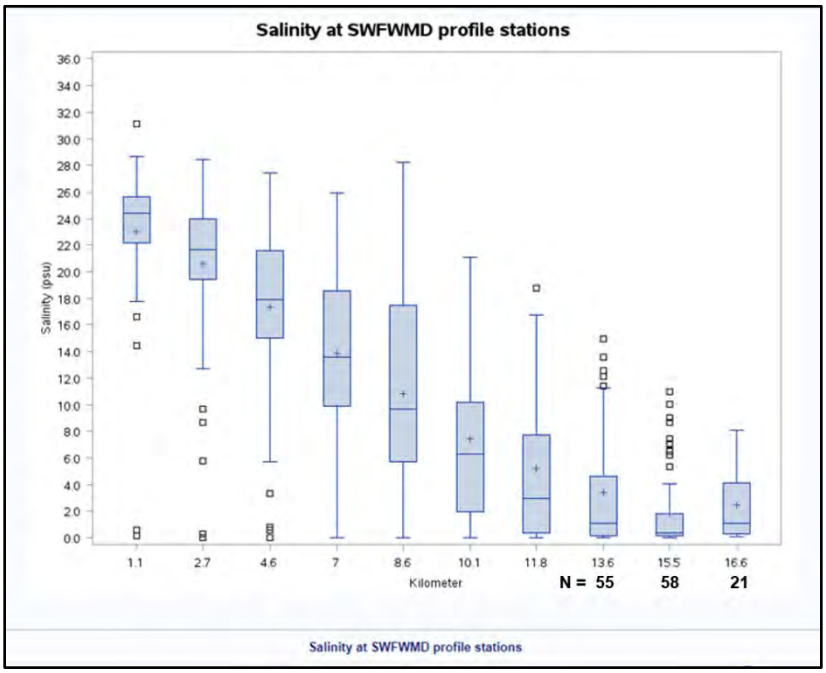


Figure 18. Box plot of mean water column salinity values at SWFWMD vertical profile stations.

The data from the District (SWFWMD) stations show a similar longitudinal pattern as the EPCHC, but with somewhat higher salinity, due in part that District sampling during 1985 to 1987 was oriented to dry periods. As a result, the EPCHC data in Figure 15 are the most informative because of their more balanced spatial and temporal coverage and long-term period of record. However, the District data are informative because of the sampling at the uppermost stations during very dry periods. The higher inter-quartile range for salinity at kilometer 16.6 compared to station 15.5 in the District data is because kilometer 16.6 was often only sampled during dry periods when salinity extended that far upriver, thus the smaller N value. On most dates, fresh water was encountered downstream of kilometer 16.6.

Figure 19 shows mean water column salinity on dates when sampling extended upstream of kilometer 16.6 by either the District or the EPCHC, with the preceding seven-day average flow at the USGS gage on 301 shown on each graph. As such, these graphs provide useful information on the upstream penetration of brackish water during very dry periods. Even though mean water column salinity as high as 6 to 8 psu was observed at kilometer 16.6, much lower salinity was observed upstream of kilometer 17 and especially kilometer 18.

This is likely due to a broad shallow sandy shoal near kilometer 16.8 that impedes the upstream movement of brackish water. This shoal is reflected in the bathymetric data generated by USF and I have personally observed on sampling trips during very dry periods the effect it had on inhibiting the upstream migration of salinity as shown below. The USF bathymetry data also shows a second shoal near kilometer 17.2. It is possible that higher salinity water could have extended farther upstream than shown in Figure 17 under extreme prolonged low flow conditions, however this would be very infrequent. Based on the last 40 years of record, seven-day average flows were less than 20 cfs four percent of the time, and less than 10 cfs only 0.6 percent of the time

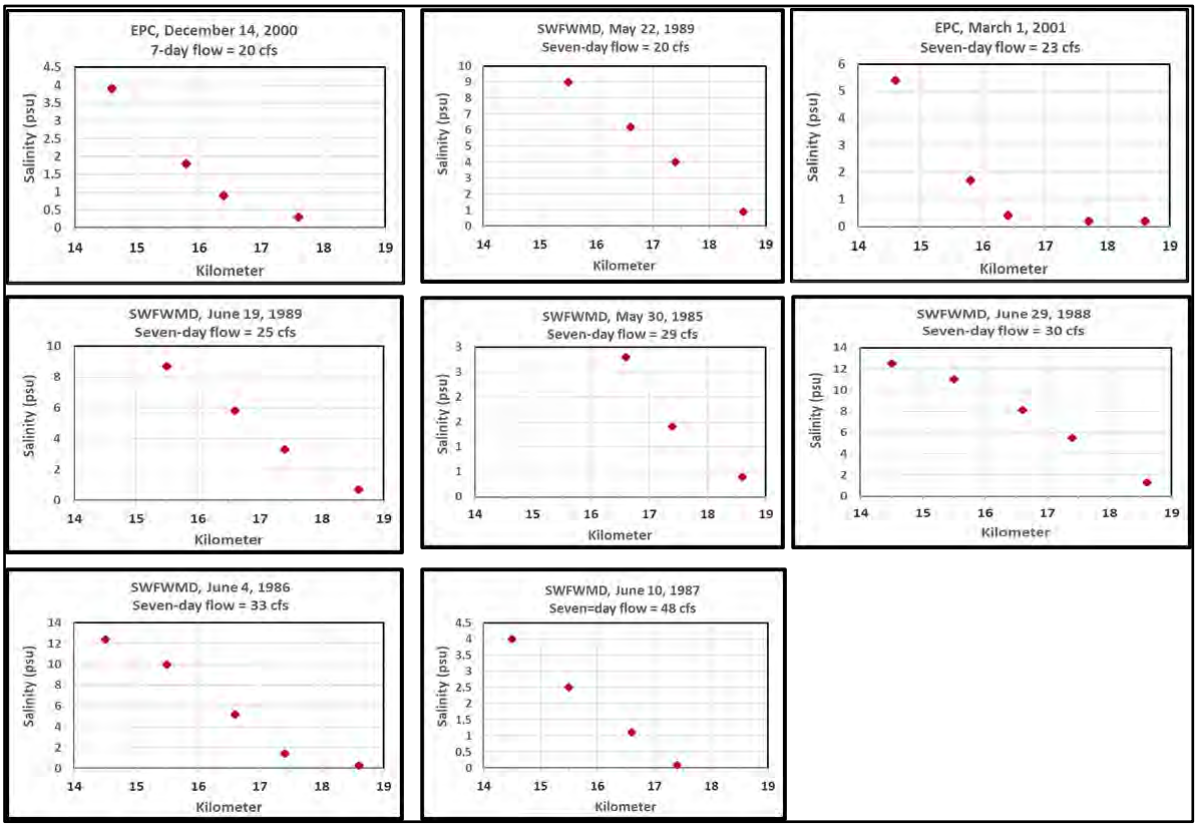


Figure 19. Mean water column salinity at upper stations in the lower river when sampling extended upstream of kilometer 16.6 by either the EPCHC or the District. The preceding seven-day average flow for each sampling date is listed on graphs.

These combined data indicate that brackish water rarely goes much beyond kilometer 17 or 18, which has been reflected in statements in previous studies. Peebles and Flannery (1992) stated "the estuarine portion of the LMR is considered to be the lower 16-18 km of the river channel, since brackish waters (>1 psu) do not typically extend upstream of kilometer 16 to 18 during the dry season."

Similarly, when discussing the division of the upper and lower river (the latter of which is sometimes referred to the estuarine section), on page 3-1 the first draft minimum flows report for the lower river (JEI 2018b) states "It should be noted the estuarine segment contains a rather large section from Rkm 24 down to Rkm 20 that is thought to be predominantly freshwater (i.e. tidal freshwater) during the majority of the year." On pages 3-25 to 3-27, this report shows the results of the empirical salinity modeling of the river and concludes the freshwater interface is near kilometer 20 (looks like about km 18.7 in the figure) at zero flow and this generally agrees with the position predicted by Fernandes (1985) under high tide and zero flow conditions near mile 11.6 (equal to kilometer 18.7).

Although there are sometimes small tidal water level fluctuations at the USGS 301 bridge during low flow conditions, long-term EPCHC sampling has not recorded brackish water there, albeit three outliers that appear anomalous (see pages 3-24 and 3-25 in JEI (2018b)). Also, the vegetation of the lower river above kilometer 17 shows species composition characteristic of a tidal freshwater zone with stands of the emergent plant spadderdock (*Nuphar luteum*) and other freshwater species.

In hindsight, it is unfortunate that the USGS recorder that was located near kilometer 17.2 measured only water levels and not specific conductance during the periods of the model calibration and verification of the EFDC mechanistic salinity model for the river. However, it is unlikely that brackish water (> 1 psu) would have occurred at that site during either the model calibration or verification periods, which ran from Jan 1, 2005 to February 28, 2005 and from March 30, 2005 to June 30, 2005, respectively. The USGS recorders that were operated during the EFDC project ran until the fall of 2006, and much higher salinity occurred at the USGS stations at kilometer 12.1 during the very dry spring of 2006 compared to all of 2004 and 2005, but data from 2006 were not used to develop the EFDC model as the timelines in the contract called for model development prior to that.

In a few spots, the current draft minimum flows report is misleading by saying the lower river is estuarine below the US 301 bridge. Given the vertical profile data available from the EPCHC and District field work and the empirical salinity modeling results presented in the first draft minimum flows report for the lower river (JEI 2018b), the language in the current draft report should be clarified to indicate that a tidal freshwater zone extends about 5 to 7 kilometers below Highway US 301. Tidal freshwater areas are important ecological zones in coastal rivers that are well described in the scientific literature (Conner et al. 2007, Barendregt et al. 2009). The presence of a tidal freshwater zone does not invalidate the geographic delineation nor the approaches taken to establish minimum flows for the upper and lower river. Clarification that a tidal freshwater zone extends for some distance in the lower river below the Highway 301 bridge would improve minimum flows report for the Little Manatee.

One last point about the salinity characteristics of the Lower Little Manatee River is the occurrence of vertical salinity gradients. Figure 20 shows the difference in surface and bottom salinity vs. mean water column salinity for four reaches of the lower river taken from the combined EPCHC and District vertical profile data for the lower river. The data were limited to stations there the depth of sampling was two meters or greater, which were fairly numerous as both sampling programs were conducted in mid-channel areas. The greatest stratification (difference between top and bottom salinity) occurred when mean water column salinity was in its middle range, as high mean salinity means there were relatively small freshwater inflows so that the salt wedge effect was minimized. Conversely, large freshwater inflows can extend freshwater conditions to at or near the river bottom, resulting in low mean water column salinity and small vertical gradients.

Vertical salinity gradients can affect circulation and mixing, the distribution and movement of various biological organisms, and water quality, particularly dissolved oxygen concentrations. As described on the following pages, problematic low dissolved oxygen concentrations are very infrequent in the lower Little Manatee, unlike the lower reaches of the Hillsborough and Alafia Rivers which can experience similar degrees of vertical salinity stratification, but have greater oxygen demand.

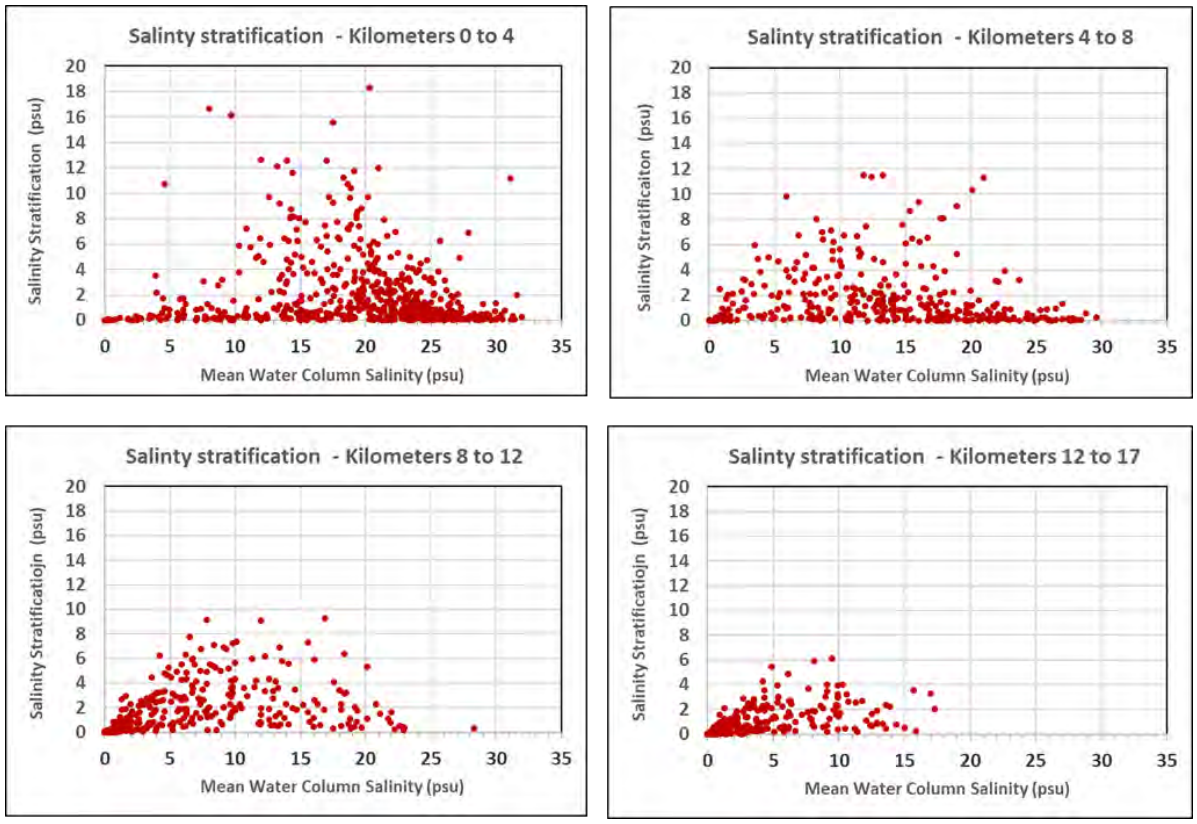


Figure 20. Salinity stratification (bottom minus surface) vs. mean water column salinity in four reaches of the Lower Little Manatee River as measured in vertical profiles taken by the EPCHC and SWFWMD.

5. Dissolved oxygen concentrations

Similar to salinity, the only data for dissolved oxygen (DO) presented in the draft minimum flows report is for the four long-term water quality stations in the estuarine reach of the lower river monitored by the EPCHC, plus the freshwater station at the Highway 301. Also, for some reason, the presentation and evaluation of DO in the minimum flows report is limited to mid-water depths, whereas bottom depths are also typically evaluated to determine if there are problems with low DO concentrations in estuarine systems.

Dissolved oxygen concentrations have been measured in the vertical profiles of in situ water quality parameters by the EPCHC and the District previously described for salinity. As discussed below, it would improve the minimum flows report to present DO data from the EPCHC sampling program. It will not change the conclusions of the report, but would be more informative regarding the water quality and ecological health of this highly valued river.

The data from both the EPCHC and the District indicate that DO values in lower river represent a very healthy ecological condition, with hypoxia (low DO concentrations) very infrequent in bottom waters. Dissolved oxygen concentrations of 2 or 3 mg/l are sometimes used identify hypoxia. However, in this document a threshold of 2.5 mg/l DO is used to denote hypoxia, as data collected with fish using trawls in the Lower Hillsborough River (where hypoxia is common) found that species richness was markedly lower in water with less than 2.5 mg/l DO (MacDonald et al. 2006).

Data for DO presented in this document are limited to the EPCHC stations due to its extensive spatial coverage, many years of record, and that this program continues today. Figure 21 shows that median values for bottom DO values are greater than 4 mg/l at all stations in the lower river, with the lower limit of the interquartile range above 3.5 mg/l at all stations.

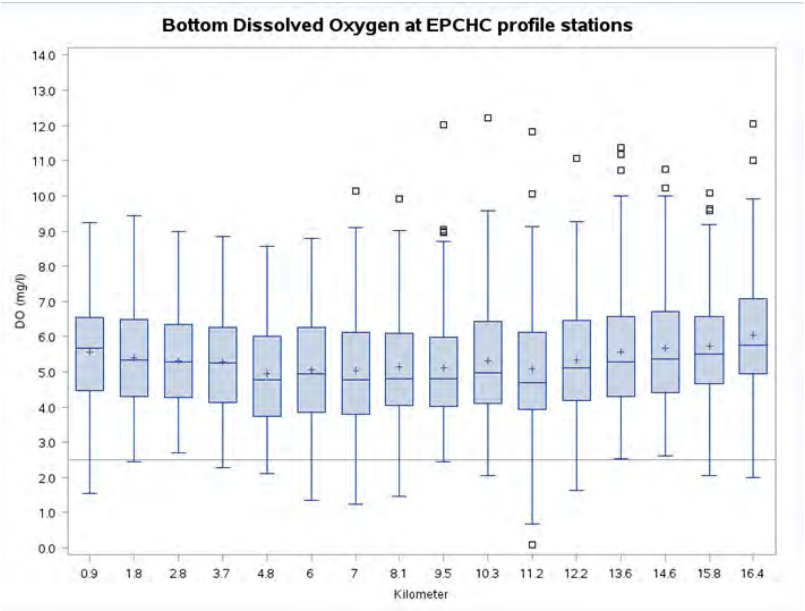


Figure 21. Box plot of bottom DO concentrations at EPCHC vertical profile stations, using same plotting conventions as Figure 17 on page 25.

Since individual outliers at low DO concentrations are not shown in Figure 19, the same population of individual bottom DO concentrations are plotted vs. river kilometer in Figure 22. Very few values are below 2.5 mg/l, with the lowest values found at the station at kilometer 11.2, which is unusually deep with two profiles recorded at over 5 meters deep.

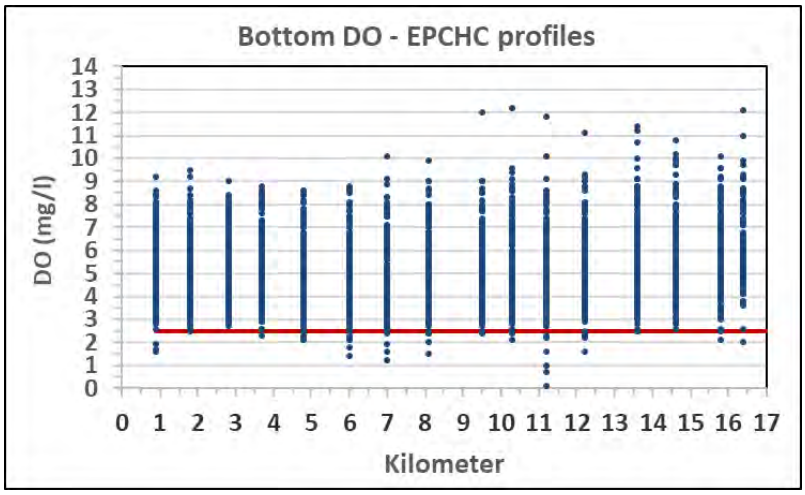


Figure 22. Individual bottom DO concentrations at EPCHC vertical profile stations

Given that bottom DO concentrations are in very healthy range, it is interesting the highest values for DO percent saturation tend to occur at stations in the upper reaches of the lower river (Figure 23). As will be discussed in another document, this is likely due to phytoplankton blooms that occur in this reach of the lower river, which can cause DO supersaturation (> 100%) in shallow waters.

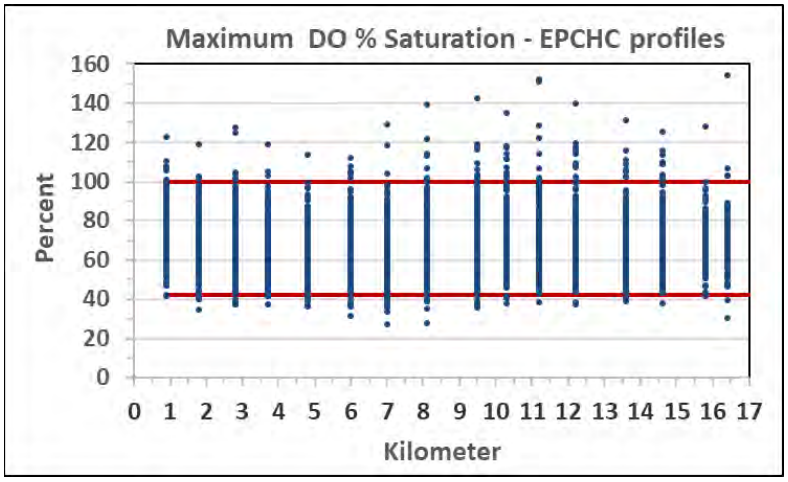


Figure 23. Maximum values of DO percent saturation at EPCHC vertical profile stations.

Because of their extensive spatial and temporal coverage, data from the EPCHC vertical profile program can be considered the “best information available” (F.S. 373.042) and it should be briefly presented and discussed in the minimum flows report. The EPCHC spends considerable funds, time, and effort to collect these data and their concise presentation would be valuable in the minimum flows report for the Little Manatee, which is the most pristine tidal river flowing to Tampa Bay.

6. Nitrogen and groundwater enrichment of the Little Manatee River

The purpose of this section is to demonstrate that although trends for many water quality parameters have stabilized or improved in recent years, the Little Manatee River remains enriched in nitrogen, which could be relevant to the evaluation of minimum flows for the lower river.

The assessment of nutrients and other water quality parameters for the lower river in the draft minimum flows report focuses on the long-term water quality sites that are monitored by the EPCHC. This is a very useful data set with monthly data going back to 1974 at the US 301 and US 41 bridges, the latter of which is in the estuarine portion of the river near kilometer 4.8. For the upper river above US 301 the report analyzed trends at four stations: two by the EPCHC from 1976 or 1981 to 2019 and two by Manatee County from 2000 to 2017.

In determining what sites to use, the report limited their statistical analysis and interpretation to sites that has at least 60 observations in the EPCHC or Impaired Water Rule (IWR) data bases. Using the nonparametric Seasonal Kendall Tau test, trends all these sites to examined to determine if various parameters showed trends though time. The good news is that for both the upper and lower river, for the large majority of parameters that could potentially be problematic, there was either no trend or a significant decreasing trend over time. However, there were several instances of increasing trends in the upper river (organic nitrogen at EPC sites 129 and 140, fluoride at EPCHC site 129, BOD 5-day and total nitrogen at Manatee County sites D1 and D3, and nitrate-nitrite at Manatee County site D1). Overall, though, the water quality trends in the upper river look good and did not influence the District's determination of minimum flows for the upper river, with which I agree.

Similarly, for the lower river the vast majority of trend tests at the EPCHC sites showed either no trend or a decreasing trend, with the exception of organic nitrogen at US 301, which is not necessarily problematic, and increasing fluoride at US 301 and two sites in the estuary, which also may not be problematic but may reflect phosphate mining discharges in the upper watershed. Time series plots of mid-water dissolved oxygen (as mg/l and % saturation), chlorophyll *a*, ammonia, total nitrogen and total phosphorus were presented, which supported the conclusions there were no apparent problematic trends. The report acknowledges that organic nitrogen showed an increasing trend at US 301 (EPCHC site 113), but "the concentrations do not appear to be resulting in adverse effects to the system based on the results of the chlorophyll concentration analysis described above."

Long-term data and sub-basin comparisons from District watershed study in the late 1980s

I concur that the recent trends in the Little Manatee indicate that water quality conditions in the river have either improved or showing no trend for several constituents, with some exceptions. However, compared to a historical pre-impacted condition, the river is still substantially enriched for certain constituents, with long-term data indicating that much of this enrichment began in the 1970s when hydrologic analyses indicate the flow regime of the river began to be affected by expansion of agricultural land and water use in the basin.

Appendix D1 to the draft minimum flows report contains graphics and presentations of data from a large number of sites that had fewer observations (n < 60) or had data collection that ended some time ago (e.g., 1999.) A number of these graphics show that concentrations of some key constituents were much lower prior to the 1970s. Figure 24 shows data from the USGS gage at US 301 near Wiumama. Although there are gaps in the data, nitrate nitrogen was typically less than 0.2 mg/l until the late 1960s, then showed increases in the 1970s, the early 80s, and the late 1990s. Similarly, water hardness (which reflects the calcium and magnesium content of the water) has shown marked increases over that same time period.

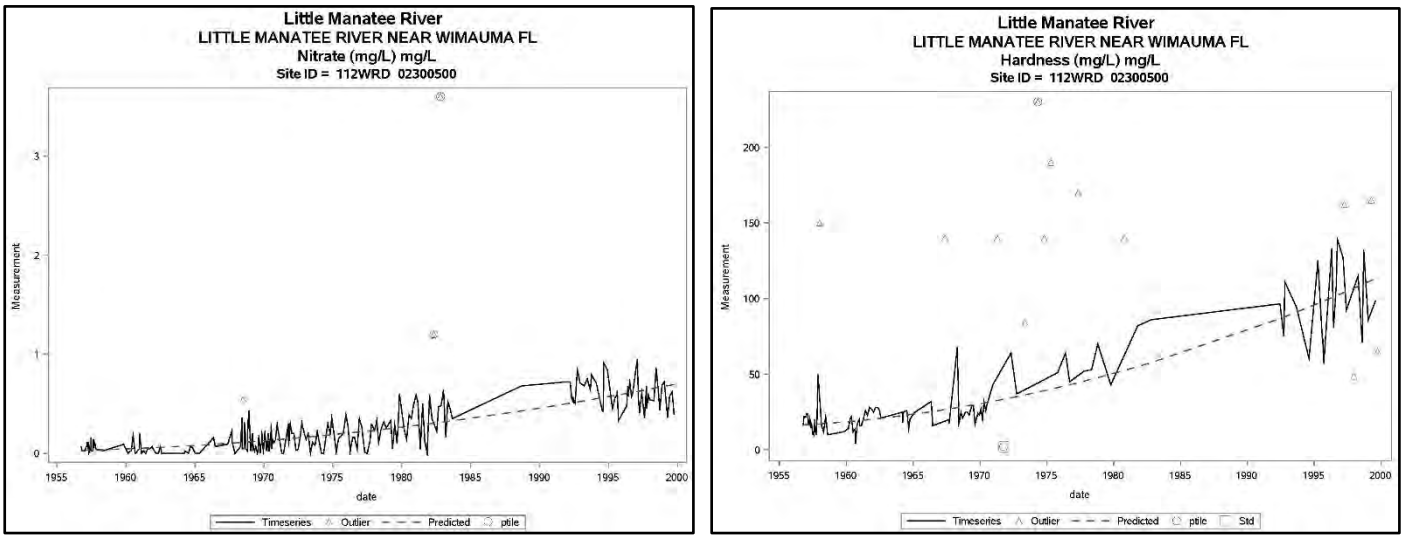


Figure 24. Concentrations of nitrate nitrogen and hardness, both as mg/l, for the USGS gage at US 301 Little Manatee River near Wimauma starting in the 1956 through 1999. Graphs taken from Appendix D-1 to the draft minimum flows report.

The status of water quality in the Little Manatee River watershed, including both the upper and lower river, was the subject of extensive study of the river watershed in the late 1980s funded by the Florida Department of Environmental Protection and managed by the District. The FDEP asked the District which watershed should be the site of such an assessment and the Little Manatee River was selected, which began a program of extensive data collection for this system.

The project involved installation of three new temporary streamflow gages by the USGS, allowing comparison of nutrient and material flux rates as loading per unit area from seven sub-basins within the watershed. Detailed photo-interpretation was conducted and updated land use/coverages in the watershed were prepared, with comparative analyses demonstrating that the effects of agricultural land use on water quality and nutrient loading from different sub-basins. Although this project was conducted when the effects of agricultural on flow and water quality in the basin were near maximum, the findings support the findings of the current draft minimum flows report. As such, the primary paper from that project (Flannery et al. 1991) should be cited in it, as it was cited in both the first draft reports for the upper and lower river (Hood et al. 2011, JEI 2018b).

The project also involved extensive data collection in the estuary including data for salinity, water quality, primary production and phytoplankton, zooplankton and ichthyoplankton. References and summaries of the findings of those studies in the estuary have been submitted to the District under separate correspondence.

The project combined data from various sources to examine trends in long-term data for the river. Graphics of data for specific conductance and nitrate + nitrite nitrogen are shown in Figure 25 for 1956 to 1990. Both parameters showed rapid increases in the late 1960s and/or mid-1970s, concurrent with increasing agricultural land use in the basin. Specific conductance, which measures the capacity of water to transmit an electrical current, reflects the mineral content of the water. The dramatic rise in specific conductance in Figure 25 is due to increased amounts of groundwater entering the river as result of agricultural irrigation that relies on wells that pump from the upper Floridan aquifer.

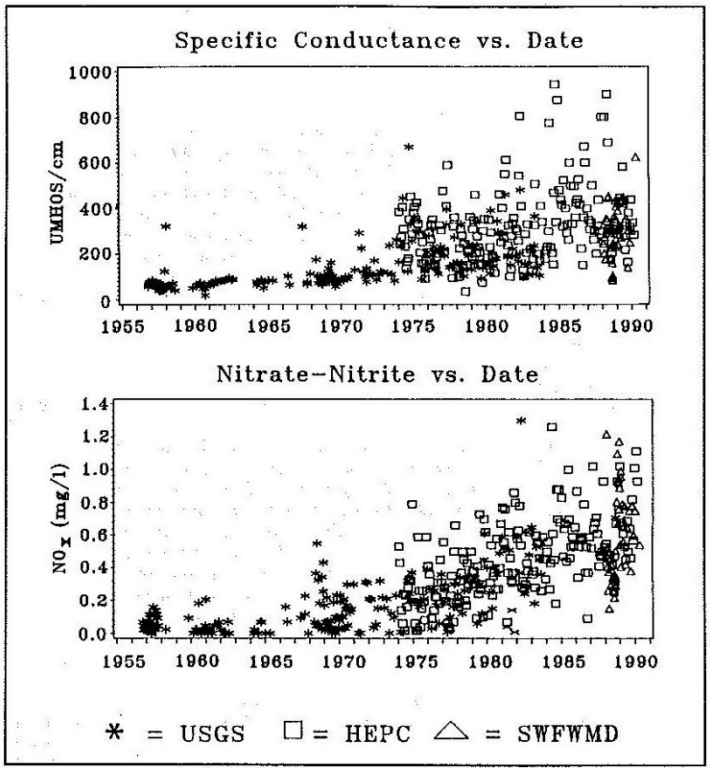


Figure 25. Time series plots of specific conductance and nitrate + nitrite nitrogen (as mg/l N) at the Little Manatee River near Wimauma at US 301 gage for 1956 through 1990 from three data sources: the USGS; the EPHCH (HEPC) and the District (SWFWMD). Reprinted from Flannery et al. (1991).

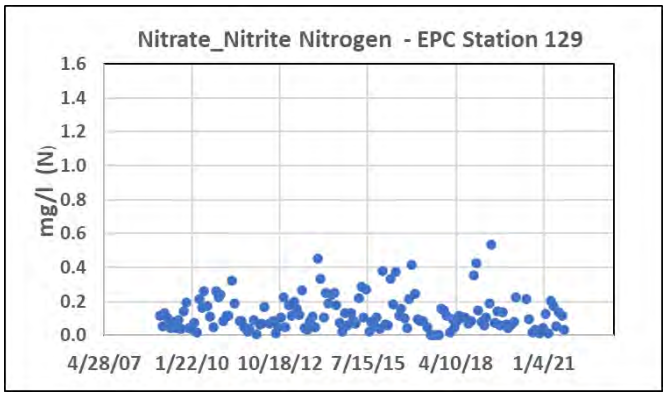
The comparison of constituent concentrations and flux rates from the watershed in this project was also informative. During the study, the most upstream site on the river at the site of the USGS gage near Ft. Lonesome was somewhat of a control site, as phosphate mining was largely inactive during the period of study and land use there was much less intensive than in the other sub-basins. Concentrations and flux rates were higher in other sub-basins, and the concentrations of nearly all

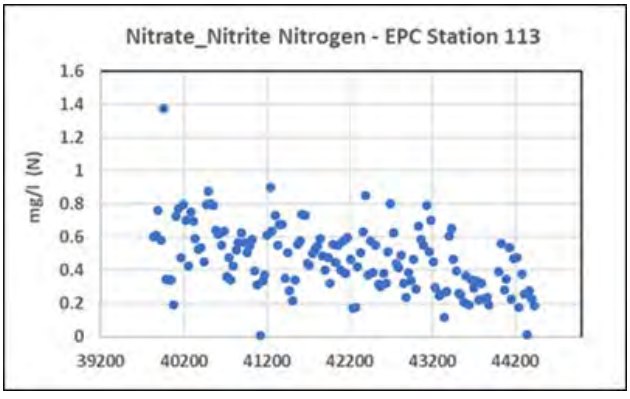
constituents increased as the river channel progressed downstream. Table 3 below lists the mean concentrations of selected constituents at the USGS gages on the river near Ft. Lonesome in the eastern part of the watershed and the downstream gage at US 301 based on bi-weekly sampling during 1988. Both specific conductance and nitrate+nitrite nitrogen were significantly greater at the downstream site, with the mean nitrate +nitrite concentration nearly three times greater there. Sulphate also increased downstream by over a factor of three due to increased ground water entering the river. Water color was greater at the upstream site reflecting the runoff from wetlands in the upper river basin, while the phosphorus mean concentration was slightly greater at the upstream site.

Table 3. Concentrations of six constituents at the USGS gages on the Little Manatee River near Ft. Lonesome and (#02300100) and at the US 301 bridge near Wimauma. Values based on 26 biweekly samples collected during 1988 taken from Flannery et al. (1991)

USGS gage location	Specific Conductance	Color	Nitrate + Nitrite N	Ortho phosphorus	Total suspended solids	Sulphate
	µmhos/cm	PCU	mg/l N	mg/l P	mg/l	mg/l
at US 301	154	143	.19	.37	2.0	16
Nr. Ft. Lonesome	271	113	.55	.34	5.2	60

Inorganic nitrogen concentrations are particularly important the Little Manatee as phytoplankton production in the lower river estuary is primarily nitrogen limited (Vargo et al. 1991). As such, I examined nitrate+nitrite concentrations at the same locations of the USGS gages listed in Table 3 that are currently monitored by the EPCHC (sites 113 and 129). Time series plots of nitrite+nitrite nitrogen at these two sites from 2009 to August 2021 are shown in Figure 26 and 27, using the same y-axis scale to help visually compare the concentrations between the two sites. There appears to be a decreasing trend at the downstream site over this 12-plus year period, but concentrations remain higher at the downstream site, averaging 0.30 mg/l since January 2019 compared to a mean of 0.09 mg/l at the upstream site. Specific conductance values are still elevated as well, averaging 329 µmhos/cm at US 301 for 2016 to 2020, whereas most values were below 100 µmhos/cm prior to the 1970s (Figure 25).





Figures 26 and 27. Nitrate + nitrate nitrogen concentrations at EPCHC sites 129 near Ft. Lonesome and site 113 at the US 301 bridge for January 2009 through September 2021.

The relevance of nitrogen enrichment to the lower river

The reason that recent nitrogen concentrations and trends are discussed in this document its relation to phytoplankton abundance in the lower river estuary. Long-term indicate that although nitrate+nitrite concentrations are improving in the river, they are still considerably elevated to concentrations observed in the river before the large increase in agricultural land use in the 1970s.

Nitrogen loading from the watershed, particularly readily available inorganic forms such as nitrate-nitrite, is a principle factor driving phytoplankton abundance and production in the lower river. Phytoplankton comprise a critical part of the base of the food web in estuarine systems, but in excess can contribute to hypoxia and excessive organic enrichment of bottom sediments. The Little Manatee does not currently have problems with hypoxia, but caution must be applied in affecting factors that can affect phytoplankton abundance in the lower river.

As was described in other correspondence with the District, the Little Manatee is unusual in that the highest chlorophyll *a* concentrations often occur in very low salinity oligohaline water, whereas in the estuarine sections of the Peace and Alafia Rivers the highest concentrations often occur in mesohaline waters (Vargo et al. 2004) This appears to occur because the residence times in the braided reaches of the Lower Little Manatee River upstream of kilometer 12 are relatively long, allowing large phytoplankton populations to develop there.

For minimum flows analysis, the basic question that needs to be asked is what will happen to a given parameter or resource characteristic if freshwater inflows are reduced due to withdrawals. That question or approach for chlorophyll *a* was not clearly evaluated in the draft minimum flows report. In another document I will submit to the District, the response of chlorophyll *a* to flow in different parts of the lower river will be examined in order to evaluate flow-based blocks that could be applied to minimum flows for the lower river.

Text continued on the next page

7. Additional data for ichthyoplankton in the lower river

The District had been fortunate to employ the services of Dr. Ernst Peebles and colleagues from the University of South Florida College of Marine Science to perform studies of ichthyoplankton, or the early life stages of fishes that are caught by plankton nets, in nine rivers within the District. These studies as also collect many planktonic invertebrates and benthic invertebrates that migrate into the water column during some stage of their life cycle. The first river for which Dr. Peebles performed a study for the District was the Little Manatee, and the findings from the Little Manatee along with the Peace and Alafia Rivers were key to developing the percent-of-flow method for managing reductions of freshwater inflows to the estuarine sections of rivers in the region (Flannery et al. 2002).

The draft minimum flows report describes the work on the Little Manatee River as "a robust study of the estuarine portion of the Little Manatee River's planktonic community occurred from January 1988 to January 1990 (Peebles and Flannery 1992). These data were re-evaluated in 2008 using newly developed analytical methods (Peebles 2008)." The draft minimum flows report presents one paragraph that describes some of the findings of these reports and includes a table of the thirty most abundant taxon/life stages for fishes caught during the two-year study (Table 4-10 on pages 100 and 101).

For some reason, that table did not include the most abundant fish species in the river, that being the bay anchovy (*Anchoa mitchilli*), along with the eggs and early larval stages that were identified to *Anchoa* spp. and the postflexion stages of the Menhaden (*Brevoortia* spp.). This might be because in catch table in the first ichthyoplankton report, the letter "e" was used to denote samples in which abundances were estimated using split samples because of the large number of individuals of that taxon/stage in the sample (Peebles and Flannery 1992). However, split samples are a commonly used technique in plankton work and these are valid abundance values for those taxon/stages. It is important that the results for the anchovies be included in the minimum flows report as the bay anchovy is by far the most abundant fish species in the Little Manatee River, in the both the ichthyoplankton and the nekton captured by seine and trawl.

Table 4 on the following page lists the values for the bay anchovy, *Anchoa* spp., and menhaden postflexion stage that should be inserted into Table 4-10 in the minimum flows report. The percent contribution to total listed in Table 4 was calculated from a count of 216,916 total specimens listed on page 99 in the draft District report. It is uncertain if that total count lists the taxa and stages listed in Table 4, but that can be checked the values in Table 4 can be compared to the percent contribution values in Table 4-10 in the draft minimum flows report using a common factor.

I also listed the mean salinity at capture and density weighted peak location of each taxon/stage in the study area taken from Peebles (2008), which included one station in Tampa Bay. These parameters are informative for describing where in the tidal river and in what salinity zones the stages of each taxon are concentrated. Using the bay anchovy as an example, the egg and larval stages are centered in higher salinity waters, but as they develop stronger swimming ability as juveniles they migrate into lower salinity water. An example of this from the first ichthyoplankton report for the Little Manatee is reprinted as Figure 28 on the following page. In previous correspondence, I have suggested it is the one figure that best justifies the District's percent-of-flow approach to managing reductions of freshwater inflows to estuaries and it should be included in the minimum flows report for the Little Manatee.

Table 4. Supplement to Table 4-10 in the draft minimum flows report. Life stages of taxa caught in 480 plankton tows in the Little Manatee River from January 1998 – January 1990 (from Peebles 2008). KmU represents the river kilometer where the taxon/stage was most abundant based on density weighted interpolation between fixed stations with Bay listed for taxon/stages most abundant at the station in Tampa Bay. Ranks are listed for where they would appear if added to Table 4-10 in the draft minimum flows report, which is ranked by mean catch per unit effort as density in number per thousand cubic meters.

Rank	Common name and stage	Scientific Name	Number collected (n)	Mean CPUE (No. per 1,000 m3)	Percent Contribution to total	KmU (Kilometer)	Mean Salinity at capture (psu)
2	Bay anchovy juveniles	*Anchoa mitchilli*	40,838	874.7	18.8%	7.1	7.2
7	Anchovies flexion	*Anchoa* spp.	11,287	130.5	5.2%	Bay	25.7
9	Bay anchovy postflexion	*Anchoa mitchilli*	7,908	93.8	3.6%	0.3	22.1
10	Anchovies preflexion	*Anchoa* spp.	9,169	80.8	4.2%	Bay	24.4
14	Bay anchovy eggs	*Anchoa mitchilli*	9,868	26.8	4.5%	Bay	23.5
19	Menhaden postflexion	*Brevoortia* spp.	2,393	18.6	1.1%	7.5	2.8

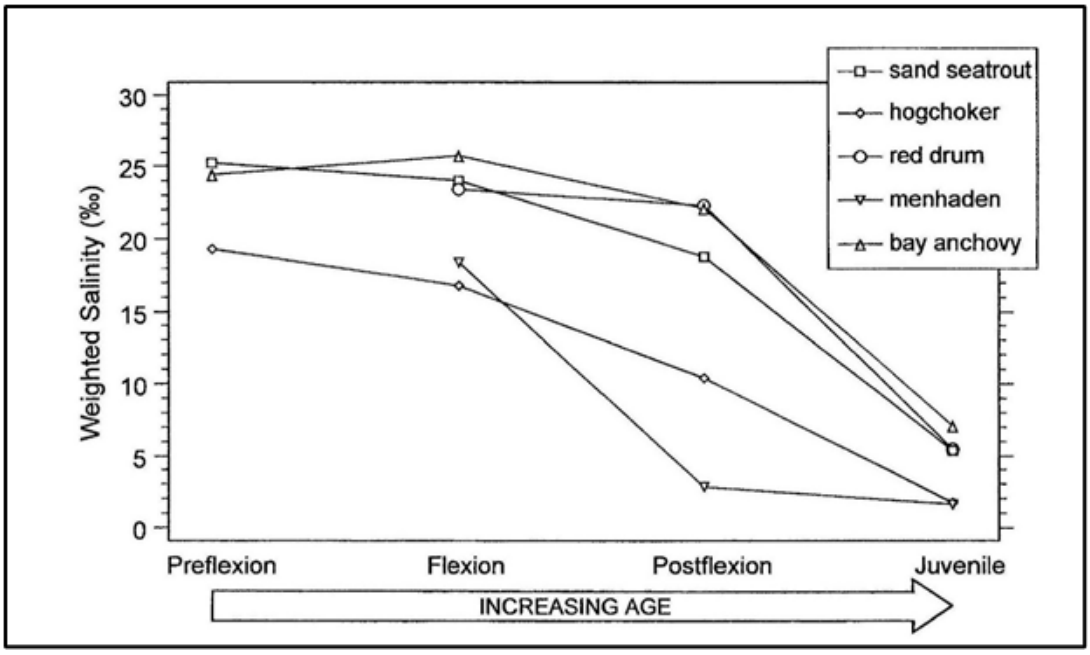


Figure 28. Decreasing mean salinity at capture with fish development for five species in the Little Manatee River

In addition to the taxon and stages listed in Table 4 on page 38, I have added values from Peebles (2008) for mean salinity at capture and location of maximum density (KmU) to the information presented on page 100 in the Table 4-10 in the draft minimum flows report below. I suggest the District add these values to Table 4-10 as it provides helpful information regarding the distribution and utilization of the tidal river by the life stages of these species.

Table 5. The most common taxa/stages in 480 plankton tows as shown in Table 4-10 in the draft minimum flows report with mean salinity at capture and maximum location (KmU) added from Peebles (2008). (The taxon/stages listed on page 18 should to be added to this table.)

Common Name	Scientific Name	Number Collected (n)	Mean CPUE (No./10^3 m^3)	% Contribution to Total	Mean salinity at capture (psu)	KmU (Kilometers)
Fish eggs (primarily drum)	*Percomorpha* eggs (primarily Sciaenid)	167,840	5829.41	77.38	26.1	Bay
Gobies, postflexion larvae	*Gobiosoma* spp.	10,599	303.35	4.89	14.8	6.0
Gobies, flexion larvae	*Gobiosoma* spp.	8,052	234.09	3.71	18.3	3.3
Gobies, postflexion larvae	*Microgobius* spp.	5,642	184.73	2.60	23.6	Bay
Gobies, preflexion larvae	Gobiid	5,493	162.68	2.53	18.8	2.4
Gobies, flexion larvae	*Microgobius* spp.	3,093	95.29	1.43	21.5	4.3
Skilletfish, flexion larvae	*Gobiesox strumosus*	2,128	60.54	0.98	15.7	4.5
Skilletfish, preflexion larvae	*Gobiesox strumosus*	1,951	56.3	0.90	17.6	2.7
Blennies, preflexion larvae	Blenid	1,159	35.1	0.53	21.5	0.1
Skilletfish, postflexion larvae	*Gobiesox strumosus*	787	21.43	0.33	11.8	7.3
Frillfin goby, preflexion larvae	*Bathygobius soporator*	779	23.55	0.36	22.0	0.6
Sand seatrout, preflexion larvae	*Cynoscion arenarius*	716	27.35	0.29	25.2	Bay
Silver perch, flexion larvae	*Bairdiella chrysoura*	629	22.46	0.36	23.5	Bay
Sand seatrout, postflexion larvae	*Cynoscion arenarius*	444	13.93	0.20	18.8	Bay
Hogchoker, postflexion larvae	*Trinectes maculatus*	433	12.12	0.18	10.4	5.8
Florida blenny, flexion larvae	*Chasmodes saburrae*	381	12.42	0.20	23.4	23.4
Frillfin goby, flexion larvae	*Bathygobius soporator*	334	10.42	0.14	21.6	21.6
Gobies, juveniles	*Giobiosoma* spp.	317	8.81	0.15	9.9	9.9
Kingfishes, preflexion larvae	*Menticirrhus* spp.	314	11.51	0.13	24.2	24.2
Silver perch, preflexion larvae	*Bairdiella chrysoura*	275	10.25	0.11	24.8	24.8
Gobies, flexion larvae	Gobiid	240	6.98	0.15	16.6	16.6
Kingfishes, flexion larvae	*Menticirrhus* spp.	238	8.94	0.10	25.0	25.0
Hogchoker, juveniles	*Trinectes maculatus*	233	6.18	0.09	1.6	1.6
Chain pipefish, juveniles	*Sygnathus louisianae*	225	7.5	0.11	22.4	22.4
Silver perch, postflexion larvae	*Bairdiella chrysoura*	216	6.62	0.10	16.4	16.4
Hogchoker, preflexion larvae	*Trinectes maculatus*	210	6.36	0.10	19.3	19.3

The first ichthyoplankton report prepared for the District contained an excellent illustration of the life stages of the bay anchovy from the preflexion larval stage through adult, which is reprinted below in Figure 29. This figure was prepared by Dr. Peebles wife, Diane Rome Peebles, who is a highly respected and renown biological illustrator and artist who has prepared many paintings and illustrations of fish species that have been widely distributed by the State of Florida. The illustration below should be included in the minimum flows report because its quality and that it helps readers better understand the life stages that were collected as part of the ichthyoplankton project and how the size and morphology of these stages is related to their distribution in the tidal river.

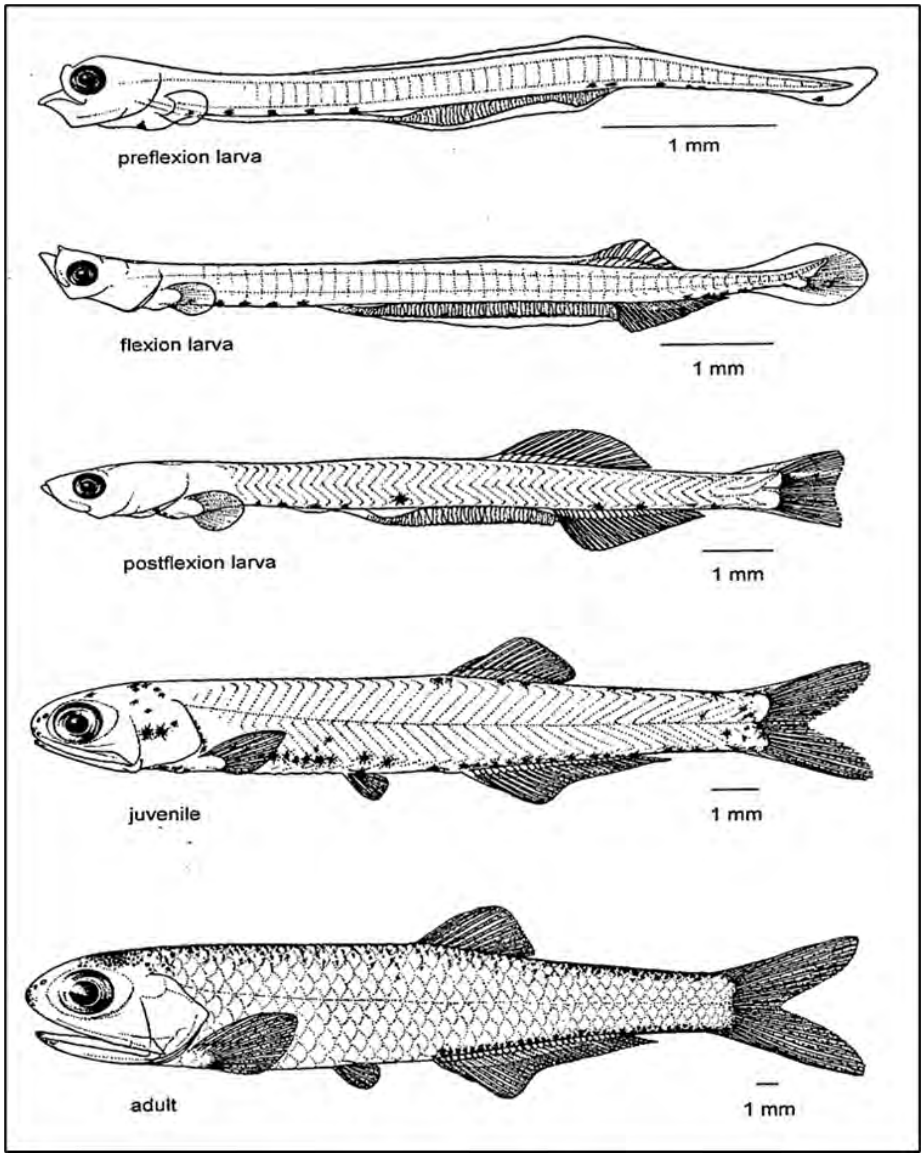


Figure 29. Development stages of the bay anchovy (*Anchoa mitchilli*) collected from the Lower Little Manatee River and Tampa Bay, measuring 4.6, 7.0, 10,5, 16 and 31 mm standard length. Reprinted from Peebles and Flannery (1992).

8. Additional data for nekton collected by seine and trawl

Section 4.3.2 of the draft minimum flows report discusses the lower river nekton community (fish and larger free-swimming invertebrates), including two sampling programs. The first was an electrofishing program at five locations in the upper portions of the lower river from approximately kilometer 18.2 to kilometer 22. Table 4-7 in the draft minimum flows report lists the species captured as part of this sampling effort, which includes many obligate freshwater species (e.g., largemouth bass, bluegill) and some estuarine species that are known to swim into fresh water (snook, striped mullet). As described on page 28 of this document, this is the tidal freshwater section of the river, which was described as such in the first draft report for the lower river (JEI 2018b) and that should be reiterated in the current minimum flows report.

It is appropriate that the emphasis of the assessment for the Lower Little Manatee River primarily concerns the nekton community in the estuarine portion of the river, as that is where nekton will be much more susceptible to the effects of reductions of freshwater inflow. The Florida Fish and Wildlife Conservation Commission has conducted extensive monitoring of the estuarine section of the lower river using both seine and trawl sampling, with the uppermost samplings extending to near kilometer 13.5, including connected side channels and large embayments to the lower river downstream of Interstate 75 (see Figure 4-7 in the minimum flows report.) The current sampling program, which employs stratified random sampling, has been conducted on roughly a monthly basis since 1996, with the review panel commenting on the unusual extensiveness of data set for fish and larger invertebrates (e.g., blue crab, pink shrimp) in the estuarine portion of the Little Manatee.

In the bottom paragraph of page 92, the draft report describes that annual variation in nekton catch data is expected due to climatic events such as droughts and tropical storms, and noted that a severe, 16-month red tide event occurred from 2017 through 2019 which led to fishery closures and may have impacted recent catch data. The report discusses changes in the composition of the fish community for the entire period of collection (1996 to 2019) and compared it to the catch in 2019. The report notes the increased dominance of the bay anchovy in 2019 and that three species accounted for 93% of the seine catch in 2019, while the period of record catch was more diverse with nine taxa accounting for approximately equal catch percentages. Variations in the annual abundance of eight abundant species were shown in graphs the report for the 1996-2019 period.

Graphics were also presented for annual variations for the period of record for the young-of- year four other species, including three species of sport and commercial importance; blue crab, common snook, and red drum. The report noted that among these species, recruitment occurred during all months, thus covering the entire flow regime of the river.

The draft minimum flows report also presents tables of the thirty most abundant species caught by seine and trawl. It is not stated why, but the tables are for the catch in the year 2019. This seems odd because the report discusses that the data from 2019 were less diverse that data from the period of record, and figures shown in the report clearly indicate the data from entire 1996-2019 were available and had been quantified. It seems like it would be more informative to present tables of abundance data for the entire period of data collection. If that would not be possible or appropriate for one of more reasons, the report should explain why the results for only 2019 are presented.

An extensive analysis of the nekton populations in the Lower Little Manatee River was prepared for the District in 2007 by the agency that collected the data, the Florida Marine Research Institute (FMRI) of the Florida Fish and Wildlife Conservation Commission. The report for that project (Macdonald et al. 2007) assessed data from the same stratified random sampling described in the minimum flows report, but with data ending in 2006, which still represents 11 years of data.

That FWRI report included a great deal of useful information. As with several other topics, much more discussion of the FMRI report was included in the first draft minimum flows report for the lower river (JEI 2018b) than in the current report, which has only a one sentence paragraph about it on page 98.

One very useful statistic reported in the FMRI report is mean salinity of capture, which generally describes the salinity zone of the river where various species are centered. As discussed on pages 11 to 13, Environmental Favorability Function (EFF) modeling was performed to evaluate changes in favorable habitat for ten fish species in the lower river. Because the salinity modeling of the river using the EFDC model concluded the < 2 psu zone of the river was the most conservative for protection, there might be a perception that is the most critical zone for estuarine fish utilization in the estuary. That is not the case, as many estuarine fishes are centered in the mesohaline reach of the river.

Mean salinity values at capture values taken from the FWRI report are listed in Table 6 for the ten species that were simulated using EFF modeling. Along with a slightly expanded discussion of the FWRI study, the mean salinity at capture values for these species should be included in the minimum flows report to describe where in the river and in which salinity zone these species are generally distributed.

Table 6. Mean salinity at capture for fish species for which changes in favorable habitat was simulated using the Environmental Favorability Function model in the draft minimum flows report. Values listed for both seine and trawl samples from 1996-2006 reported by MacDonald et al. (2007). All values as practical salinity units (psu).

Common Name	Scientific Name	Seine	Trawl
		Salinity (psu)	
Hogchoker	*Trinectes maculatus*	5.3	5.1
Clown goby	Microgobius gulosus	9.0	10.0
Rainwater killifish	*Lucania parva*	9.0	15.7
Striped mojarra	*Eugeres plumeri*	9.8	8.0
Naked goby	*Gobiosoma* bosc	8.8	7.7
Small gobies	*Gobiosoma* spp.	6.5	14.0
Common snook	*Centropus unidecimalis*	6.1	5.2
Sailfin molly	*Poecilia latipinna*	8.5	7.9
Sheepshead	*Archosargus probatocephalus*	11.0	15.1
Mosquitofish	*Gambusia holbrooki*	2.0	Not caught

Mean salinity at capture values for seine and trawl samples from the FMRI report could also be added to the tables of the most common species caught in the seine and trawl catch presented in the minimum flows report. Accordingly, I have added those values to the seine and trawl catch tables from the minimum flows report on the next two pages. However, it would improve these tables to use the period of catch data to calculate the abundance values in the table, not just from 2019.

Table 7. The thirty most common taxa caught by a 21.3 seine during the FMRI's Fisheries Independent Monitoring (FIM) program for stratified-random sampling in the Lower Little Manatee River during 2019. Reprinted from Table 4-9 in the draft minimum flows report for the Lower Little Manatee River with values added for mean salinity at capture taken from MacDonald et al. (2007).

Common Name	Scientific Name	Total Catch	% of Total Catch	Mean salinity at capture (psu)*
Bay Anchovy	*Anchoa mitchilli*	82,634	80.11	14.8
Menidia Silversides	*Menidia spp.*	9,594	9.30	10.5
Mojarras	*Eucinostomus* spp.	3,753	3.64	10.5
Menhadens	*Brevoortia* spp.	1,628	1.58	6.7
Tidewater Mojarra	*Eucinostomus harengulus*	1,152	1.12	12.9
Scaled Sardine	*Harengula jaguana*	821	0.80	20.9
Hogchoker	*Trinectes maculatus*	665	0.64	5.3
Clown Goby	*Microgobius gulosus*	568	0.55	9.6
Rainwater Killifish	*Lucania parva*	416	0.40	9.0
Rough Silverside	*Membras martinica*	256	0.25	12.6
Red Drum	*Sciaenops ocellatus*	231	0.22	13.1
Pinfish	*Lagodon rhomboides*	219	0.21	13.3
Striped Mojarra	*Eugerres plumieri*	215	0.21	9.8
Silver Jenny	*Eucinostomus gula*	162	0.16	19.4
Naked Goby	*Gobiosoma bosc*	87	0.08	8.8
Spot	*Leiostomus xanthurus*	86	0.08	10.5
Leatherjacket	*Oligoplites saurus*	86	0.08	13.2
Gobiosoma Gobies	*Gobiosoma* spp.	81	0.08	6.5
Common Snook	*Centropomus undecimalis*	74	0.07	6.1
Striped Mullet	*Mugil cephalus*	70	0.07	10.0
Pink Shrimp	*Farfantepenaeus duorarum*	60	0.06	12.6
Frillfin Goby	*Bathygobius soporator*	34	0.03	14.9
Blue Crab	*Callinectes sapidus*	32	0.03	7.9
Redfin Needlefish	*Strongylura notata*	29	0.03	15.8
Seminole Killifish	*Fundulus seminolis*	24	0.02	1.8
Silver Perch	*Bairdiella chrysoura*	21	0.02	11.8
Gray Snapper	*Lutjanus griseus*	21	0.02	13.0
Spotted Seatrout	*Cynoscion nebulosus*	19	0.02	10.4
Sheepshead	*Archosargus probatocephalus*	12	0.01	11.0
Gulf Killifish	*Fundulus grandis*	9	0.01	11.6

*** Mean salinity at capture for 1996 - 2006 taken from MacDonald et al. (2007)**

Table 8. The thirty most common taxa caught by a 6.1 meter trawl during the FMRI's Fisheries Independent Monitoring (FIM) program for stratified-random sampling in the Lower Little manatee River during 2019. Reprinted from Table 4-9 in the draft minimum flows report for the Lower Little Manatee River with values added for mean salinity at capture taken from MacDonald et al. (2007).

Common Name	Scientific Name	Total Catch	% of Total Catch	Mean salinity at capture (psu)
Bay Anchovy	*Anchoa mitchilli*	9,230	73.31	12.0
Eucinostomus	*Eucinostomus* spp.	1,796	14.26	13.8
Hogchoker	*Trinectes maculatus*	482	3.83	5.1
Clown Goby	*Microgobius gulosus*	264	2.10	10.0
Pink Shrimp	*Farfantepenaeus duorarum*	189	1.50	12.5
Gobiosoma Gobies	*Gobiosoma spp.*	118	0.94	14.0
Blue Crab	*Callinectes sapidus*	82	0.65	10.8
Hardhead Catfish	*Ariopsis felis*	58	0.46	8.8
Tidewater Mojarra	*Eucinostomus harengulus*	44	0.35	10.8
Sand Seatrout	*Cynoscion arenarius*	42	0.33	8.9
Southern Kingfish	*Menticirrhus americanus*	42	0.33	14.7
Red Drum	*Sciaenops ocellatus*	27	0.21	6.4
Code Goby	*Gobiosoma robustum*	24	0.19	21.0
Striped Mojarra	*Eugerres plumieri*	23	0.18	8.0
Gulf Pipefish	*Syngnathus scovelli*	14	0.11	19.0
Spotted Seatrout	*Cynoscion nebulosus*	12	0.10	8.8
Lined Sole	*Achirus lineatus*	11	0.09	8.7
Frillfin Goby	*Bathygobius soporator*	11	0.09	15.9
Atlantic Stingray	*Dasyatis sabina*	11	0.09	12.8
Leopard Searobin	*Prionotus scitulus*	10	0.08	22.9
Sheepshead	*Archosargus probatocephalus*	9	0.07	15.1
Inshore Lizardfish	*Synodus foetens*	9	0.07	21.3
Florida Blenny	*Chasmodes saburrae*	6	0.05	25.4
Longnose Gar	*Lepisosteus osseus*	6	0.05	8.5
Gulf Flounder	*Paralichthys albigutta*	6	0.05	21.9
Naked Goby	*Gobiosoma bosc*	5	0.04	7.7
Spot	*Leiostomus xanthurus*	5	0.04	21.9
Gray Snapper	*Lutjanus griseus*	5	0.04	13.0
Bighead Searobin	*Prionotus tribulus*	5	0.04	17.6
Southern Puffer	*Sphoeroides nephelus*	5	0.04	21.2

*Mean salinity at capture for 1996- 2006 taken from MacDonald et al. (2007)

In previous correspondence with the District, I have suggested that more attention could be given to the FMRI study, with possibly just a couple of paragraphs, to highlight the information that is in it. I also suggested that one page from the FMRI report that shows graphics for the red drum (*Sciaenops ocellatus)* be reproduced in the minimum flows report to provide an example of the information that is in the FRMI report. That page from the FMRI report (MacDonald et al. 2027) is reprinted on page 47. As discussed on page 3, I believe that when the District concluded to combine the draft reports for the upper and lower river there was an desire to make the report concise and some useful information in the previous draft report for the lower river got dropped. Greater elaboration on some of those topics would improve the current draft minimum flows report.

It should be also be noted that the technical approach and conclusions related to potential impacts to the nekton community in the previous draft minimum flows report for the lower river (JEI 2018b) was different than in the current minimum flows report. As with the current minimum flows report, the previous draft report utilized the Environmental Favorability Function (EFF) modeling to evaluate the effects of flow reductions on changes in favorable habitat for a number of fish species.

However, the previous report also reported the findings of regression equations prepared by Peebles (2008) and MacDonald et al. (2007) to predict the abundance of the stages of fish or invertebrate species as a function of freshwater inflow. The report discussed criteria that District had proposed from earlier work to identify regressions to predict fish abundance as a function of flow that are suitable for minimum flows analysis (Heyl et al. 2012). Those acceptance criteria specify that the regressions must include a) a minimum 10 observations per variable, b) a positive linear or 'midflow maximum abundance' quadratic response, c) no significant serial correlation and d) and an adjusted coefficient of determination (r^2) of at least 0.3.

Based on these criteria, the report utilized the ichthyoplankton regressions for juvenile yellow menhaden and bay anchovy and the nekton regression for blue crab and striped mullet, noting these nekton species have economic as well as ecological value. After evaluating the results, it was concluded that blue crab would have a 15% reduction in abundance with a 16% reduction in flow. The report then compared this finding and the results of the EFF habitat suitability modeling and concluded the minimum flows determined for the freshwater section of the river would be protective of the estuarine section of the river and basically recommended that the same minimum flows be adopted for both the upper and lower river.

As discussed on page 10, when the District had the previous draft reports for the upper and lower rivers combined into one report, some technical approaches changed, including dropping the regressions of flow with fish and invertebrate abundance. Also, separate minimum flows were proposed for the upper and lower river, but the flow blocks for upper river were applied to the lower river, which as discussed on pages 9 and 10, I find very problematic.

The difference in these approaches raises the question of reexamining relationships between flow and the abundance of key fish and invertebrate species. The District apparently concluded some of these regressions to predict abundance as a function of flow were suitable for use in the previous draft minimum flows report for the lower river (JEI 2018b). The current draft report shows a graphic

(Figure 4-11 on page 99) that shows that the yearly the young-of-the-year for four species showed large variations in annual abundance within seasonal recruitment windows, including blue crab, snook, and red drum, which are known to have strong estuarine dependence.

Given that there is now 14 years more data than when the previous regressions for nekton were developed by MacDonald et al. (2007), so a reexamination of relationships of the abundance of some key fish and invertebrate species with freshwater inflow could be warranted. If this results in slight postponement in the adoption of minimum flows for the Little Manatee, that could be well justified given the importance of the Little Manatee River as a nursery zone for estuarine dependent species and its status as the most intact and ecological healthy tidal river flowing to Tampa Bay.

9. Greater elaboration of the characteristics and functions of low salinity zones in the lower river related to favorable fish habitat and food web relationships

On page 2-26 in their initial report, the review panel states "In the conclusions for this topic, it would be useful to summarize how other data considered (e.g., zooplankton) also indicated the need to protect the low salinity habitat, so as to provide as a weight of evidence approach for selection of the 15% EFF habitat reduction. Note that establishing the precise flow blocks for the estuary also needs additional analysis."

I concur with this suggestion, but would add that low salinity zones include both oligohaline and mesohaline zones in the river and the discussion include the characteristics of these zones that contribute to food webs that support fish abundance, in addition to the favorable habitat in terms of salinity and shoreline habitat that is predicted by the EFF modeling. This discussion could be fairly brief, probably a page, but it should cite relevant studies of the Little Manatee and from the general literature to support its main points.

In previous correspondence, I have provided to the District references and brief summaries of additional ecological studies of the lower river that should be cited in the minimum flows report, including studies of phytoplankton by Vargo (1989 ,1991) and zooplankton by Rast et al. (1991). In addition, there is a review of the feeding habits of juvenile estuarine dependent fishes and blue crabs by Peebles (2005) and study of the nursery function of estuaries using stable isotope analysis by Hollander and Peebles (2004) that discuss or incorporate data from the Little Manatee.

I don't know believe this discussion will directly affect the determination of the final percent withdrawal percentages to be determined for the lower river, but I do think that considerations of the response of salinity, chlorophyll a, and fish community characteristics to freshwater inflow could be incorporated in the determination of appropriate flow-based blocks for the lower river, which in turn could affect the determination of allowable flow reduction percentages within each block. In separate document I will submit to the District, I will present some analyses of salinity and chlorophyll *a* related to the determination of flow-based blocks for the lower river.

Figure 26 on the following page with text for new topic beginning on page 48

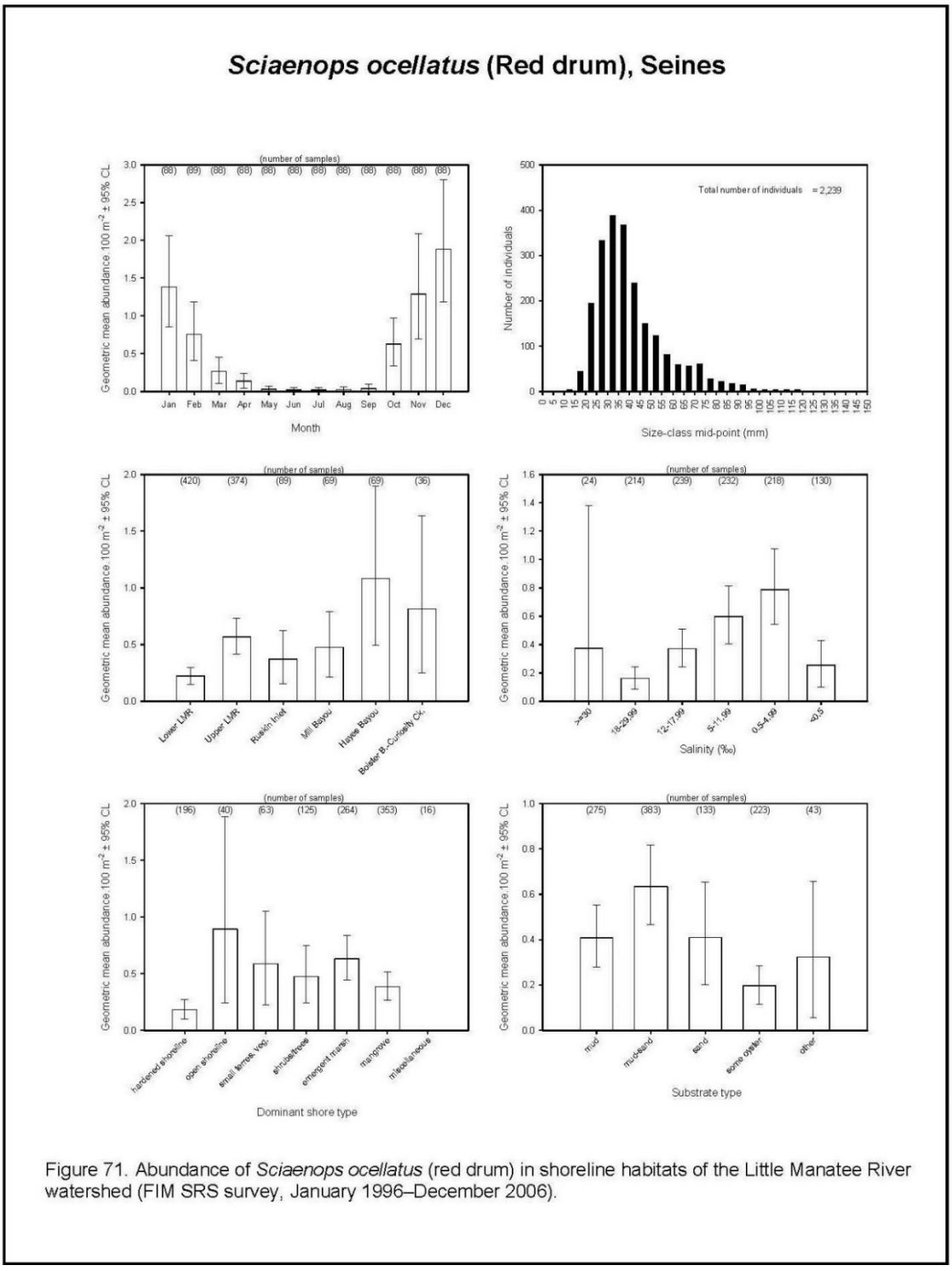


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

Figure 30. Graphics for the seine catch of red drum shown as an example of a page from the FRMI report for the Little Manatee River that could be shown in the minimum flows report to highlight the information available from that report (MacDonald et al. 2007).

10. Clarification on previous District method for adjusting flow record to create a baseline flows

In order to better describe the District's work on the Little Manatee River, some clarification is offered regarding the previous method the District used adjust the flow record for excess agricultural water to create a baseline flow record for the river. Fortunately, it is a moot point now, that has been remedied by the new method for calculating a baseline flow record, which I support.

Based on previous work in the Little Manatee River watershed, it was apparent that excess agricultural water was entering the Little Manatee River when the first minimum flows report for the upper river was prepared, so adjustments were made to the gaged flow record to create a baseline flow record. Early evaluations involved simply subtracting 15 cfs from the gaged flows. However, this was replaced by a method that examined statistically significant trends in various yearly percentile flows within the three calendar blocks used for the minimum flows, then adjusting the flow record based on changes in these percentiles with a step change observed in 1978. This is the method that is described on pages 4-32 to 4-43 in the first minimum flows report for the upper river (Hood et al., 2011), and the review panel for that report had no criticism of it (Powell et al 2012).

However, apparently due to a miscommunication at the District, the method of subtracting 15 cfs was baseline flow record that was provided to the consultant that did the HEC-RAC modeling, which Janicki Environmental discovered when reviewing the output from that previous modeling effort. On page 3-8, the reevaluation of minimum flows for the upper river (JEI 2018a), this is described as below.

"The District previously considered two alternative methods for developing a correction for excess flows due to agriculture during the development of minimum flows for the Upper Little Manatee River. The daily 15 cfs withdrawal appears to be chronologically the first correction considered and that is the method described in the HEC-RAS report and presumably used in the PHABSIM analysis as described in the summary in Chapter 2. The second method, utilizing the difference in percentile flow values between the two benchmark flow periods was well described in section 4.2.7 of the 2011 minimum flows report, but based on review of the model framework, does not appear to have actually been used for development of the proposed minimum flows."

This method is also acknowledged in the first draft report for the lower river (JEI 2018b), which on page 2-10 states "Methods to adjust the historical timeseries of flows for anthropogenic streamflow augmentation was the subject of much research as described in section 4.2.7 of the original minimum flows report and the reevaluation of the freshwater minimum flow."

Although it was not ultimately used in the minimum flows analysis, the presentation and discussion of this method for baseline flow adjustment in the first minimum flows report for the upper river provides very useful information for trends in low, medium, and high flows in the Little Manatee River until 2009 (Hood et al. 2011). Withdrawals from the river by FP&L withdrawals and point source discharges from Mosaic site D-001 are also described in more detail in that report.

11. Clarification on source of Myakka River excess flow estimates

It is interesting and encouraging that the current method to adjust the flow record used for the Little Manatee gave estimates of excess flows that showed a similar seasonal pattern to that calculated for the Myakka River by the MIKE SHE /MIKE 11 integrated modeling platform (MIKE SHE), which is described on page 105 of the current minimum flow report. The results from the MIKE SHE modeling effort were taken from the minimum flows report for the Lower Myakka River and cited as Flannery et al. (2011). However, in previous correspondence, I have informed the District that references to the MIKE SHE results report should cite the work by Interflow Engineering LLC, who applied the model to the Myakka River and citations for their work are included in the minimum flows report for the Lower Myakka.

While at Interflow Engineering, review panel member John Loper led the MIKE SHE modeling effort and he and I collaborated with Dr. Chen of District staff and a former member of Janicki Environmental to write an article that described how those results were applied to the salinity modeling of the Lower Myakka River (Flannery et al. 2009), which is listed in the Literature Cited for this document.

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From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Kristina Deak; Lei Yang; Xinjian Chen; Gabe I. Herrick; Jordan D. Miller; Randy Smith; Danielle Rogers; Chris Zajac; Ron Basso
Cc:	MIke Wessel
Subject:	DRAFT supplementary analyses, data presentations and clarificaitons
Date:	Tuesday, January 25, 2022 7:35:27 AM
Attachments:	Little Manatee River supplementary analyses - DRAFT - Sid Flannery, Jan 24, 2022.pdf

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[EXTERNAL SENDER] Use caution before opening.

Hello Kym, Doug, and District staff,

Attached is a pdf file of a DRAFT document I prepared that presents some supplemental analyses, data presentations, and technical clarifications related to the evaluation of minimum flows for the Little Manatee River.

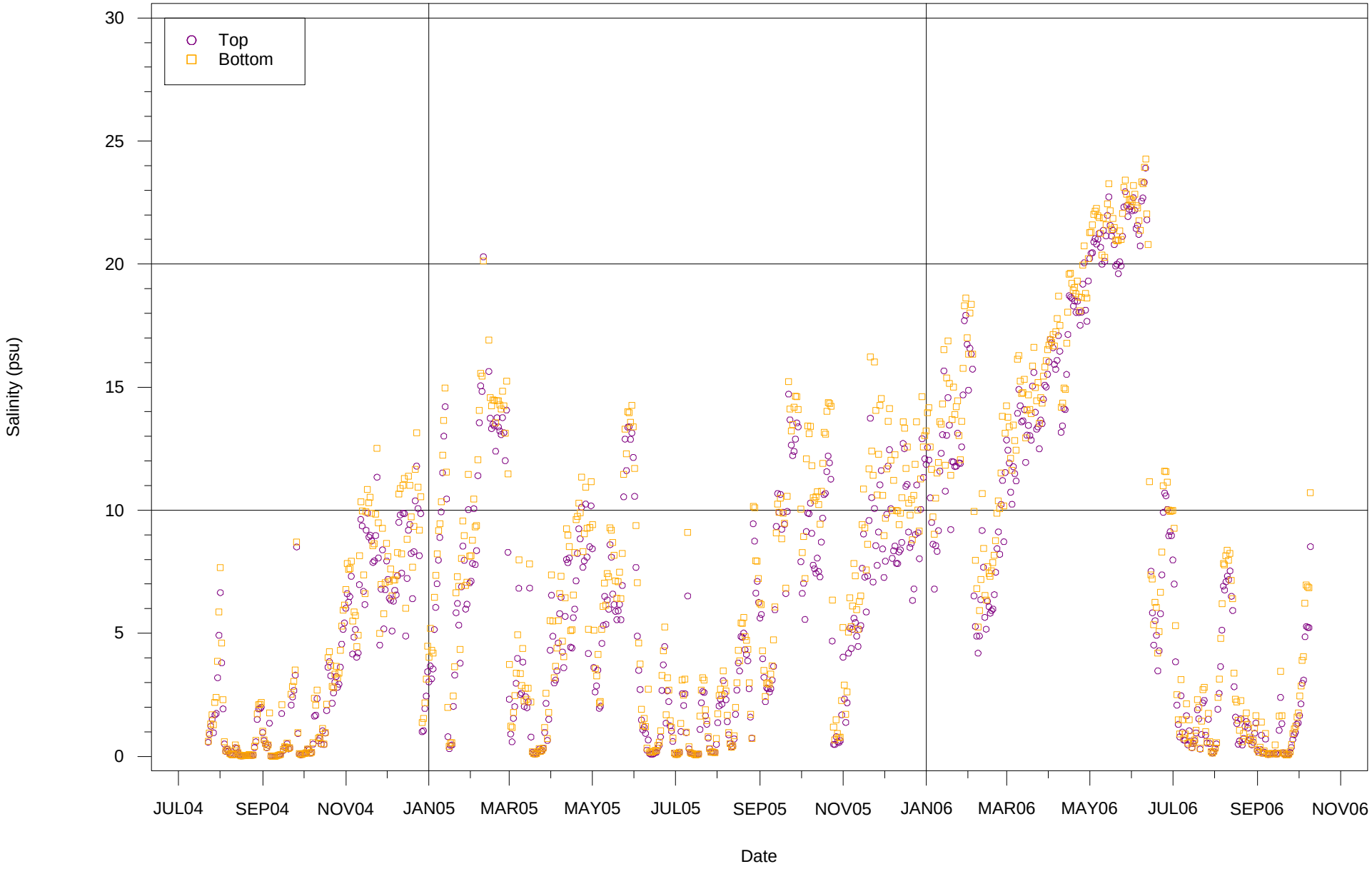
At some point I would like for the finalized version to be sent to the review panel for the minimum flows report, but not yet. I will consider any comments the District has on this draft. If you have any comments, could you get them to me by EOB next Monday (Jan 31). I am having a couple of other environmental scientists / ecologists look it over as well.

Thanks,
Sid

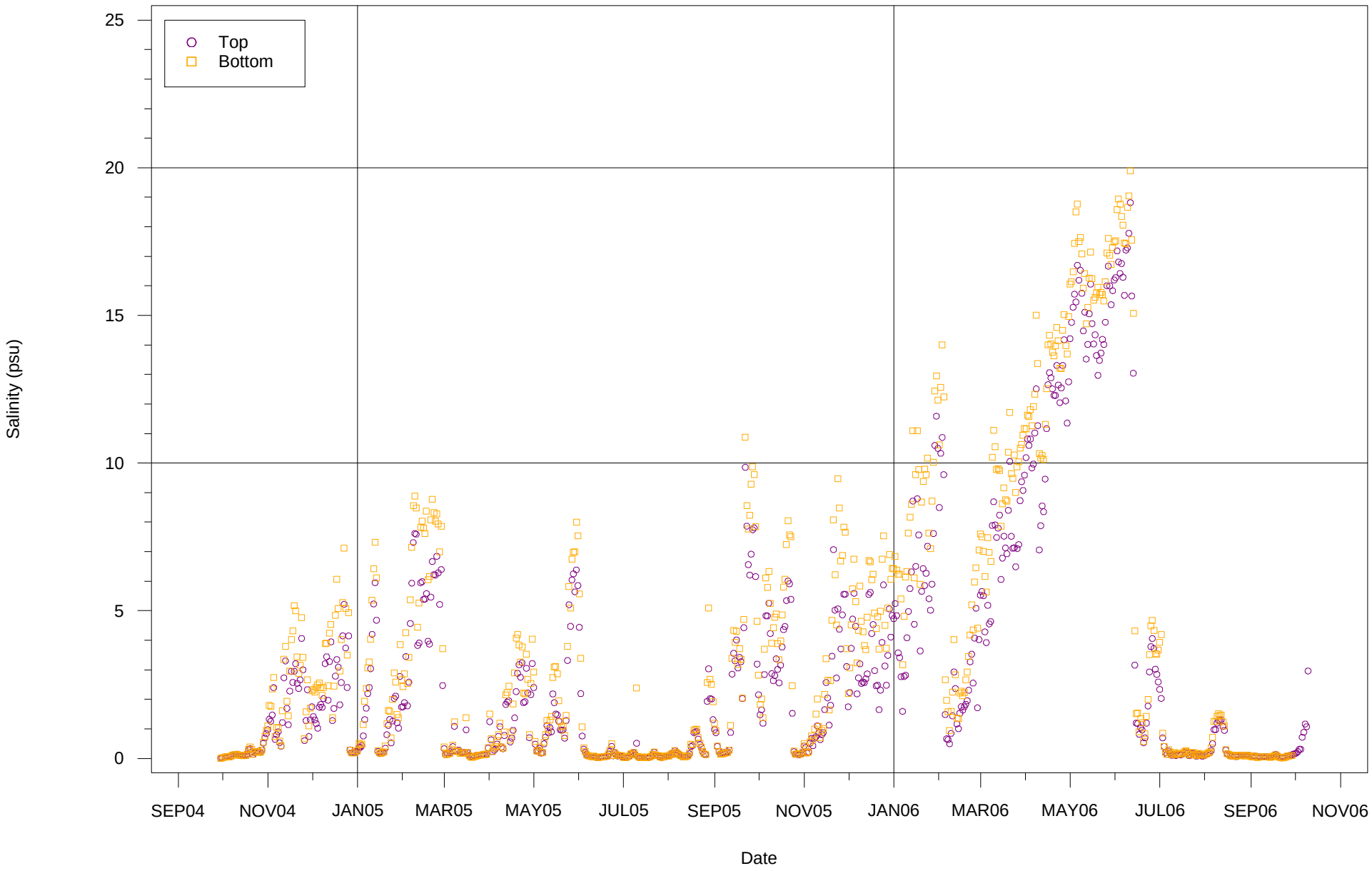
Little Manatee River USGS Station at River Kilometer 0.8
Top and Bottom Salinity, Daily Average



Little Manatee River USGS Station at River Kilometer 8.3
Top and Bottom Salinity, Daily Average



Little Manatee River USGS Station at River Kilometer 12.1
Top and Bottom Salinity, Daily Average



From:	Sid Flannery
To:	Doug Leeper; Randy Smith
Cc:	Kym Holzwart
Subject:	USGS Little Manatee salinity plots going into 2006
Date:	Thursday, February 10, 2022 3:01:12 PM
Attachments:	Little Manatee Salinity time series USGS 1.pdf Little Manatee Salinity time series USGS 2.pdf Little Manatee Salinity time series USGS 3.pdf

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[EXTERNAL SENDER] Use caution before opening.

Hello Doug and Randy,

As I mentioned at today's virtual meeting, the USGS salinity recorders that were operated for the development of the EFDC model for the Lower Little Manatee River actually ran into early October 2006. However, not knowing what the future hydrologic conditions would be, the project contract called for data to be analyzed only into 2005.

See the attached plots. Near the mouth of the river the salinity response during 2006 was not greatly different than during the previous years, but much higher salinity values were recorded in 2006 at the recorder at kilometer 12.1 and to some extent at kilometer 8.3 as well. As I also mentioned during the meeting, the project to compute the ungaged flows to the lower river did not extend into 2006.

Thanks for your time today, it was appreciated.
Sid

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Randy Smith; Chris Zajac; Doug Leeper
Subject:	Re: Little Manatee River Minimum Flows Development
Date:	Thursday, February 17, 2022 1:56:50 PM

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and others,

Thanks for letting me know that the Environmental Favorability Function (EFF) modeling is being revised. I expect the results may be similar to before, but it will be best to examine the results from the latest version of the EFF models. I also understand the EFDC hydrodynamic model that is used to predict salinity in the lower river is also being revised. Again, I expect the results may be similar to the existing model, but that can't be determined until the EFDC model is revised.

As I have previously described, the types of results I want to examine for the EFF modeling results are fairly simple. First, for each selected species, plot the quantity of favorable habitat as a function of baseline flow. Secondly, for these same species, for a few percent flow reduction scenarios (e.g. 20%, 30%) plot the percent reduction in favorable habitat as a function of flow.

The purpose of these analyses is to see if the amount of favorable habitat under baseline conditions and the reductions in favorable habitat for different percent flow reductions respond to flow in a linear or nonlinear manner. These results will be examined for two purposes: (1) to assess relevant flow blocks for the lower river, and (2) to assess to what degree the flow duration characteristics of the minimum flows analysis period (e.g., 2015 to 2019) could have affected the minimum flow determination.

For these analyses to be most useful, it would be helpful to review them fairly early in the minimum flows analysis process. Your email says that once the District has revised the draft report, staff will meet with me to go over the revised results. I think it would be more advantageous to provide to me the model output I have requested prior to revising the draft report. Alternatively, the District could do the types of analyses I have suggested, but those results should be reviewed in a meeting prior to revising the draft report.

I have made a similar request for salinity output from the EFDC hydrodynamic model for the river, which is actually simpler as there are not several species involved. That output will be analysed in a similar manner as described above to examine how salinity quantities (e.g. area, volume) and percent reductions in these salinity quantities vary as a

function of freshwater inflow. Similarly, it would be advantageous to provide the output to me prior to revising the draft report, or the District perform such analyses and we meet prior to revising the draft report.

As discussed above, I expect the output and results from the revised EFF and EFDC models may be similar to the current models. Also, the types of analyses I am looking to do are fairly straightforward, and in that regard, I suspect the plots I want to produce may look similar whether they are generated from the existing or the revised models.

I also understand the District would like to finalize the minimum flows report and adopt minimum flows for the Little Manatee this calendar year. In that regard, it could be advantageous to provide to me the output from the existing models fairly soon. I could do the types of analyses I am suggesting to see if there are any general relationships. Those results could be used to focus on analyses on the output from the revised models once those models are finalized. As described above, either I or the District could do those analyses on the revised model output, but I reiterate those results should be reviewed prior to revising the draft report.

I think this proposal of providing to me the output from the existing EFF and EFDC models fairly soon poses a big advantage for the timely completion of the minimum flows report and adoption of the minimum flows this year. I hope that the District can consider this request and we can discuss it further.

Thanks,
Sid

On Thu, Feb 17, 2022 at 6:59 AM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

> Good Morning Sid,
> Randy filled me in on the topics discussed during your meeting last week. As you know, we are in the process of conducting additional work to address the peer review comments, which will include a re-do of the Environmental Favorability Function analysis for the lower river. Once we have completed our work and have revised the draft report, we will schedule a meeting with you to go over the revised results before we resume meetings with the peer reviewers.
> Best regards,
> Kym
>
> Kym Rouse Holzwart, M.S.
> Certified Senior Ecologist
> Senior Environmental Scientist

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From:	Sid Flannery
To:	Kym Holzwart; Chris Zajac; Doug Leeper; Randy Smith
Cc:	Xinjian Chen; Gabe I. Herrick; Kristina Deak; Lei Yang; Danielle Rogers; Jordan D. Miller; esherwood; Dave Tomasko; MIke Wessel (MWessel@janickienvironmental.com)
Subject:	Status of EFDC and EFF modeling for the Little Manatee River
Date:	Thursday, May 12, 2022 8:34:56 AM

[EXTERNAL SENDER] Use caution before opening.

Hello Kym,

Thanks to the District for informing me that a scope of work is being pursued with the consultants to do additional work on the Little Manatee River minimum flows, including making refinements to the EFDC model and that new model runs will be performed. A thought in that regard is reiterated below.

As I described in previous correspondence, it would be very informative to simulate changes in shoreline lengths in the Little Manatee River that are less than various salinity values for baseline flows and the flow reduction scenarios. The Little Manatee is somewhat unusual in the large amount of shoreline per river length upstream of the I-75 bridge, which is dominated by oligohaline marshes and farther upstream by freshwater vegetation. As previously described, the ratio of shoreline length to river area or volume can vary considerably, and it is possible that changes in shoreline length might be a more sensitive parameter to the effects of flow reductions than river volume or area.

Also, it has been my understanding that the EFF fish habitat modeling for the river will also be revised. Is that correct? As described in previous correspondence, I would like to receive output for the EFF modeling for several fish species for baseline flows and a few flow reduction scenarios. If the EFF models are being revised, I can wait until the revised models and new simulations are run. However, if the EFF modeling is not being revised, I might like to do some analyses on the existing model output starting in June.

Apart from assessing EFDC and EFF model output, I will use data and reports I already have to assess the relationships of freshwater flow to chlorophyll *a* concentrations and salinity at various locations in the Little Manatee. The purpose of these analyses and the assessment of EFDC and EFF model output is two-fold: (1) to assess flow blocks that might be applicable to the estuarine resources of the lower river; and (2) to assess how the flow duration characteristics within different multi-year periods might influence the findings of the minimum flows analyses and the determination of the minimum flows.

A key factor for both of these analyses is whether various parameters,

including model output, respond to flow in largely a linear or nonlinear manner. I would appreciate it if the District can apprise me if the EFF modeling is being revised, and as work on the EFDC modeling proceeds, a rough timeline on when the revised simulations might be completed.

Thanks,
Sid

From:	Sid Flannery
To:	Kym Holzwart; Gabe I. Herrick; Xinjian Chen; Lei Yang; Kristina Deak; Jordan D. Miller; Doug Leeper
Cc:	Chris Zajac; Randy Smith
Subject:	Short description of Clewell et al. (2002) methods in the Little Manatee River minimum flows report
Date:	Tuesday, September 6, 2022 10:52:18 AM
Attachments:	0199_Clewell_Vegetation_color reduced size.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and Little Manatee River minimum flows report co-authors,

This email pertains to inserting a few sentences about the Clewell et al. (2002) report in the description of the vegetation communities in the lower river in the minimum flows report for the Little Manatee. That report is attached and I understand it also resides in the District's online technical library.

The Clewell report is cited and briefly described on page 111 of the draft minimum flows report in the discussion of salinity values that are related to vegetation communities in the tidal river. In the draft supplemental analyses document I submitted back in January, I mentioned the Clewell report should also be cited in the section about the lower river floodplain that starts on page 69. I think it would be good to also insert a couple of sentences there about that report as it involved plant identifications and estimates of species percent cover in 77 quadrats sampled on the banks of the tidal river. Since the other discussions of vegetation communities in the lower Little Manatee river in the minimum flows report are restricted to aerial photo-interpretation, it would be valuable to alert readers that there is a thorough on the ground assessment of plant species and vegetation communities in the lower river. This could be an important reference document if plant species distributions change over time due to sea level rise, flow reductions, or whatever.

In previous correspondence, I have suggested some other ways the discussion of the morphology and vegetation communities of the lower river could be enhanced. I have also suggested several other graphics from previous District studies of fish and other communities in the Little Manatee that could be inserted into the minimum flow report to enhance its portrayal of the ecology and salinity relationships of the tidal river as they pertain to the determination of minimum flows.

Tomorrow, I hope to submit a document I recently prepared regarding the assessment of relationships of freshwater inflow with chlorophyll *a* concentrations in the Little Manatee River that will include another figure that would be good to include in the minimum flows report.

Sid

AN ANALYSIS OF VEGETATION-SALINITY RELATIONSHIPS IN SEVEN TIDAL RIVERS ON THE COAST OF WEST-CENTRAL FLORIDA (DRAFT)

Technical Report of the
The Southwest Florida Water Management District
Brooksville, Florida

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December 2002

04642

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December 2002

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CHAPTER ONE
INTRODUCTION

1.1 Purpose of the study

This project was conducted to better define relationships between salinity regimes and the distribution of wetland plant species and communities in tidal rivers in Southwest Florida. In addition to providing valuable ecological information for the region, these results will be used by the Southwest Florida Water Management District (the District) to support the establishment of minimum flows and levels for rivers.

As part of its role in the management of natural systems, the District must establish minimum flows and levels for streams and other flowing watercourses. Minimum flows are defined in Florida statutes as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area". Implicit in this definition is that the Water Management District's must establish the hydrologic needs of natural systems associated with flowing water bodies, so that that limit at which further withdrawals will cause significant harm to the ecology of the are can be determined.

An emphasis of the District's minimum flows program has been the maintenance of freshwater flow to coastal estuaries. Freshwater flow from creeks and rivers is a dominant factor affecting the physical, chemical, and biological characteristics of estuarine systems. In addition to their inherent attributes as natural systems, estuaries support valuable sport and commercial fisheries are important to the Florida's economy (Bell et al. 1982, Comp, 1985).

In keeping with its role of determining minimum flows, the District has conducted a long-standing program of data collection and research concerning freshwater inflows to estuaries in the region. These studies have included assessments of river hydrology, estuarine salinity and water quality, and biological relationships with freshwater inflows. An important component of the District's minimum flows studies have involved tidal wetlands associated the region's estuaries. Tidal wetlands, such as mangroves, salt marshes, and floodplain forests, provide many important functions in estuaries with regard to water quality, energy dynamics, and the production of fish and wildlife in estuarine systems (Odum et al. 1984, Lewis et al. 1985, Coultas and Hsieh 1997).

Since they are areas where fresh water and sea water mix, estuaries are characterized by pronounced salinity gradients. Salinity is highest near the mouth of the estuary near the sea, gradually changing to freshwater conditions at its upstream end. The distributions of wetland plant species and communities are strongly related to these salinity gradients. The withdrawal of large amounts of fresh water could affect tidal vegetation by increasing salinity and altering the abundance and distribution of different plant communities in the estuarine system.

Although much has been published on the salinity relations and distribution of tidal wetland plants, this project was designed to gather such information specifically for tidal wetlands in southwest Florida. Factors related to the climate, biogeography, and geomorphological characteristics of southwest Florida could exert effects on salinity/plant relationships that specific to the region. New information on such relationships could improve the District's ability to manage freshwater flows so that significant harm does not occur to tidal wetlands associated with estuaries in the region.

1.2 The study area

The geographic areas that were the focus of this project were the tidal river zones of larger estuarine systems. The tidal reaches of creeks and rivers are critical areas of estuaries in southwest Florida, since much of the critical low and medium salinity habitats are located upstream of the river mouths (Estevez et al., 1991, Flannery et al. 2002). Also, gradients in plant communities are often most clearly expressed within the tidal rivers, due to the strong salinity gradients that exist there.

Seven tidal rivers were selected for study in this project (Figure 1.1) The rivers in the study can be divided into two groups. The first is a group of three southern rivers that are tributaries to either Charlotte Harbor (Peace and Myakka rivers) or Tampa Bay (Little Manatee River). The other group is comprised of four northern that rivers are located on what is called the Springs Coast - the shallow coastal zone that extends along Pasco, Hernando, and Citrus counties within the District. The rivers in this region selected for study were the Weeki Wachee, Chassahowitzka, Crystal, and Withlacoochee.

The first criterion for inclusion in the study was that salinity data were available for that river, so that comparisons of plant distributions to salinity gradients could be made. As described in Chapter 2, salinity data for each of these rivers were available from a series of previous studies. With the exception of the Myakka River, all of these studies were either conducted or sponsored by the District.

The other criterion for river selection was that plant communities are largely intact along the length of the tidal river. This being the case, all transitions in plant species and communities should be present and not influenced by physical alterations such as shoreline hardening or fill. For the most part, this was the case for all the tidal rivers. Some exceptions were the upstream end of the Weeki Wachee River and the mangrove zones of the Peace and Myakka Rivers.

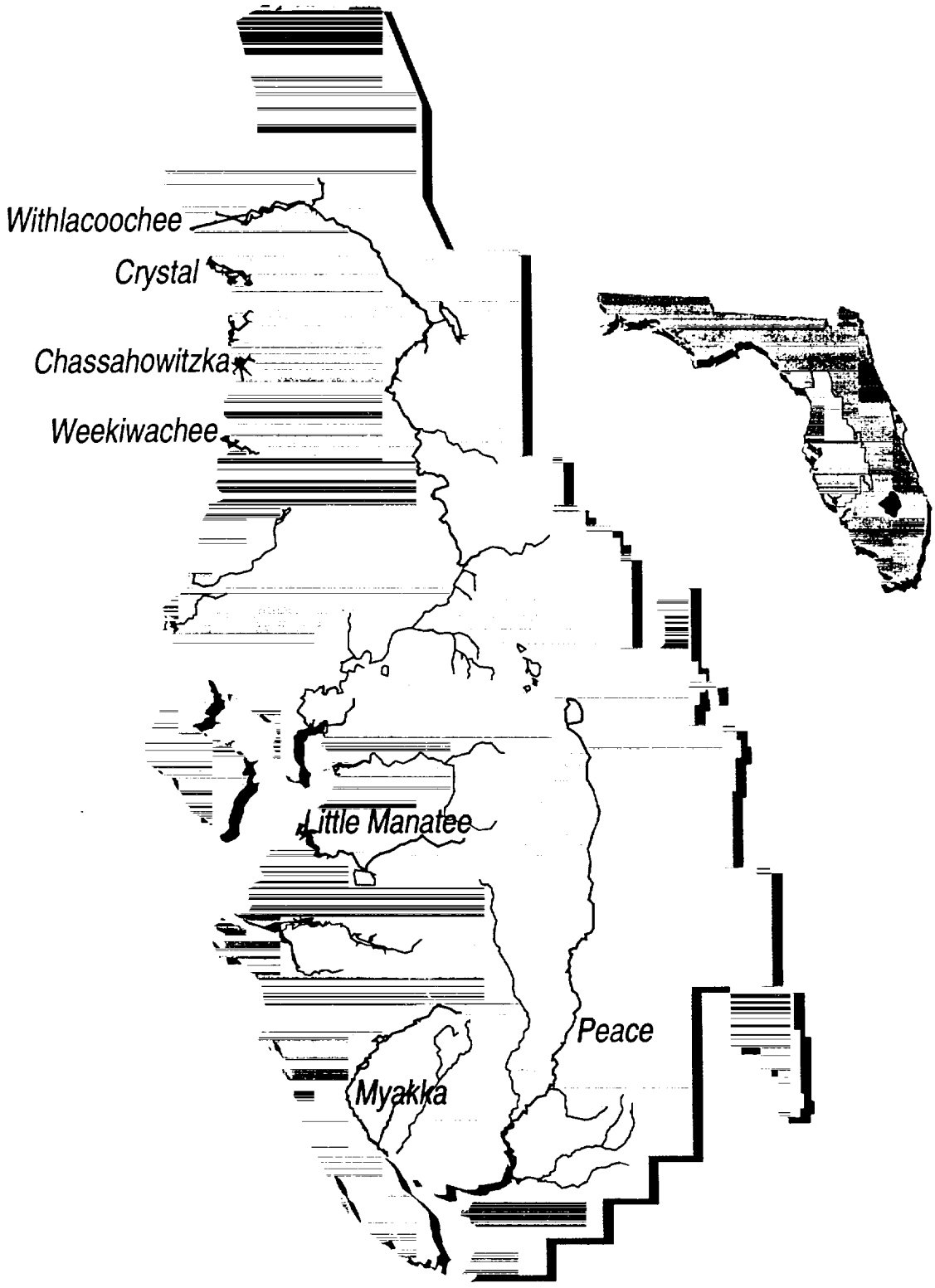


Figure 1.1 Location of the study rivers

1.3 Study components

The distribution of major plant communities associated with the rivers was documented by two projects that used photo-interpretation to produce data layers and maps with a Geographic Information System (GIS). Both of these projects were conducted by Marine Research Institute of the Florida Department of Environmental Protection (FMRI 1997, 1998). The maps resulting from those projects that are included in this report show the broad, general distribution of wetland communities in relation to each tidal river. The maps also show the general configuration of the tidal rivers including their braids, islands, distributaries, and adjacent coastal and upland areas.

The distribution of individual plant species in the study rivers was documented by a field study in which plant species composition was recorded at a total of 462 shoreline sites on the seven tidal rivers. Using salinity data available for each river, frequency distributions of salinity were estimated for river-mile locations corresponding to each shoreline vegetation site. Analyses were then conducted of the relationships between salinity and the distribution of plant species.

As described further in Chapter 2, the results for salinity-species relationships presented in this study are most applicable to the herbaceous species. The study design emphasized herbaceous plants immediately adjacent to the river channel, as it was assumed these plants would be most closely related to river salinity.

The distribution and salinity relations of woody plant species, such as mangroves and trees in tidal freshwater floodplain forests, were not explicitly covered by the design of this study. Although useful information for these species is presented in this report, interpretation for woody plants is largely limited to the general distribution of mangroves and wetland forests as documented by the GIS maps.

1.4 Study participants

The study was designed and coordinated by the staff of the Southwest Florida Water Management District, who also participated in data collection, analysis, and report preparation. Michael Flannery was the project manager for the study and wrote chapters 1, 2 and 3. Plant species identifications and coverage estimates generated during the initial site sampling were performed by Richard Eilers, who was with the University of South Florida Herbarium. Andre Clewell, of A. F. Clewell Inc., performed a general reconnaissance of plant species present along the tidal rivers and revisited many of the sites where the initial vegetation sampling was conducted. Dr. Clewell was also involved in data interpretation and the wrote most of chapters 4 and 5. Ralph Montgomery, of PBS&J, Inc., was involved in the early data management for the project. Data management for the project was then turned over to Susan Janicki, of Janicki Environmental, who produced all the statistical analyses, figures, tables, and appendices presented in the report. Tony Janicki of Janicki Environmental participated in discussions of data presentation and analyses. Quincy Wylupek of the District assisted with field work. The participation of these individuals is gratefully acknowledged.

CHAPTER TWO
DATA SOURCES AND METHODS

2.1 Overview

A goal of this project was to compare vegetation distributions to existing physical, hydrologic, and salinity information for the seven rivers. In order to make the results of this study comparable to existing information for these rivers, conventions used in previous studies were used to describe locations and salinity distributions within the rivers. Existing information for the rivers was also used to distribute vegetation sampling efforts within and among rivers, so the results for the seven study rivers would be most comparable. The data sources and methods that were used in this project for river characterization, site selection, data collection and analysis are described below.

2.2 River configuration and vegetation mapping using photo interpretation and GIS

The vegetation maps of the rivers shown in Figures 4.1 – 4.7 were produced at the District using Geographic Information System (GIS) files developed by the Florida Department of Environmental Protection for two other projects (FRMI 1997, 1999). The maps for the Peace and Myakka Rivers were developed as part of a project to examine changes in tidal river vegetation over time (FMRI, 1999). The maps from that project presented in this report (Figs. 4.1 and 4.2) were developed from aerial photography taken in 1994.

The maps for the other five rivers (Little Manatee, Weeki Wachee, Chassahowitszka, Crystal, Withloacoochee) were developed for another project conducted by the FMRI (1997) to improve the delineation of vegetation communities in the tidal reaches of those rivers. The aerial photography used for that project was taken in 1990. Greater details concerning the data sources and methods used to develop these GIS coverages can be found in the two reports for those projects (FMRI 1997, 1999)

2.3 River distance scales

River distance scales for the seven rivers presented in this report were based on distance scales used in previous studies. For consistency, all scales are expressed in units of miles. The distance scale for the Myakka River was adapted from that used by Hammett (1992), whereas the scale for the Peace River was adapted from that used by Stoker et al (1989). The scale for the Little Manatee River was developed by Peebles and Flannery (1992). The distance scales for the four northern rivers (Weeki Wachee, Chassahowitzka, Crystal, and Withlacoochee) were taken from a studies of these rivers performed

by the U.S. Geological Survey (Yobbi and Knochemus; 1989a, 1989b). Mote Marine Laboratory (e.g. Dixon 1986) also conducted a series of ecological studies of these rivers during this time period using the same distance scale. Using landmarks and river miles identified in each of these studies, a centerline up the center of each river channel was manually delineated on 1" x 200' aerial photos. Using a roller wheel, these centerlines were then divided into lengths of 1/10 miles and used to estimate river mile locations of sites in the field.

2.4 Streamflow data

Streamflow data are used to for three purposes in this project: (1) to characterize the variability of the flow regimes of the seven rivers; (2) to characterize streamflow conditions prior to the collection of vegetation data, and (3) to characterize streamflow conditions when salinity data were collected for each river.

Since the vegetation field studies were conducted in 1989 and 1990, comparisons of streamflow characteristics among rivers were limited to the period from 1970 to 1990. The year 1970 was chosen as a staring point as that is when the collection of daily streamflow data began for the Lower Withlacoochee River. Also, it was considered that this period was long enough to capture a series of inter-annual fluctuations in wet and dry years. Some authors (Coastal Environmental 1996; Flannery and Barcelo 1998, Hickey 1998, Basso and Shultz 2002) have suggested that the 1970s represent a shift in climatic conditions that have affected streamflow trends in west-central Florida. Therefore, the 1970-1990 period might best reflect streamflow conditions that affected vegetation distributions observed in this study.

The quantity and quality of streamflow data varied between rivers. On the Peace, Myakka, Little Manatee and Withlacoochee Rivers, streamflow data were obtained for the most downstream USGS gage on the main stem of each river. These gages were the Peace River at Arcadia (#02296750), Myakka River near Sarasota (#0229830), the Little Manatee River near Wimauma (#0230500), and the Withlacoochee River Bypass Channel near Inglis (02313250). Complete daily records were available for these gages for the 1970-1990 period.

Daily flows records for the entire period of study were not available for remaining three rivers (Weeki Wachee, Chassahowitzka, Crystal), all of which fed by coastal springs in the northern region of the study area. Flows in the Weeki Wachee River were periodically measured during the 1970-1990 period. However, flows in the Weeki Wachee are highly correlated with water levels in a nearby Floridan aquifer well. Yobbi and Knochemus (1989a) presented a regression equation by which water levels in a nearby Floridan aquifer well can be used to estimate daily flows in the Weeki Wachee River. This regression was used to estimate daily streamflow values for the years 1975-1990. Water levels in the well were available on an approximately five-day intervals during 1970-

1974, so flows were only estimated for those days. Since flow from the springs respond to changes in climatic conditions slowly, the periodic flows (5-day intervals) during 1970-1974 record probably closely reflect the range and variability of daily flows during this period, and statistical summaries of flows for the entire 1970-1990 period are presented in this report.

Flows in the Chassahowitzka River can be similarly estimated using a regression equation of river flow with water levels from a nearby Floridan aquifer well (Yobbi and Knochemus 1989b). Water levels for this well (ROMP 19-2) were available on a daily basis for the years 1976-1989. Therefore, estimated streamflow values presented for the Chassahowitzka are limited to that period.

Flows in the Crystal River are very difficult to measure due to large tidal influence on flow that extends to the river headsprings. The USGS reported average daily flows for Crystal River for the period 1965-1977. However, these records are rated as poor because of the effects of tides, aquatic vegetation, and winds on streamflow in the wide river channel. On some days, negative (upstream) flows were recorded for Crystal River due to the effects of incoming tidal water or wind effects. If flows are averaged over 14-days intervals, these averages all become positive reflecting a balancing of tidal effects during longer periods. Yobbi and Knochemus (1989a) were able to estimate daily flows from Crystal River for eleven dates during their study. However, flow data prior to the collection of vegetation or salinity data for this District project were not available. As a result, streamflow data presented for Crystal River in this report are limited to values published by the USGS for the 1970-1977 period.

2.5 Salinity data

Salinity data for the seven rivers were obtained from previous studies. In all of these studies, vertical salinity profiles were measured at a series of fixed location stations in each river. With the exception of the Chasshowiska River, profiles were measure at the surface (0.3 to 0.5 meters depth) and at deeper one-meter intervals (1m, 2m, etc.). For this project, salinity values were averaged from surface and one meter depths to get an average for the top meter of water, since it was believed this would be most applicable to the salinity of river waters inundating riverbank plants on high tides. With the exception of the Chassahowitzka, all references to surface salinity in this report refer to this top 1-meter average. Vertical salinity profiles in the Chassahowitzka River were conducted in two-foot intervals, and values from the two-foot depth are presented as surface salinity values in this report

The time periods over which salinity data were collected varied between rivers. The most extensive salinity data are for the Peace River, where data have been collected as part of hydrobiological monitoring program of the Lower Peace River/Upper Charlotte Harbor system (PBS&J, 1999). Collection of salinity profile measurements in the river began at a number of fixed location stations in

the river in mid-1970s and have been conducted on a monthly basis for a number of years. Data presented in this report are largely for the period 1975-1990. Differences in the number of observations in Table 3.3 are due to different starting or ending dates for various stations.

Salinity profiles in the Little Manatee River were measured as part of a series of studies conducted by the District and the University of South Florida College of Marine Science (Flannery et al. 1991, Peebles and Flannery 1992). Salinity profiles were measured at a series of fixed location stations by the District periodically from 1985-1987, then measured on a bi-weekly basis during 1988 and monthly during 1989. Data for the Peace and Little Manatee Rivers were all collected either on incoming tides or near a slack high-tide condition.

Salinity data for the Myakka River were collected as part of studies conducted by Sarasota County In cooperation with the Florida Department of Environmental Regulation (Lowrey et al. 1990). Vertical salinity profiles were measured at a series of fixed location stations in the tidal reach of the river nineteen times during 1989. The tidal conditions varied among dates. Salinity data for the Weeki Wachee, Crystal, and Withlacoochee River were collected by the District and Mote Marine Laboratory, extending from 1984 though the early part of 1986 (Dixon 1986). Salinity profiles were measured in the river on a monthly basis at or near slack high tide. Salinity data in the Chassahowitzka were measured by the U.S. Geological Survey six times during 1985 at slack high tide (Yobbi and Knochemus 1989b). Greater elaboration on the salinity characteristics of these rivers can be found in the studies cited above.

Statistics for salinity values at the fixed location stations in the study rivers were generated using SAS statistical software. Percentile values (e.g. median, p10, p90, etc.) from the entire sample population of surface salinity measurements were generated for each station in the seven rivers. Based on the river mile locations of these stations, linear interpolation was used between stations to estimate median and 95th percentile salinity values at the sites where vegetation data were recorded. With the exception of the Myakka River, salinity data at the fixed stations extended to the upstream limit of the vegetation sampling.

Salinity data were not available for the upstream reach of the study area in the Myakka River, as the most upstream salinity station was located at mile 16.2. The median surface salinity value at this station was 0.1 ppt, so median salinity values of 0.1 ppt were assumed at upstream locations. Brackish water, however, periodically migrates upstream of this station, as the maximum surface salinity recorded at mile 16.2 was 11.1 ppt. In order to get some estimates of dry season salinity upstream that location, 95th percentile surface salinity values were estimated at vegetation sites upstream of mile 16.2 based on extrapolating the declining slope of 95th percentile values at the measured stations to points upstream.

The median and 95th percentile values assigned to the vegetation sites are listed with the plant species data for each site in Appendix E. For the Myakka River in particular, salinity in that river likely gets considerably higher than the values reported in this study. The representiveness of the salinity data for the seven rivers is discussed in Chapter Three.

2.6 Vegetation sampling

An objective of this project was to document relationships between salinity gradients and transitions of plant species and communities along the tidal reaches of the seven rivers. The distribution of forested wetland communities in the river floodplains can be largely documented by photo interpretation, as shown in Figures 4.1 through 4.7. Although small groups of isolated trees are not shown by these maps, the distribution of major stands of both mangroves and bottomland hardwood forests are illustrated. These maps are also show the distribution of major marsh communities along the study rivers.

Field data collection for this project was oriented to describing the distribution of herbaceous plants associated with the riverbanks, including dominant marsh species. It was assumed these plants would be most affected by the salinity regimes of the respective rivers. Plants located further inland from the river channel should be influenced more greatly by lateral gradients in topography, soil physical characteristics, soil salinity, and localized drainage patterns and groundwater levels. Secondly, it was assumed that herbaceous species might respond more quickly to changes in salinity than woody species, and patterns observed in the herbaceous vegetation might be more affected by the recent salinity characteristics of the rivers.

The collection of vegetation data in the field was conducted during a period between September 1989 and March 1990. Vegetation was sampled at a large number of sites on each river by placing a PVC frame on the bank of the river and estimating the percent coverage of all species within the framed quadrat. The PVC frame quadrat was 1.5 meters wide x 3.0 meters long. At each site, the short edge of the quadrant was placed at the most waterward plant stem (the stem that was located furthest out in the river channel). The log end of the frame was then laid toward the riverbank, extending 3.0 meters toward the shore. Plant species within each quadrant were identified and the coverage of each species was visually estimated.

Observations of species/presence absence were also recorded for plant species located within a distance of approximately 2 meters on either side of the quadrat, within the same distance to shore (3 meters). Although not presented in this report, notes were also taken on the major vegetation community located landward of each vegetation site.

The locations of the vegetation sites sampled on each river are illustrated in Appendix A. On the four rivers north of Tampa Bay, the most downstream vegetation site was located near the mouth of each river as delineated by previous studies (Dixon 1986, Yobbi Knochemus 1989a, 1989b). Salt marshes dominated by *Juncus romerianus* extend to the mouths of each of these rivers. There was a salinity station located very close to the mouth of each of the northern rivers.

Field sampling of vegetation in the three southern rivers (Peace, Myakka, Little Manatee) began well upstream of the river mouths. In the downstream reaches of these tidal rivers, which are more sub-tropical, riverbank plant communities are dominated by mangroves. The quadrat sampling employed by this study did not work in mangrove forests, and the distribution of mangroves was primarily characterized by photo interpretation. A transition from mangrove forests to salt marsh communities occurs at some distance upstream in each of these rivers. These transitions are shown clearly in Figures 4.1 through 4.3. Field sites for quadrant sampling began at the first downstream occurrence of salt marsh communities in each of these rivers and extended upstream.

The number and distribution of sites where vegetation was field sampled on each river was based in salinity regime of that river. Salinity data at the downstream end of the study area in each river were examined to determine the range of salinity values that typically occurred along the length of that river. For example, the median salinity at the mouth of the Weeki Wachee River was 11.3 ppt (Table 3.6), while the median salinity at the mouth of the Crystal River was 16.6 ppt (Table 3.8). In an effort to relate the number of vegetation samples in each river to the typical range of the salinity gradient, more samples were placed in the Crystal River compared to the Weeki Wachee because of its greater salinity gradient within its study area. In this manner, it was intended that the in that the number of vegetation sites for a given salinity interval (e.g. 2 to 4 ppt) would be fairly balanced among rivers.

A guideline that was used in this manner was that four vegetation sites were to be placed in a river for every 1 ppt salinity in the longitudinal salinity gradient as represented by the median salinity value at the downstream end of the study area. For example, a median salinity value of 16.6 ppt at the mouth of the Crystal River corresponded to a total of 67 vegetation sites sampled on that river (4 sites for every 1 ppt). In the southern rivers, salinity data at the downstream end of the study area (where mangroves began a transition to salt marshes) were used. Salinity data were still being acquired and manipulated when the number of vegetation sites were determined, so the ratio of vegetation sites to the typical salinity range varied somewhat from the 4 sites per 1 ppt guideline. With the exception of the Chassahowitzka River, the number of sites per 1 ppt salinity ranged from 3.1 on the Peace River to 4.9 on the Withlacoochee. The ratio of number of sites per 1 ppt salinity for four of the rivers (Myakka, Little Manatee, Weeki Wachee, and Crystal) were grouped between 3. 6 and 4.2.

The Chassahowitzka was sampled most intensely, representing an outlier with a ratio of seven sites per 1 ppt salinity. The number of vegetation sites sampled on each of the seven rivers are listed below.

River	Number of sites
Peace	60
Myakka	73
Little Manatee	72
Weeki Wachee	41
Chassahowitzka	84
Crystal	67
Withlacoochee	67

The distribution of the vegetation sampling sites within each river was based on the maximum upstream extent of brackish water (> 0.5 ppt salinity) in the dry season as recorded by other studies (Dixon 1986, Yobbi and Knochemus 1989a, b, Peebles and Flannery 1992, Hammett 1992, PBSJ 1999). The total number of samples was distributed between the downstream limit of the study area (mouth of river on northern rivers; mangrove/marsh transition of southern rivers) and the upstream extent of brackish water in the dry season. Based on the number of samples distributed over this distance, an average distance between sampling sites was calculated.

The calculated average distance between sites was used by crews in the field to identify sites for vegetation sampling. Using a map of river distances, a boat moving upstream in the channel of the each river was turned laterally toward the shore at roughly equal intervals to sample vegetation. The right bank and left bank of each river was sampled alternately. If a riverbank was hardened or otherwise altered to where there was no vegetation, then the opposite bank was sampled if it were suitable. If both banks were not suitable, then sampling resumed at the first upstream occurrence of riverbank vegetation, regardless of left or right bank. In the downstream areas of the southern rivers where marshes were interspersed with mangroves, sites were selected in the marsh communities. In the upstream areas dominated by floodplain forests, sites were selected where herbaceous vegetation occurred waterward from the floodplain forests. In the Withlacoochee River, three sites were located in stands of herbaceous plants above the general study area.

As a result of these sampling protocols, the presented in this study are most applicable to the distribution of herbaceous plants on banks of the study rivers. Although mangroves were occasionally recorded at the vegetation sites and data for three species of mangroves are presented in this report, the sampling design for this project was not oriented to capturing the distribution of mangroves along the salinity gradient. Similarly, although data for floodplain shrubs and trees are presented in this report, sampling occurred waterward of woody vegetation so this study does not represent a comprehensive treatment of the species

occurrence or distribution of woody vegetation in these rivers. As stated above, the GIS maps (Figures 4.1 – 4.7) can be used to identify the general distribution of woody plant communities in these rivers. A description of the floristic composition of those communities would require further investigation. With these caveats, the data presented in this study, including both the GIS maps and the vegetation site data, provide some useful information on the occurrence and distribution of common woody species in these tidal rivers.

2.7 Plant Identification.

Plant names in this report follow Wunderlin (1998). Field work by the senior author during 1997 allowed the verification of several uncommon species that were either tentatively identified or were possibly misidentified from sterile material in the previous site sampling. Several names used for purposes of data entry in 1989 and 1990 were revised accordingly and noted in Appendix B. Data were excluded in this report for plants that could not be identified to species. Data were also excluded for species that normally occur as free-floating individuals. All were freshwater species that occasionally float into river reaches with higher salinity regimes than can be tolerated for long, except during periods of lower than normal salinity.

CHAPTER 3

PHYSICAL, HYDROLOGIC, AND SALINITY CHARACTERISTICS OF THE TIDAL RIVERS

3.1 Introduction

The area of interest for this project was the tidal reaches of the seven study rivers. Vegetation distributions in these tidal reaches are influenced by the geomorphological characteristics of the rivers, particularly the composition, configuration, and elevation of the river channels and shorelines. These physical characteristics are strongly influenced by tidal forces which can extend many miles upstream in the river systems. The quantity and sediment load of fresh water flowing from the upstream watersheds also exert strong effects on the physical characteristics of the tidal rivers. The volume of freshwater inflows also affects the salinity regimes of the rivers and movements of the mixing zone of fresh and saline waters.

There are large differences in the physical, hydrologic and salinity characteristics of the seven study rivers. Three of the rivers (Weeki Wachee, Chassahowitzka, and Crystal) are very short rivers in which flows are dominated by ground-water discharges from coastal springs. In contrast, the rivers in the southern part of the study area (Peace, Myakka, and Little Manatee) have highly variable flow regimes that are dominated by surface runoff from extensive network of tributaries. Despite these physical and hydrologic differences, the distribution of plant communities in the tidal rivers shown some common patterns due to the strong effects of the salinity gradients in the river systems. The physical, hydrologic and salinity characteristics of the seven study rivers are briefly described in this chapter. Maps referenced in this chapter that show the configuration and vegetation communities of the tidal reaches of the seven rivers are included with Chapter 4. Additional information on the physical, hydrologic and salinity characteristics of tidal reaches of these rivers can be found in other studies that are referenced in the discussion below.

3.2 Physical characteristics of the tidal rivers

The seven rivers can be divided into southern and northern groups. The three southern rivers drain either to Charlotte Harbor (Peace and Myakka Rivers) or Tampa Bay (Little Manatee River). The Peace River is one of the two large river systems within the District, with a watershed area of over 2,300 square miles. This 105 mile long river flows in a southerly direction from the Polk Uplands though the Desoto Plain and Coastal Lowlands physiographic provinces (White 1970). Tidal water level fluctuations extend upstream of the confluence with Horse Creek, approximately 20 miles upstream of the river mouth.

The hydraulic and salinity characteristics of the tidal reach of the Peace River are described by Stoker et al. (1989). Tides affecting the lower river are predominantly mixed semi-diurnal, with two low and two high tides of unequal height over the tidal day. Tidal amplitudes of approximately 2 ½ feet can extend from the river mouth to a station that was monitored at Highway 761, approximately 19 miles upstream. The floodplain of the Peace River in the tidal reach is up to a mile wide, and the channel of the river contains many braids and islands (see Figure 4.1).

The Myakka River also flows in a southerly direction to Charlotte Harbor directly west of the Peace River. The Myakka River is a much smaller river, however, with a watershed area of 650 square miles. The hydraulic and salinity characteristics of the tidal reach of the Myakka River were described by Hammett (1992). The average tide range near the mouth of the river was 2.2 feet, decreasing to 1.65 feet at a gage located approximately 17 miles upstream, and 0.45 feet at a gage located about 26 miles upstream. High freshwater flows in the river dampen tidal fluctuations at upstream locations. Compared to the Peace, the channel and floodplain of the tidal reach of the Myakka is narrower and much less braided (Figure 4.2).

The Little Manatee River is a small river with a watershed of about 221 square miles. The Little Manatee flows in a westerly direction to eastern shore of Tampa Bay. The hydrologic and salinity characteristics of the river were described by Fernandez (1988) and discussed by Peebles and Flannery (1992). Very small tidal water level fluctuations have been observed during low flows at the USGS gage at Highway 301, located about 15 miles upstream. Tidal water levels fluctuations in the downstream reaches of the tidal river are similar to the Myakka and Peace rivers. The river channel is highly braided in the upstream estuarine reach, between river mile (RM) 7 and RM 10 (Figure 4.3). The river is largely restricted on one channel between RM 3 and RM 7, although three oval-shaped bayous are connected to the river. Downstream of RM 3 the river channel is braided though a series of mangrove islands.

The remaining four study rivers (Weeki Wachee, Chassahowitzka, Crystal, and Withlacoochee) are located in a distinct karst region north of Tampa Bay that is known as the Springs Coast. The geologic characteristics of this area were described by Hine and Belknap (1986), while a broader treatment of the area is provided by Wolfe (1990). This coast in this region is characterized by a broad, thick, flat shelf of carbonate rock. Over most of this region the top of this carbonate stratum is at or near the land surface. This carbonate shelf extends offshore, creating a shallow, low energy marine environment. Artesian groundwater flow exists over much of the area, giving rise to numerous springs in the coastal region. Tides in the region are predominantly mixed, semi-diurnal. Tide ranges generally fluctuate between 2.0 and 2.9 feet between neap and spring tides (Hine and Belknap 1986).

The Weeki Wachee River is located in the southern region of the Springs Coast. The flow of the river is dominated by groundwater discharges from headsprings about seven miles upstream of the river mouth. Additional groundwater flow also enters the river along its channel (Cherry et al. 1970, Yobbi and Knochemus 1989a). Yobbi and Knochemus (1989a) report that the average flow of the Weeki Wachee River near it headsprings is 176 cfs, but the river may gain another 20 percent of flow from downstream groundwater discharges. The freshwater reaches of the river channel are generally narrow (< 60 feet) and flow in the river is swift. The tidal reach of the Weeki Wachee River is the shortest of any river in southwest Florida. Tidal water level fluctuations extend to river mile 6.7, but brackish water is generally restricted to the most downstream two miles of the tidal river. The river channel is hardened between RM 1.3 and RM 2.0 Downstream of RM 1.3 the river shoreline is unaltered and the river channel widens to about 200-400 feet in width (Figure 4.4). A short spring-fed stream, the Mud River, enters the Weeki Wachee River about 0.7 miles upstream of the river mouth. Headsprings in the Mud River discharge brackish water.

The Chassahowitzka River is approximately five miles in length (Figure 4.4). In contrast to the Weeki Wachee, where the headsprings are not tidally affected, tidal water levels extend to the headsprings of the Chassahowitzka River. Yobbi and Knochemus (1989b) report that water levels typically fluctuate 0.5 to 1.0 feet over a tidal cycle near the river headsprings. Flows from the river headsprings are thus tidally affected, and springflow increases at low tides due to less head pressure over the spring vents. The average flow for the Chassahowitzka River is reported at 140 cfs, but flows may be increased by 50 percent by contributions from downstream springs (Yobbi and Knochemus 1989b). The quality of water discharging from springs to the Chassahowitzka River varies from fresh to brackish, due to the proximity of the saltwater/freshwater diffusion in the Floridan Aquifer. Although a few springs located near the head of the river are predominantly fresh, most springs discharging to the river or its coastal tributaries are brackish (Yobbi and Knochemus 1989b).

The Crystal River is the largest river on the Springs Coast for which the flows come predominantly from springs. The average flow for Crystal River was 975 cfs based on daily flow estimates generated during 1965-1977 (Yobbi and Knochemus 1989b). The channel of the Crystal River is about 7 miles long. Flows in the river are dominated by groundwater discharges from an extensive series of springs in Kings Bay – the name given to a wide reach at the river at its headwaters. The quality of water discharging from springs in King's Bay varies from fresh to brackish. The channel of the Crystal River is about 400 at the west end of Kings Bay, increasing to about 1, 500 feet wide near the river mouth (Figure 4.5).

The Withlacoochee River differs from the other northern study rivers in that its flow regime includes both substantial groundwater discharges and surface runoff. With a watershed of over 2000 square miles, the Withlacoochee comprises the

other large river system within the District. The headwaters of the Withlacoochee are in the Green Swamp in central Florida. The river flows predominantly in a northerly direction for approximately 80 miles, then turns westerly near the City of Dunellon and flows another 20 miles to the Gulf. Near Dunnellon the river receives flow from the Rainbow River, which dominated by ground-water discharges from Rainbow Springs. The average flow for the Rainbow River is 705 cfs, with relatively subdued seasonal variation characteristic of spring-fed rivers. The Withlacoochee River also receives springflow further upstream from Gum Slough springs complex and discharges from Lake Panasoffkee, a spring-fed lake in the middle reaches of the river.

With its comparatively large watershed and substantial baseflow from groundwater sources, the Withlacoochee has characteristics of both a spring-fed and surface drainage river (Estevez et al 1991). During dry periods flows to the lower river are dominated by springflow, resulting in high water clarity. During rainy periods flows in the river increase substantially and become more colored, characteristic of a "black-water" Florida River.

The hydrologic regime of the tidal reach of the Withlacoochee River has been highly modified since 1970. Eleven miles upstream of the river mouth the Withlacoochee is impounded at Lake Rousseau. This 4,000 acre impoundment was built in the early 1900s for hydroelectric power. Prior to 1970, all releases from the reservoir flowed to the channel of the Lower Withlacoochee River. Although water losses from the reservoir to evaporation and groundwater seepage were increased from an unimpounded condition, there were no withdrawals or diversions from the reservoir and the flow regime of the Lower Withlacoochee River was only slightly altered by the construction of Lake Rousseau.

In the 1960s extensive water control structures were constructed at Lake Rousseau as part of the Cross Florida Barge Canal, as the reservoir was to serve as an important link in the canal system. The western-most section of the barge canal extending from Lake Rousseau to the Gulf of Mexico was completed, including a lock system connecting the canal and the reservoir. The excavation of the barge bisected the channel of the Lower Withlacoochee River, dividing it into two separated reaches. The most upstream two-mile section of the lower river that is connected to Lake Rousseau now flows to the barge canal. When inflows to Lake Rousseau from the Withlacoochee River are high, water is released to this section of the lower river, which then flows through the barge canal to the Gulf. The mouth of the barge canal is located about 1 mile south of the natural channel of the lower Withlacoochee River near Yankeetown (Figure 4.7).

A bypass channel from Lake Rousseau was constructed to deliver flow from the reservoir to the remaining nine-mile section of the Lower River that lies below where the canal bisected the river. An 8,000 foot long bypass channel and

spillway serves this purpose. The capacity of the bypass spillway is 1,540 cubic feet per second (cfs). When inflows to Lake Rousseau are less than that flow rate, virtually all surface outflows from Lake Rousseau are directed though the bypass channel to the nine-mile section of the Lower Withlacoochee River that flows to the river mouth. Outflows from Lake Rousseau in excess of 1,540 cfs are diverted down the two-mile section of the river connected to the barge canal.

In 1969, work on the Cross Florida barge canal was halted and the canal was officially decommissioned in 1988. However, the barge canal facilities at Lake Rousseau and the Lower Withlacoochee River remain. The lock and canal are now used to periodically allow recreational boat traffic from the Gulf to the middle section of the Withlacoochee River via Lake Rousseau.

Construction of the barge canal and its associated water control structures have affected on the flow regime of the Lower Withlacoochee River, as high flows are now diverted down the barge canal. For the period 1970 to 1990, the mean flow through the bypass channel to the section of the lower river that flows to the river mouth was 1120 cfs. During this same period, flows through the two-mile reach of the river connected to the barge canal was 420 cfs. Flows to the barge canal are intermittent, however, and characterized by brief periods of very high flows. Greater details on the physical and hydrologic modifications to the lower river resulting from construction of the barge canal can be found in Downing et al (1988).

The physical, salinity and water quality characteristics of the tidal reaches of the Withlacoochee River are described in Yobbi and Knochemus (1989b) and Dixon (1986). Although the average flow of the Lower Withlacoochee River is similar to that of Crystal River, the channel of the Withlacoochee is considerably narrower, being generally 150 to 400 feet wide in its tidal reaches. As with the other rivers in the region, tides at the mouth of the Withlacoochee River are predominantly mixed semi-diurnal. Tidal amplitudes between the lowest and highest tides during a tidal day average about 2.5 feet.

3.3. Variability of freshwater flows to the tidal rivers

The volume of freshwater flow to a tidal river is a primary factor affecting the circulation, sedimentation, water quality, and salinity characteristics of the tidal river. These factors, in turn, control the biological structure and productivity of the tidal river system, including the distribution of submerged and wetland plants. The magnitude and variability of freshwater flow to the seven tidal rivers evaluated in this study differ greatly. Statistical summaries of freshwater flows to the tidal rivers and salinity data within the tidal rivers are presented in the following sections. As described in Chapter Two, streamflow data from 1970 to 1990 were analyzed to characterize the flow regimes of the rivers for this project. In two rivers (Chassahowitzka and Crystal), subsets of years within this period were analyzed due to the limited period of record for these rivers.

Table 3.1A lists flow values for each river for the study period by percentile values. This procedure ranks the daily flow values from low to high for the entire study period and then identifies the flows that correspond selected percentile breaks in the data. For instance, the P10 flow is greater than 10% of the daily values and less than 90% of the daily values; the P70 flow is greater than 70% of the daily values and less than 10% of the daily values; etc. The p50 flow is the median flow.

Table 3.1A lists percentile values for the flow data for the seven rivers expressed in cubic feet per second (cfs), which is the unit used by the USGS to express streamflow data. The streamflow gages these data were taken from are described in Chapter 2. An important qualifier regarding application of these results to the tidal rivers is the proportion of each river's watershed that the gage represents. The proportions of the river watersheds measured by the gages are listed below for the five study rivers that receive considerable surface runoff

River	Percent of watershed area
Peace	89%
Myakka	52%
Little Manatee	67%
Withlacoochee	98%

The other three rivers receive the vast majority of their flow from groundwater discharges. As described in section 3.2, there are groundwater discharges to the downstream reaches of these rivers that are not represented by the gaged flow values.

A comparison of the percentile flow values in Table 3.1A provides a measure of the quantity of freshwater flow to the different tidal rivers, allowing for differences in the proportion of the watersheds represented by the gages. The median flow values for the Crystal and Withlacoochee Rivers are considerably greater than for the other rivers. This reflects the size of these rivers, plus the flow regimes of these rivers include sizeable groundwater discharges, which keep the median flows comparatively high. Maximum flows are greatest for the Peace and Myakka Rivers, due to large quantities of surface runoff these rivers carry during wet periods. Again, it is reiterated the flow regime of the Withlacoochee River is truncated due to diversion of high flows down the Cross Florida Barge Canal.

The Weeki Wachee and Chassahowitzka Rivers are similar in their flow values, with the Weeki Wachee being somewhat higher for most of the percentile values. The greater extremes (min and max) for the Chassahowitzka River reflect the action of tides flows in that river, compared to the Weeki Wachee River where the effects of tides on the headspring are minimal.

Useful comparisons of the variability of flow regimes can be made by scaling the percentile flow values to a common standard. The percentile values listed in Table 3.1A are expressed as a percent of the median flow for each river in Table 3.1B. As expected, variation about the median is less for the spring-fed rivers in the northern region. The least variation is observed in the Weeki Wachee, where the minimum flow values was 70% of the median and the maximum flow value was 144% of the median. Greater variation is observed in the Chassahowitzka and Crystal Rivers, in part due to the effects of tidal forces on flows from these springs. Negative values expressed for minimum values for the Chassahowitzka and Crystal Rivers in Tables 3.1A and 3.1B are due to waters flowing upstream due to incoming tides over the course of a day.

Similarly, the relatively large maximum values for the Chassahowitzka and Crystal rivers are related to periods when there was considerable downstream flow due the effects of falling tides. Variation in the Chassahowitzka over the majority of the flow regime (10^{th} to 90^{th} percentiles) is similar to the Weeki Wachee, as this largely excludes periods when tidal flows where biased toward rising or falling conditions. Variation in the Crystal is somewhat greater, however, due to the very pronounced effects of tides in the wide river channel and the problem of expressing flows over daily intervals. As described in Section 2.3, averaging flows in the Crystal River over 14-day periods can balance tidal effects and give a more representative picture of freshwater flows (Yobbi and Knochemus 1989a).

The variability of the flow regimes in the southern rivers, where flows are dominated by surface runoff, is considerably greater than in the northern rivers. The flow regime of the Myakka is the most variable of the southern group, as this river is noted for extremes in flow between droughts and floods (Estevez et al. 1991). The minimum and 10^{th} percentile flows for the Myakka are 0 and 4 cfs (Table 3.1A), respectively, equivalent to 0 and 4 percent of the median daily flow (Table 3.1B). Also, the percentages of the median for the upper percentiles are greatest for the Myakka. For example, the percentage values for the 60^{th} to 90^{th} percentiles for the Myakka are 150% and 622% greater than the median flow, respectively. The range of percentage values for the 60^{th} and 90^{th} percentile flows for the other two southern rivers (Peace and Little Manatee) is slightly less (137% to 524%).

Percentile flows expressed as percentages of the median flow are roughly similar for the Peace and Little Manatee Rivers over much of their flow regime (10^{th} to 90^{th} percentiles). These rivers are indicative of the variation of flow that occurs in streams in the region from Tampa Bay to Charlotte Harbor. The high maximum percentage (16,474%) for the Little Manatee is due to extremely high flows that were recorded in 1988.

3.4 Salinity characteristics

The freshwater flow regimes described above control the location and variability of salinity distributions in the tidal reaches of the study rivers. Empirically characterizing natural variability in salinity, however, is more difficult than for streamflow to more limited data. In contrast to streamflow, where complete daily records are available for periods of years, salinity measurements at a number of stations along the length of each tidal river are available only for a limited number of sampling dates. Salinity data presented for this project are restricted to series of fixed stations that were measured periodically along the length of each river. The number of dates when salinity measurements were made in each river range from 5 to 6 for stations in the Chassahowitzka River to between 144 and 240 for stations in the Peace River (not all stations were sampled equally in each river). Despite large differences in the number of salinity observations among rivers, meaningful information about the salinity regimes in the tidal rivers and their relation to plant distributions can be obtained

Salinity data for these rivers have also been recorded at a number of continuous recorders in each river by the USGS. These recorders, which measure salinity and temperature in 15-minute intervals, have been operated for periods of two or more years in the different rivers. Because of their frequent data measurement, these recorders can collect data over a wide variety of freshwater flow and tidal conditions. Data from these recorders have been presented in various studies (Yobbi and Knochemus 1989a,b, Stoker et al. 1989, Hammett 1992, and PBSJ 2003). These studies can be consulted to get additional information of the variability of salinity at these recorders in the study rivers.

These recorders have only been deployed at one to three fixed locations in each of the study rivers, and for the purposes of this project, do not provide adequate information of the shape or extent of the salinity gradient in each river. Consequently, as described in Chapter 2, data presented in this report are limited to more spatially extensive series of fixed stations that were recorded during boat trips on a number of dates in each river.

3.4.1 Distributions of salinity measurements in relation to daily flows

The salinity data base for each river is compared to the flow regime of that river in Table 3.2, in which the flow regime for each river is broken into percentile classes (e.g. 10^{th} to 20^{th} percentiles) along with the number of salinity sampling trips that were taken within each flow interval. Table 3.2 allows examination of whether salinity measurements were fairly evenly distributed over the flow regime, or if salinity in one or more components of the flow regime (e.g. low or high flows) was over-sampled or under-sampled, contributing to any biases in the salinity data base for each river. .

The most complete and least biased salinity data base is for the Peace River, where salinity trips on the river have totaled 240 with very good distribution over the flow range. This data base has resulted from monthly sampling that has occurred between twelve and seventeen years for the various stations. The salinity data for the Little Manatee, where 41 trips were made, is fairly well distributed over the flow regime, with some greater sampling of high flows compared to low flows. The salinity data for the third southern river, the Myakka, is not as extensive, with a total of 19 trips. Moderately low flows (30^{th} to 40^{th} percentiles) were sampled more than twice than any other flow interval, but one high flow interval (80^{th} to 90^{th} percentiles) was the next highest interval sampled with three salinity observations.

The most apparent limitation of the Myakka data is the lack of salinity measurements during low flows (minimum to 10^{th} and 10^{th} to 20^{th} flow percentiles). Consequently, the salinity data presented in this report do not represent the high salinity values that occur in the Myakka River during very low flows. In contrast, the data bases for the Peace and Little Manatee Rivers do capture low-flow, high salinity conditions that occur in those rivers. The salinity data for the Peace include the 1985 drought, and data for the Little Manatee include very dry spring-time conditions during 1988 and 1989. The data in this report, however, do not capture the extreme conditions that occurred in the 2000-2001 drought, which was an unusually severe drought that may have resulted in salinity conditions somewhat higher that represented in this report.

The salinity data for the northern rivers was collected during the 1984-1985 period, which captured a wide range of flow conditions. The year 1984 was wet, followed by a severe drought in the first part of 1985 which switched to high flows with the passage of Hurricane Elena during September 1985. The salinity data for the Withlacoochee River capture both low and high flow conditions, with 4 and 6 observations in the minimum to 10^{th} and the 90^{th} to maximum flow percentiles. However, moderately high flow conditions are somewhat over-represented in the compared to low flow conditions in the Withlacoochee salinity data base, as there are 10 salinity observations in the 60^{th} to 90^{th} percentiles compared to only two observations in the 20^{th} to 40^{th} percentiles.

The distribution of salinity samples for the Weeki Wachee River is also biased toward high flows, although three samples were taken during the low-flow 10^{th} to 20^{th} percentiles. These observations, which were taken during the spring of 1985, provide a reasonable measure of high salinity conditions that occur in the Weeki Wachee River. However, salinity data during the lowest flows in the river (<145 cfs) such as are not represented by this data base. Sampling in the Chassahowitzka River was the most limited of all the rivers, and strongly biased to very low flow conditions (min to 10^{th} percentiles). Salinity data for this river was largely taken during the low flow conditions during 1985 (Yobbi and Knochemus 1989b).

Although flow data were not available for the Crystal River during the period of salinity measurement, salinity data for this river were taken over the same period and with the same frequency as for the Weeki Wachee and Withlacoochee Rivers (1984 to early 1986). As groundwater levels in the vicinity of Crystal River probably responded to wet and dry periods similarly to groundwater levels in the regions near the Weeki Wachee and Withlacoochee Rivers, the distribution of flows was also probably similar to those rivers. As with the salinity data for the Withlacoochee and Weeki Wachee, the salinity data for the Crystal probably captured a range of flows but was may have been somewhat biased toward high flow conditions.

3.4.2. Inter-annual and seasonal variations in flows in relation to the periods of salinity measurement

In addition to examining the variation of flows and as percentile distributions, it is informative to examine seasonal and inter-annual variations in flows in the study rivers and effect of these variations on salinity distributions. Due to their different watershed characteristics and sources of flow (groundwater discharge vs. surface runoff), seasonal and inter-annual variations of flow are much greater for the southern rivers compared to the northern rivers.

Figures 3.1 though 3.7 show time series plots of mean annual flows for the seven rivers (A series) along with bar charts of mean monthly flows for each river (B series). Also shown for each river are the years when salinity measurements were recorded for each river and mean flows for months when salinity measurements were recorded. These figures clearly show there is much greater inter-annual variation in mean annual flows in the southern rivers (Peace, Myakka, Little Manatee). The percentage ratio between the highest and lowest mean annual flows for the 1970-1990 period was over 500% for the Peace River and about 400% for the Myakka River and Little Manatee Rivers. It is important to note the 1970-1990 period doesn't capture the compete range of inter-annual variability in these rivers, as drier and wetter years have occurred outside of the 1970-1990 period.

Inter-annual variations in mean annual flows are much less in the northern rivers, with the percentage ratio between the highest and lowest mean annual flows ranging between from 1.2 for the Chassahowitzka River to 1.7 for the Withlacoochee. Although these variations are more subdued, they do follow regional, inter-annual patterns in climatic trends, as low flows were observed in 1981 or 1985 and high flows were observed in 1984.

Figures 3.1 though 3.7 also have shown the years when salinity data were collected on the study rivers. As described in section 3.2, extensive salinity data for the Peace River were collected over a range of wet and dry years (Figure 3.1A). The data for the Myakka River were collected during two years with slightly below average flows (Fig. 3.2A), and data for the Little Manatee were

collected during average to slightly wet years (Fig. 3.3A). Salinity data were collected in the Weeki Wachee and Withlacoochee Rivers during average to slightly wet years (Figs. 3.4A and 3.7A), while data for the Chassahowitzka was collected during the driest year of record for that river (3.5A). As described above, flow data were not available for the Crystal River for the period of salinity measurement (1984-1986), but it is assumed the distribution of flows was similar to the Weeki Wachee and the Withlacoochee.

Although the variation of mean annual flows is meaningful, important seasonal variations can occur within a year which are masked by mean annual values. A case in point is 1985, when near-record low flows occurred in the springtime, but high flows in the summer caused the yearly average to be slightly below normal. Plots of mean monthly flows are also included in the B series in Figures 3.1 through 3.7. Variations in mean monthly flows for the southern rivers show the typical pattern for surface drainage rivers in west-central Florida, with low flows occurring in the spring and fall and a pronounced summer wet season. A minor peak in flows also occurs in February and March with the passage of winter cold fronts prior to the decline of flows in the spring. The large differences between dry season and wet season flows in these rivers cause dramatic shifts in salinity distributions, particularly during the transition from the spring dry season to the summer. Monthly flows are most variable in the Myakka River, as the mean flow for September is over 600% greater than the mean flow for May.

The variation in mean monthly flows for the northern rivers is much less. The variation in the Weeki Wachee River follows the spring to summer transition, but in a very subdued manner. The Withlacoochee behaves similarly, but it is reiterated that high flows in this river are now diverted down the barge canal, so the natural seasonal variation that would occur has been altered. The distribution of mean monthly flows for the Chassahowitzka is unusual with high flows occurring in the winter. This seasonal pattern is due to effects of tides, and increased flows from the spring during very low tides during the winter. The Crystal River shows a somewhat similar pattern due to tidal effects.

Also portrayed with the mean monthly flows for the 1970-1990 period are the mean monthly flows for periods when the salinity measurements were taken. On the average, the salinity data for the Peace River were collected during typical conditions during most months, but were sampled during slightly drier than normal conditions during the summer wet season. Based on mean monthly flows, salinity was sampled in the Myakka River during drier than normal conditions, but as described in Section 3.3.1, salinity measurements were not recorded during very low flows based on the distribution of daily values (Table 3.2). The monthly data for the Little Manatee did not show any consistent pattern with regard to the months when salinity data were collected compared to mean monthly flows for the 1970-1990 period.

Similar to the comparison of the distribution of salinity measurements to the distribution of daily flows, Figure 3.4B indicates the Weeki Wachee and Withlacoochee River on the average were sampled for salinity during slightly wetter than normal conditions throughout the year. However, these average values mask the low flows that occurred in the winter and spring of 1985. As previously discussed, similar conclusions may also be made for the Crystal River. Salinity measurements for the Chassahowitzka River were limited to the period from May through September 1985, when monthly flows were below average.

3.5 Temporal variations in salinity over seasonal cycles

The material presented above has discussed the distribution of salinity measurements in relation to flows, but not variations in the actual salinity values. Time series plots of salinity are presented in Figures 3.8 and 3.9 for two locations in the channel of each river to illustrate typical, seasonal salinity variations that occur within each river. Plots are shown for one station in the downstream, higher-salinity reach of each river and another tidal station that is frequently freshwater.

Plots for the three southern rivers (Fig. 3.8) show the large variations in salinity that occur in these rivers. Salinity at the downstream station in each of these rivers reached to at least 25 parts per thousand (ppt) in the dry. With the onset of summer rains, salinity dropped to less than 10 ppt. at these sites. The location of these sites range from 2.2 miles above the river mouth on the Little Manatee to 4.7 miles above the river mouth on the Myakka. Salinity values in reaches further downstream were higher. These downstream sites would all be in the mangrove dominated zone of each of the southern rivers.

The other stations shown for the southern rivers in Figure 3.8 are located further upstream, ranging from mile 7.19 on the Little Manatee River to mile 14.6 on the Peace. These stations can be fresh during much of the year, but reach salinity values over 10 to 15 ppt. in the dry season. Although not shown in Figure 3.8, stations located further upstream remain fresh for greater portions of the year and do not reach salinity values as high in the dry season. Further upstream, reaches of the tidal river will remain fresh year round although there are fluctuations in water levels and current reversals driven by tides. This is referred to as the tidal freshwater reach of a river.

In contrast to the southern rivers (Figure 3.8), the downstream sites plotted in Figure 3.9 for the northern rivers are near the mouth of each river. The range of salinity values were generally lower in these rivers as reflected by the time series plots for these downstream stations. Maximum salinity values were near 20 ppt for the Weeki Wachee and Withlacoochee Rivers; near 24 ppt for the Crystal River and near 18 ppt for the Chassahowitzka. Peak values all occurred in the spring of 1985 at the height of a drought. Fluctuations in salinity at these

downstream stations were less than the downstream stations shown for the southern rivers shown in Figure 3.8.

The upstream stations on these rivers were all relatively close to the river mouths, ranging from 1.02 miles upstream on the Weeki Wachee River to 3.9 miles on the Crystal River. The proximity of these stations to the river mouths reflects that brackish water penetrates much less further in these rivers compared to the southern rivers.

3.6 Statistical summaries of salinity distributions in the tidal rivers

The most concise and informative outputs for describing salinity distributions in the seven study rivers are a series of paired figures and tables presented for each of the rivers. These outputs are presented in Tables 3.3 though 3.9 which are grouped with Figures 3.10 through 3.16. On each page, a box and whisker plot of salinity at the fixed stations on a river is presented over a statistical summary of percentile salinity values corresponding to that figure. In addition to selected percentiles, the tables include values for other statistical parameters (mean, standard deviation, coefficient of variation, and number of observations) and the river mile location for each station. Maps of the rivers showing river mile scales are shown in Figures 4.1 though 4.7 and Appendix A.

The data in the box and whisker plots are presented as follows. The horizontal bar in within each box represent the median salinity for that station. The upper edge of the box represents the upper quartile (75^{th} percentile value), while the lower edge of the box represents the lower quartile (25^{th} percentile value). The vertical bar extending upward from the box reaches to the 90^{th} percentile value, while the vertical bar extending downward from the box reaches to the 10^{th} percentile value. Individual observations above and below the 90^{th} and 10^{th} percentile values are identified by open circles. With the exception of the data points represented by the circles, the values of all the percentile breaks shown in the plots are listed in the corresponding tables below.

The box and whisker plots illustrate typical variations in salinity along the longitudinal axis of each tidal river. With two exceptions, sampling extended far enough upstream to reach freshwater conditions, as denoted by median salinity values of less than 0.5 ppt. Exceptions to this were the Chassahowitzka River, in which the salinity of the most upstream station was 1.0 ppt, and the Crystal River, which had a median salinity of 0.6 ppt at its most upstream station. These values are due to the higher background salinity of these rivers which are fed by tidally affected coastal springs. Some springs in these rivers may discharge fresh water, but this water is mixed with discharges from higher salinity springs in the river channel.

Although median salinity values of fresh water were recorded at one or more upstream stations on the other five rivers, the box and whisker plots indicate that

salinity can get considerably higher than freshwater at the most upstream stations in the Myakka and Little Manatee Rivers. A maximum top meter salinity of 11.1 ppt was recorder in the Myakka River, and as described in section 3.2, salinity measurements were not recorded during the lowest 20% of flows on this river. As a result, brackish water probably extends considerably farther upstream than demonstrated by the data available for this study. Similarly, salinity at stations on the Myakka River shown in Figure 3.11 probably gets higher than the values presented in this report.

Similar situations are found for the Little Manatee and Weeki Wachee Rivers, where the maximum salinity at the most upstream station was 8.2 ppt and 13.1 respectively. Sampling on these rivers was conducted during high tides and included very dry conditions, and it is unlikely that salinity frequently gets much higher than these values. For example, the 90th percentile salinity on the Weeki Wachee was fairly low (2.1 ppt), indicating the maximum value was a rare occurrence.

The salinity values at the upstream stations on the Peace, Chassahowitzka, Crystal and Withlacoochee Rivers showed very little variation, indicating these stations were usually above the effect of tidal forces on river salinity. As described earlier, the background salinity in the Chassahowitzka and Crystal Rivers is slightly elevated due to the discharges of brackish coastal springs.

The shape of the box and whisker plots show very important information of the nature of the salinity gradient in each river. In the Peace River a relatively steep gradient exists between river mile (RM) 20 and RM 12. Based on median values, this represents a change from fresh water to over 19 ppt. The distribution of individual data points (open circles) shows, however, that salinity can get considerably higher at these stations during dry periods. The Myakka River shows a similar pattern with a steep salinity gradient occurring between RM 2.7 and RM 13.9, a distance over which median salinity values change from 19.3 ppt to 0.5 ppt. The Little Manatee, has a particularly steep salinity gradient, with median salinity values of 24 ppt at the river mouth dropping to 0.9 pt at a station 8.3 miles upstream.

Longitudinal salinity gradients in the northern rives do not cover as large a salinity range, but occur over shorter distances. The median salinity at the mouth of the Weeki Wachee River is 11.3, ppt, but a station with a median salinity value of 0.5 ppt is located only 1.25 miles upstream. The generally shallow, narrow character of the Week Wachee River channel and the force of the freshwater flow keep brackish water from penetrating very far inland on this river. A similar situation exists on the Withlacoochee River, where the gradient of median values changes from 13.6 ppt at the mouth to 0.2 ppt at a station 2.32 miles upstream.

The salinity gradient on the Crystal River covers a similar salinity range, as a station only 0.43 miles upstream of the river mouth has a median salinity value of 12.2 ppt. However, the salinity gradient on this river is slightly longer that the Weeki Wachee and Withlacoochee Rivers, due partly to the effect of the wider river channel allowing greater brackish water penetration upstream. The median salinity at the mouth of the Chassahowitzka River (11.9 ppt) is very similar to the other northern rivers, but as described earlier, the upstream salinity values are slightly greater to slightly brackish groundwater discharges. An interesting aspect of the gradient on the Chassahowitzka is the comparatively rapid change in salinity between RM 1.8 and RM 3.0, where median salinity values drop from 9.5 ppt to 3.3 ppt. This zone of transition is due to changes in the river channel's morphology, as it changes from a wide channel in a marshy area to a narrower channel in a forested zone (Figure 4.5).

The box and whisker plots are very illustrative of areas of the rivers where salinity variation is the greatest. For example, the inter-quartile range is represented by the heights of the boxes that extend between the 25th and 75 the percentile values. The inter-quartile range is one indicator how greatly salinity varies around it central tendency (mean or median). On five of the rivers the inter-quartile range is the greatest where the median salinity is about 7-8 ppt. This is a highly variable zone in of each of these tidal rivers in that salinity can range from fresh to fairly high values. The location of the largest inter-quartile range is at the station with a median value of 11.8 ppt on the Peace River, but there was no station on the Peace in the area with median values in the 7 to 8 ppt range as with the other rivers. Inter-quartile ranges do not show a strong spatial trend on the Chassahowitzka River, except that they drop markedly above river mile 2.25.

The characteristics of these salinity gradients are compared to vegetation distributions in Chapters Four and Five.

Table 3.1.A. Percentiles of daily streamflow values for the seven rivers expressed as cfs (A) and as percentage of the daily median flow for each river (B). Flows data reported for the years and gages described in Section 2.3.

Table 3.1A. Percentiles of daily streamflow values for the seven rivers.

River	min	10%	20%	30%	40%	median	60%	70%	80%	90%	max
Myakka	0	4	13	31	56	88	132	204	325	547	7560
Peace	14	110	161	211	273	356	489	750	1130	1860	16500
Little Manatee	1	20	28	37	47	59	75	101	158	309	9720
Weeki Wachee	120	145	152	158	163	171	180	191	202	216	247
Chassahowitzka	-106	91	101	110	117	124	131	139	150	165	279
Crystal	-1010	186	450	649	823	988	1150	1340	1605	1940	3650
Withlacoochee	53	680	819	924	1040	1130	1220	1330	1440	1520	1840

Table 3.1.B. Percentiles of daily streamflow values listed above expressed as percentages of the median flow

River	min	10%	20%	30%	40%	median	60%	70%	80%	90%	max
Myakka	0	5%	15%	35%	64%	100%	150%	232%	369%	622%	8,590%
Peace	14%	31%	45%	59%	77%	100%	137%	211%	317%	523%	4,634%
Little Manatee	2%	34%	47%	63%	80%	100%	127%	171%	268%	524%	16,474%
Weeki Wachee	70%	85%	89%	92%	95%	100%	105%	112%	118%	126%	144%
Chassahowitzka	-185%	73%	81%	89%	94%	100%	106%	112%	121%	133%	225%
Crystal	-202%	19%	46%	66%	83%	100%	116%	136%	162%	196%	369%
Withlacoochee	5%	60%	73%	82%	92%	100%	108%	118%	128%	135%	163%

Tables 3.2. Number of sampling dates when salinity measurements were taken within percentile flow ranges for the six of the seven rivers. Flow ranged based on percentiles of ranked daily values between 1970 to 1990. Results not shown for Crystal River due to a lack of flow data during the period of salinity measurement.

River	Flow ranges as percentiles of daily values										
	min - 10%	10-20 %	20-30 %	30-40 %	40-50 %	50-60 %	60-70 %	70-80 %	80-90 %	90%-max	SUM
Myakka	.	.	1	8	2	1	.	1	3	1	17
Peace	29	23	16	27	27	22	22	25	25	25	241
Little Manatee	3	2	2	5	6	12	5	8	7	8	58
Weeki Wachee	.	3	1	.	1	2	3	2	8	8	26
Chassahowitzka	5	.	1	.	.	.	.	.	.	.	6
Withlacoochee	4	.	1	1	1	1	3	4	3	6	24

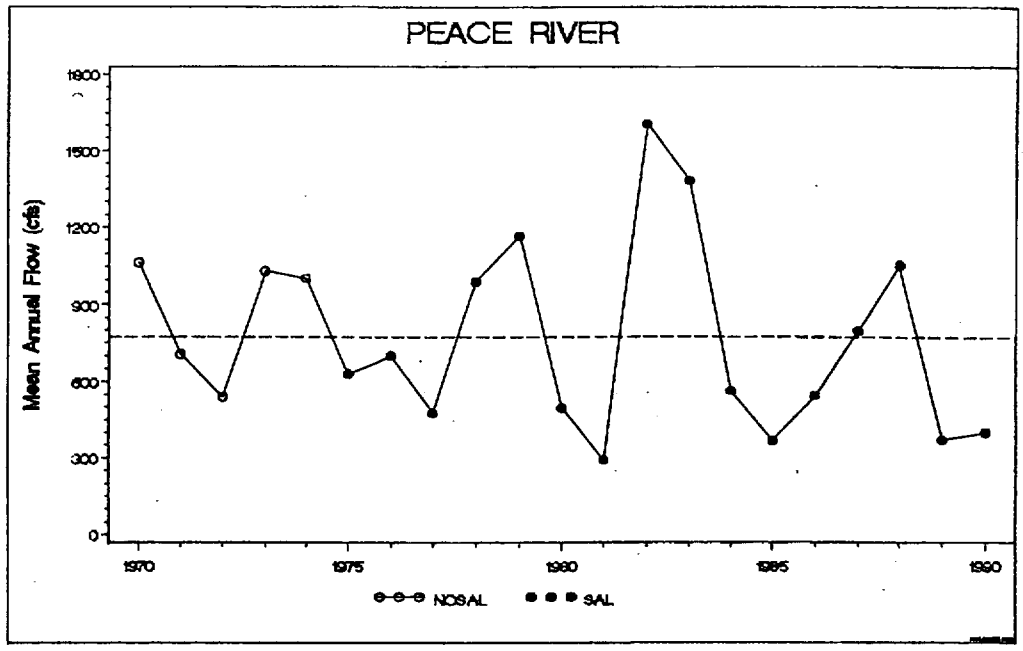


Figure 3.1.A. Mean annual flows for the Peace River for 1970-1990 with years with salinity measurements denoted by shaded dots.

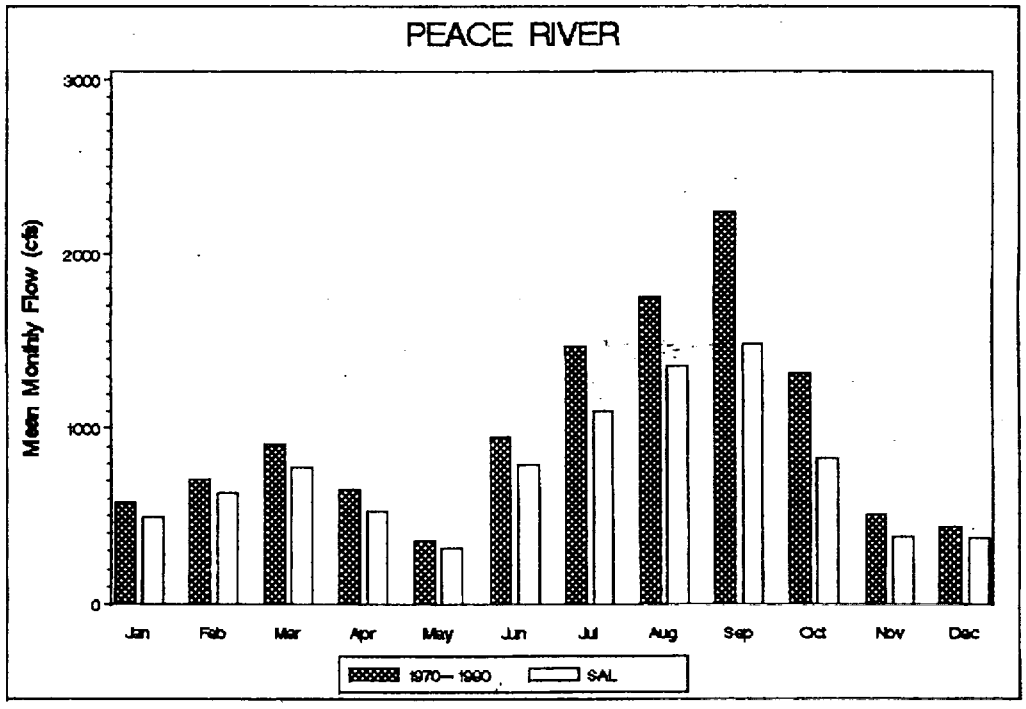


Figure 3.1.B. Mean monthly flows for the Peace River for 1970-1990 (shaded) and mean monthly flows for months with salinity measurements (unshaded).

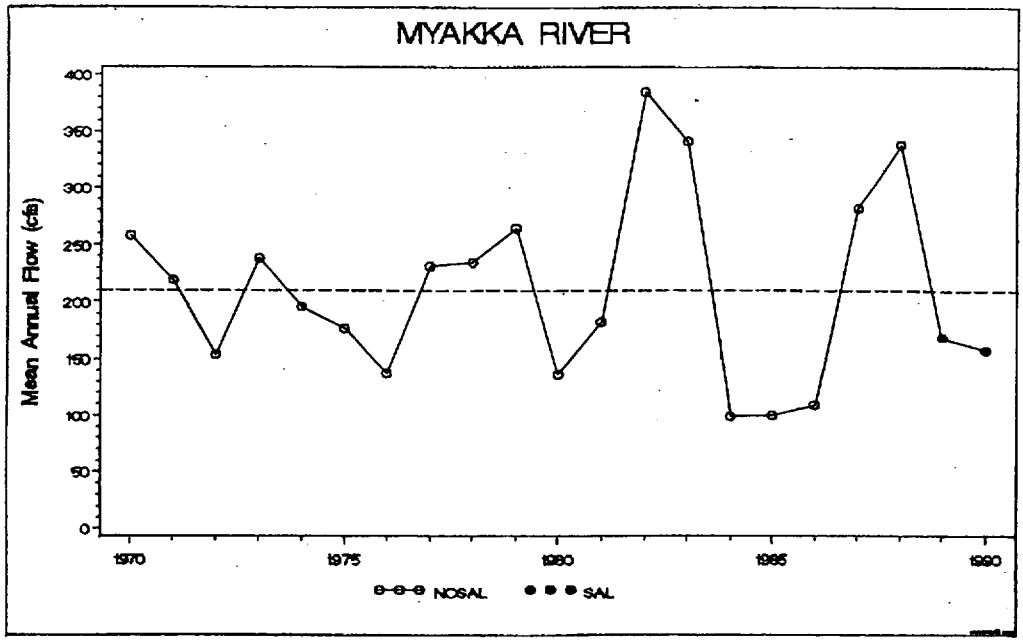


Figure 3.2.A. Mean annual flows for the Myakka River for 1970-1990 with years with salinity measurements denoted by shaded dots.

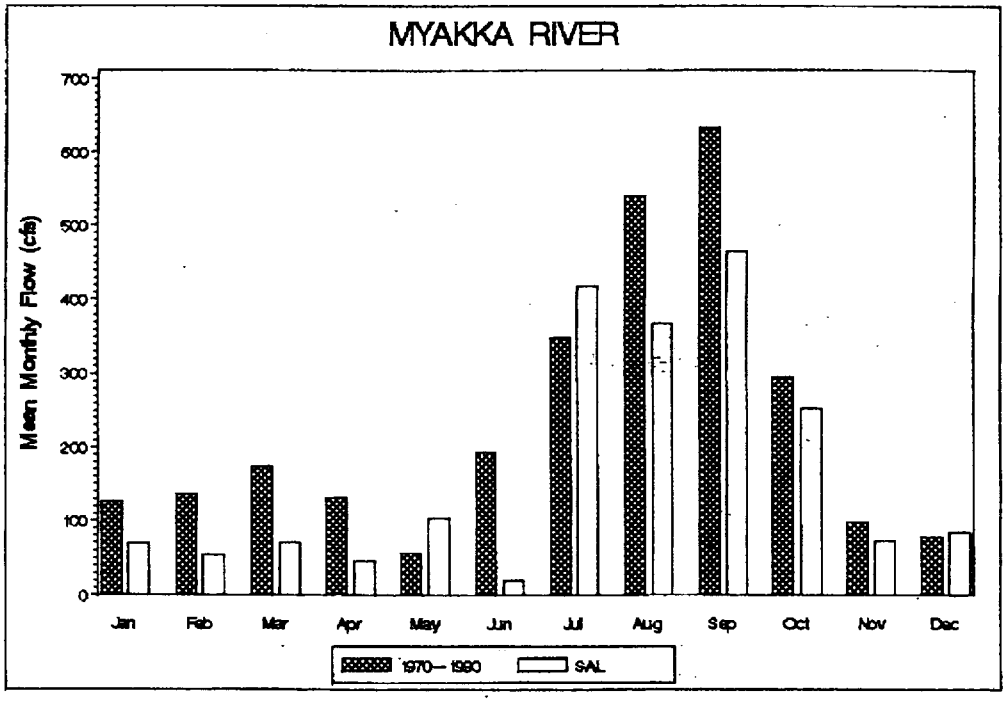


Figure 3.2.A. Mean monthly flows for the Myakka River for 1970-1990 (shaded) and mean monthly flows for months with salinity measurements (unshaded).

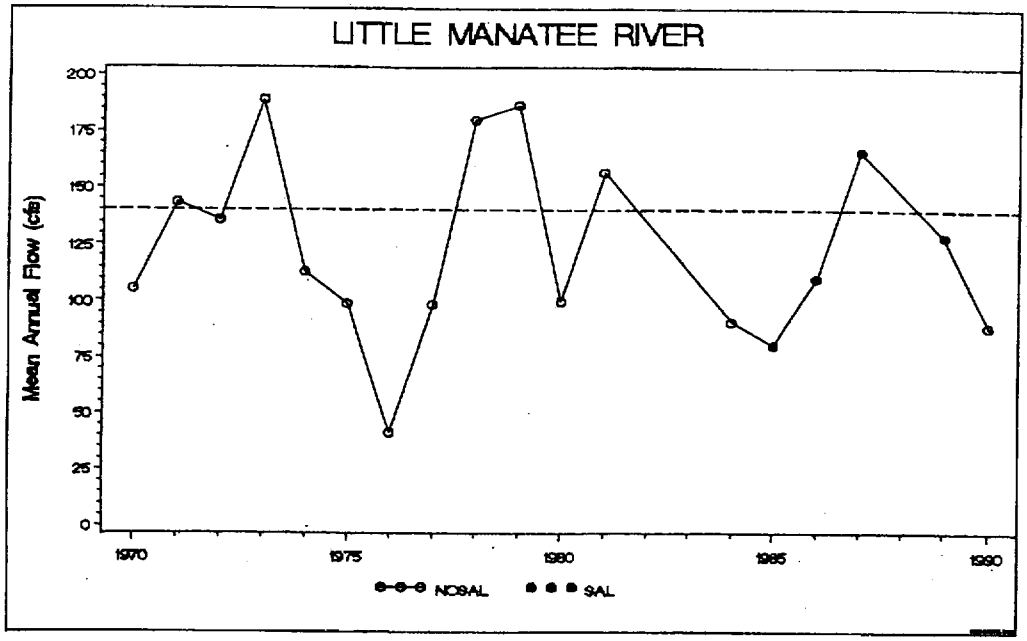


Figure 3.3.A. Mean annual flows for the Little Manatee River for 1970 - 1990 with years with salinity measurements denoted by shaded dots.

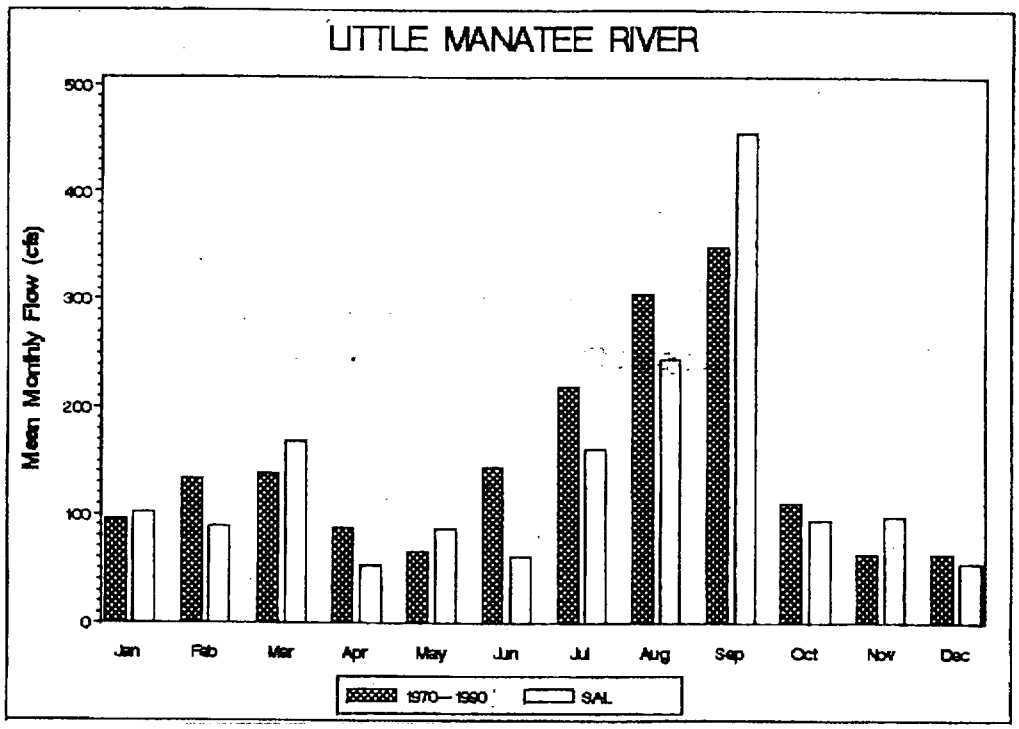


Figure 3.3.B. Mean monthly flows for the Little Manatee River for 1970-1990 (shaded) and mean monthly flows for months with salinity measurements (unshaded).

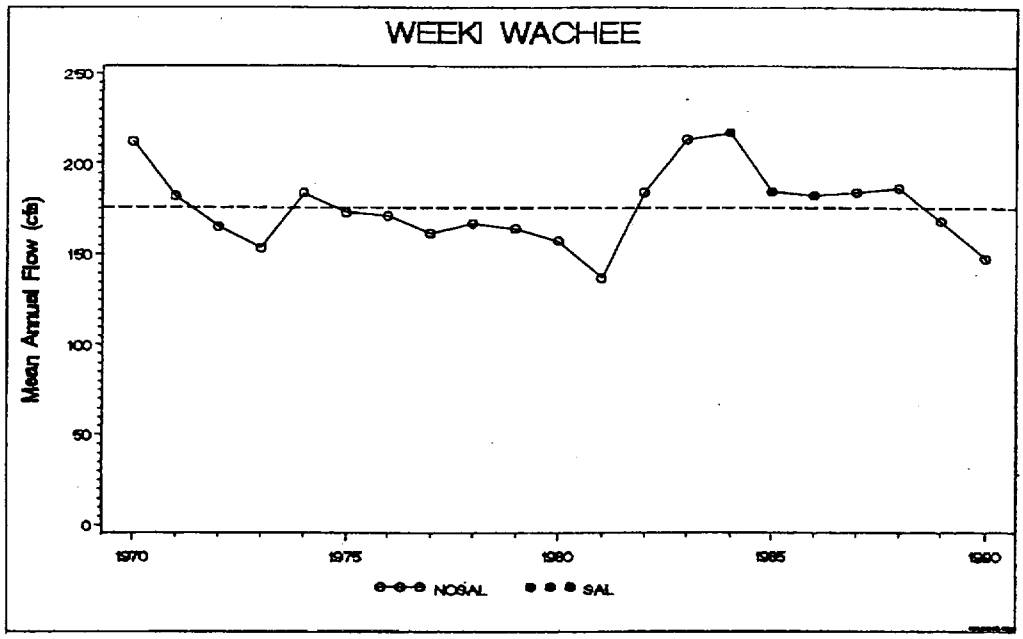


Figure 3.4.A. Mean annual flows for the Weeki Wachee River for 1970 - 1990 with years with salinity measurements denoted by shaded dots.

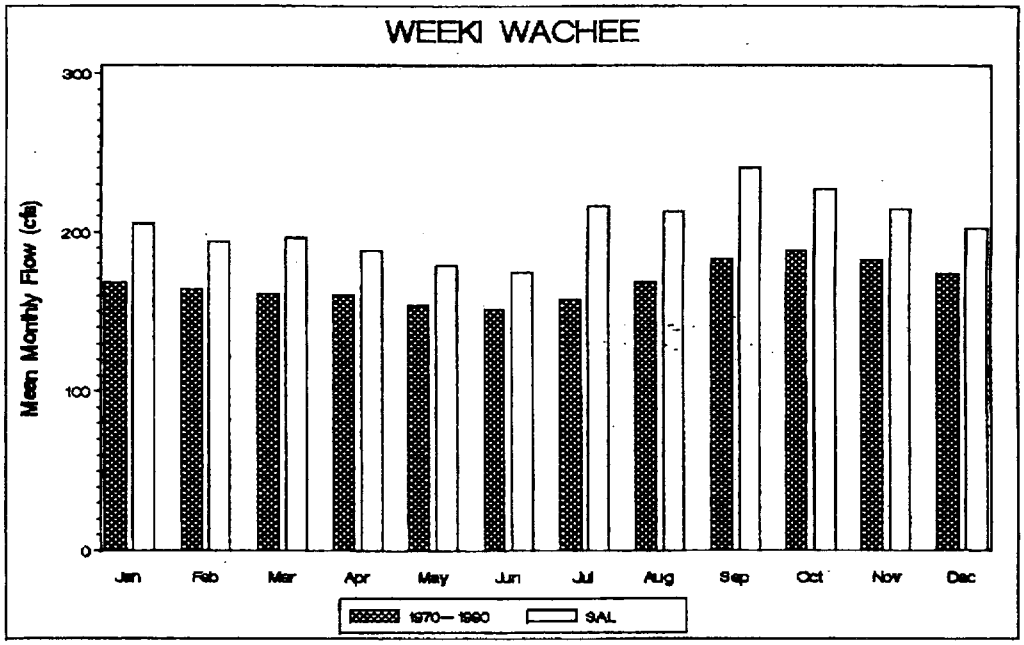


Figure 3.4.B. Mean monthly flows for the Weeki Wachee River for 1970-1990 (shaded) and mean monthly flows for months with salinity measurements unshaded

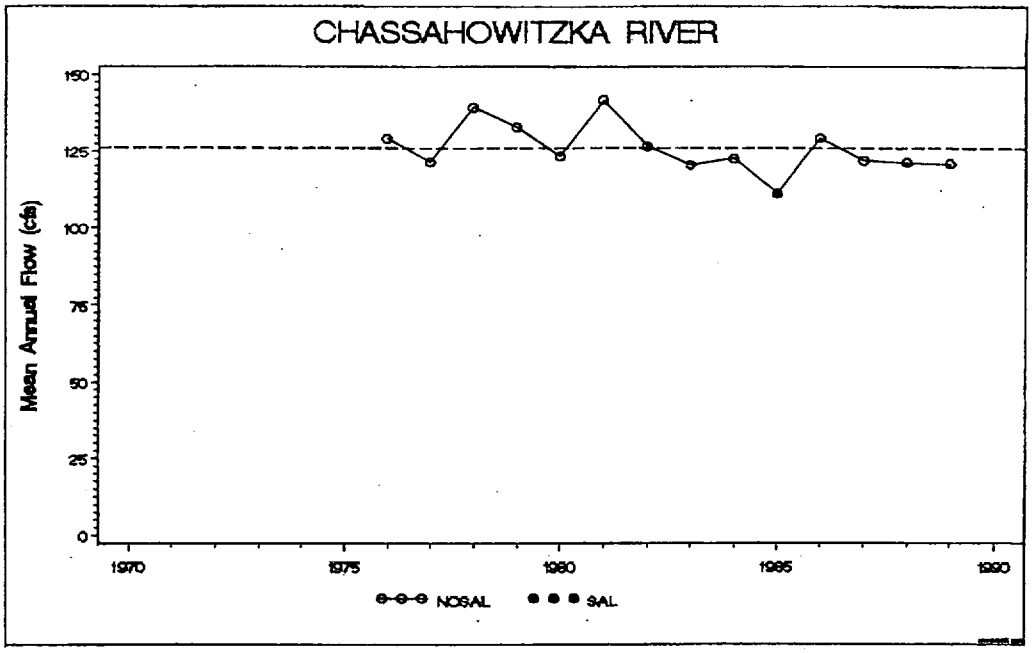


Figure 3.5.A. Mean annual flows for the Chassahowitzska River for 1970-1990 with years with salinity measurements denoted by shaded dots.

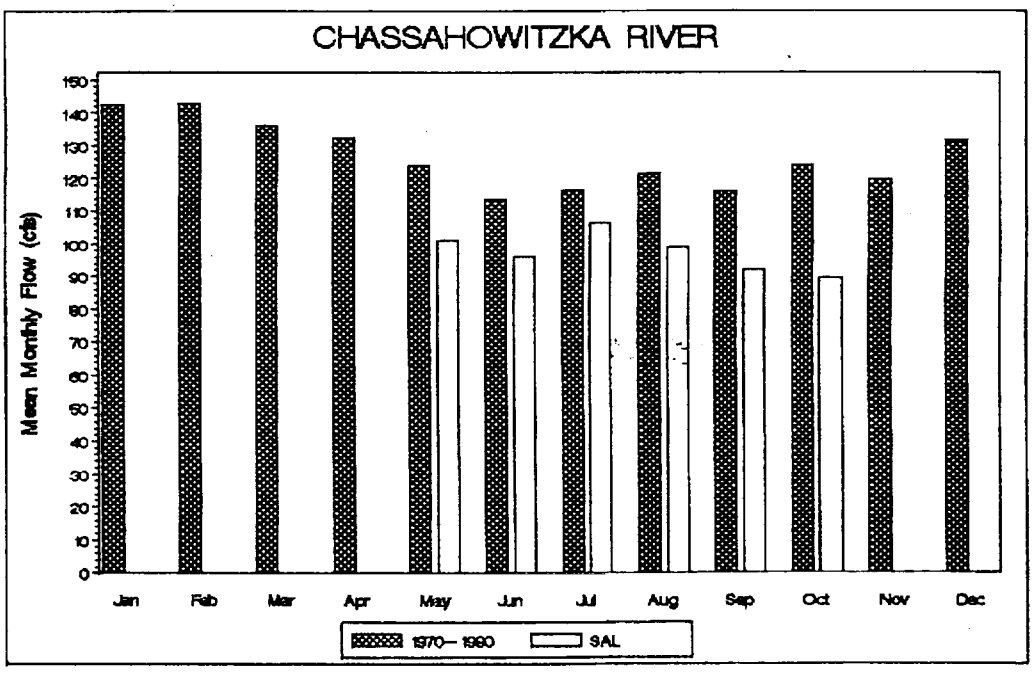


Figure 3.5.B. Mean monthly flows for the Chassahowitzka River for 1970-1990 (shaded) and mean monthly flows for months with salinity measurements (unshaded).

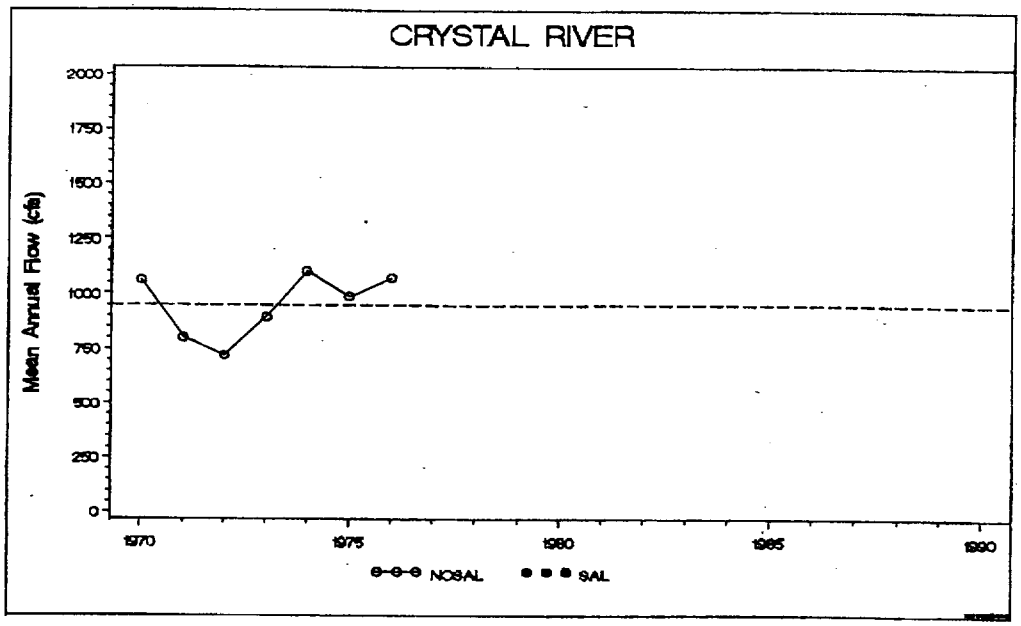


Figure 3.6.A. Mean annual flows for the Crystal River for 1970 -1990 with years with salinity measurements denoted by shaded dots.

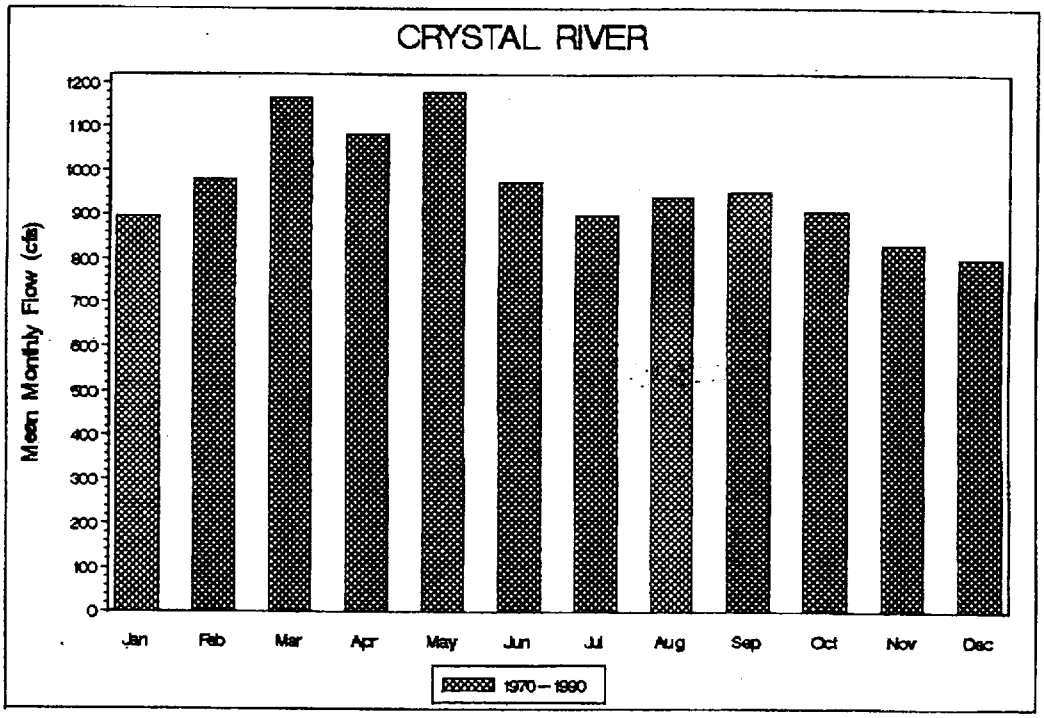


Figure 3.6.B. Mean monthly flows for the Crystal River for 1970-1990. Months with salinity measurements not shown due lack of daily flow records during period of study (1984-1985).

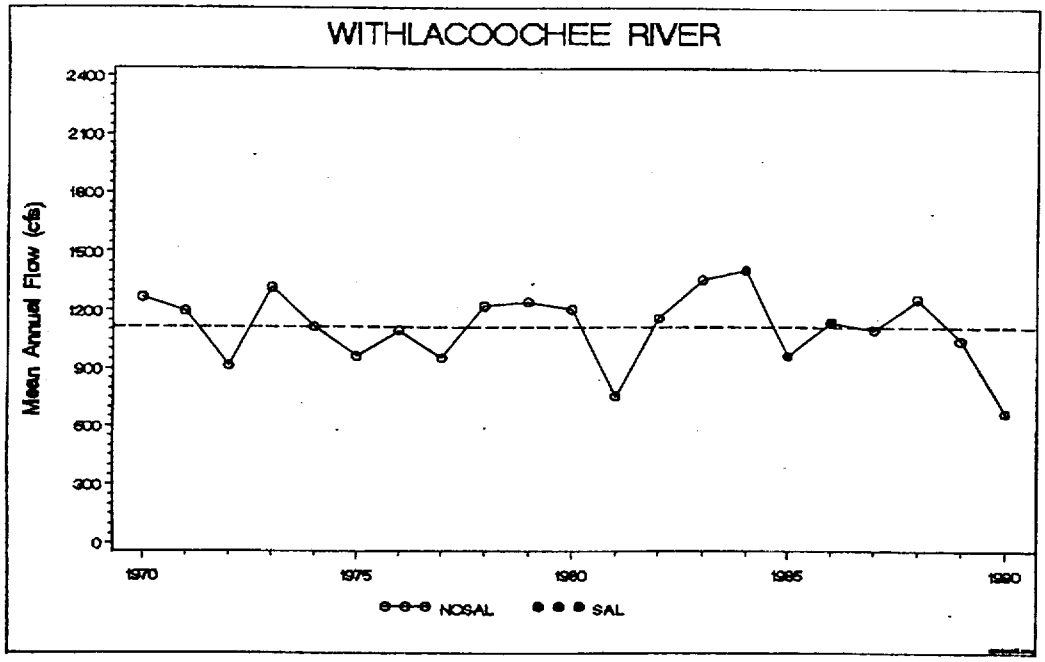


Figure 3.7.A. Mean annual flows for the Withlacoochee River for 1970-1990 with years with salinity measurements denoted by shaded dots.

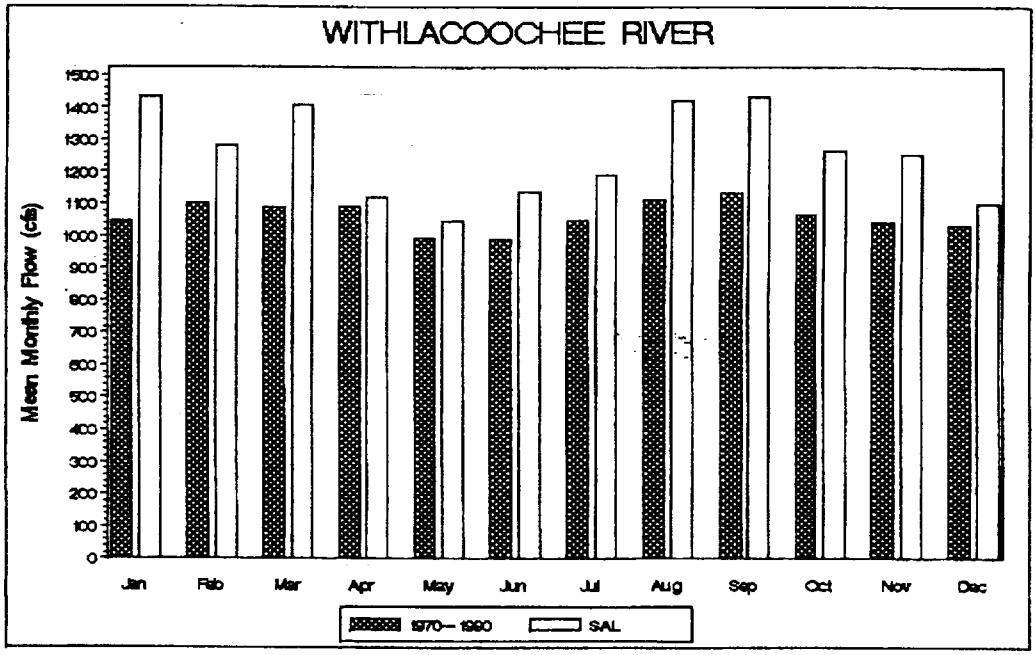


Figure 3.7.B. Mean monthly flows for the Withlacoochee River for 1970-1990 (shaded) and mean monthly flows for months with salinity measurements (unshaded).

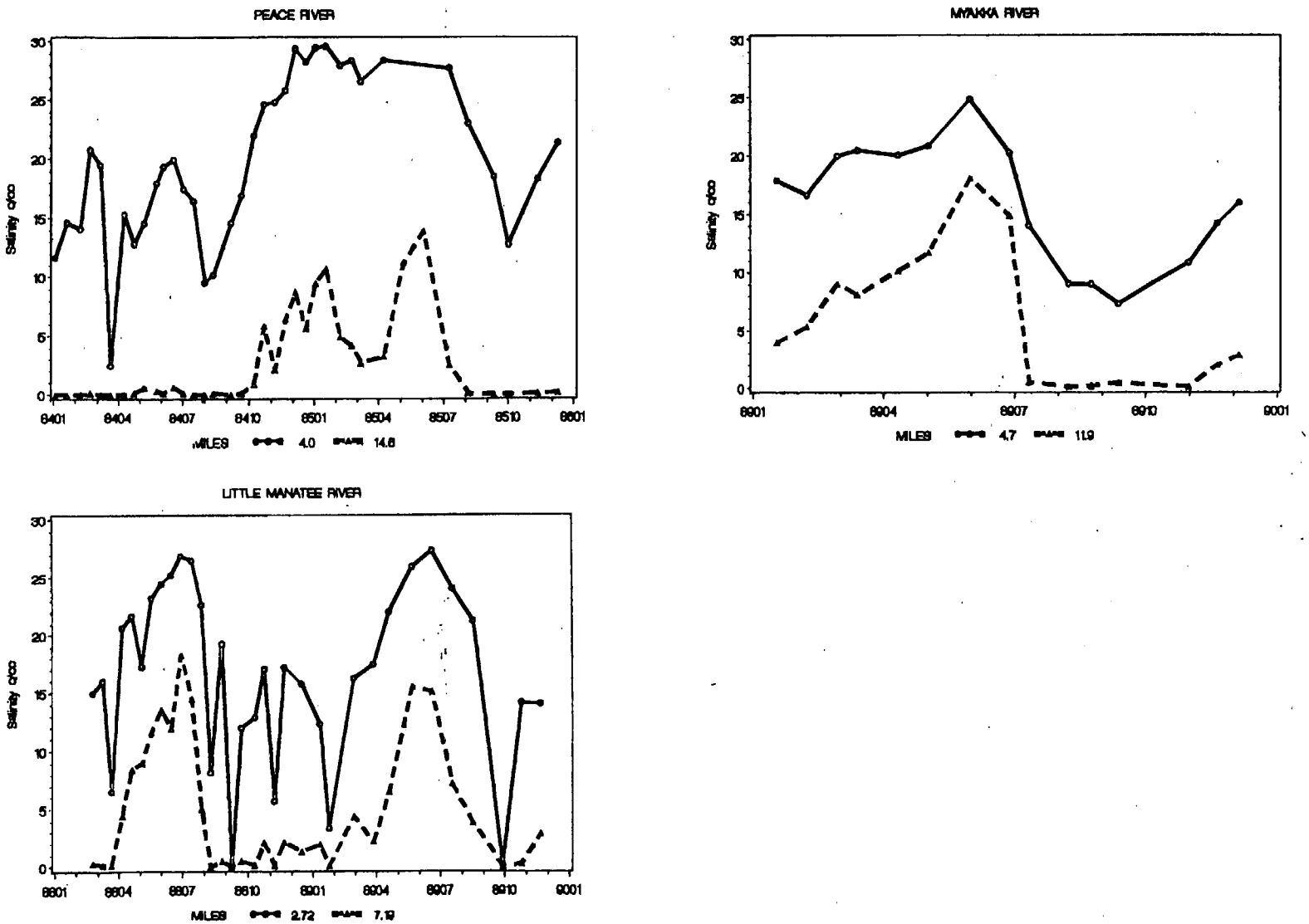


Figure 3.8. Time series of top meter salinity values for two river mile locations on the Peace (1984-1986), Myakka (1989), and Little Manatee (1988-1989) Rivers.

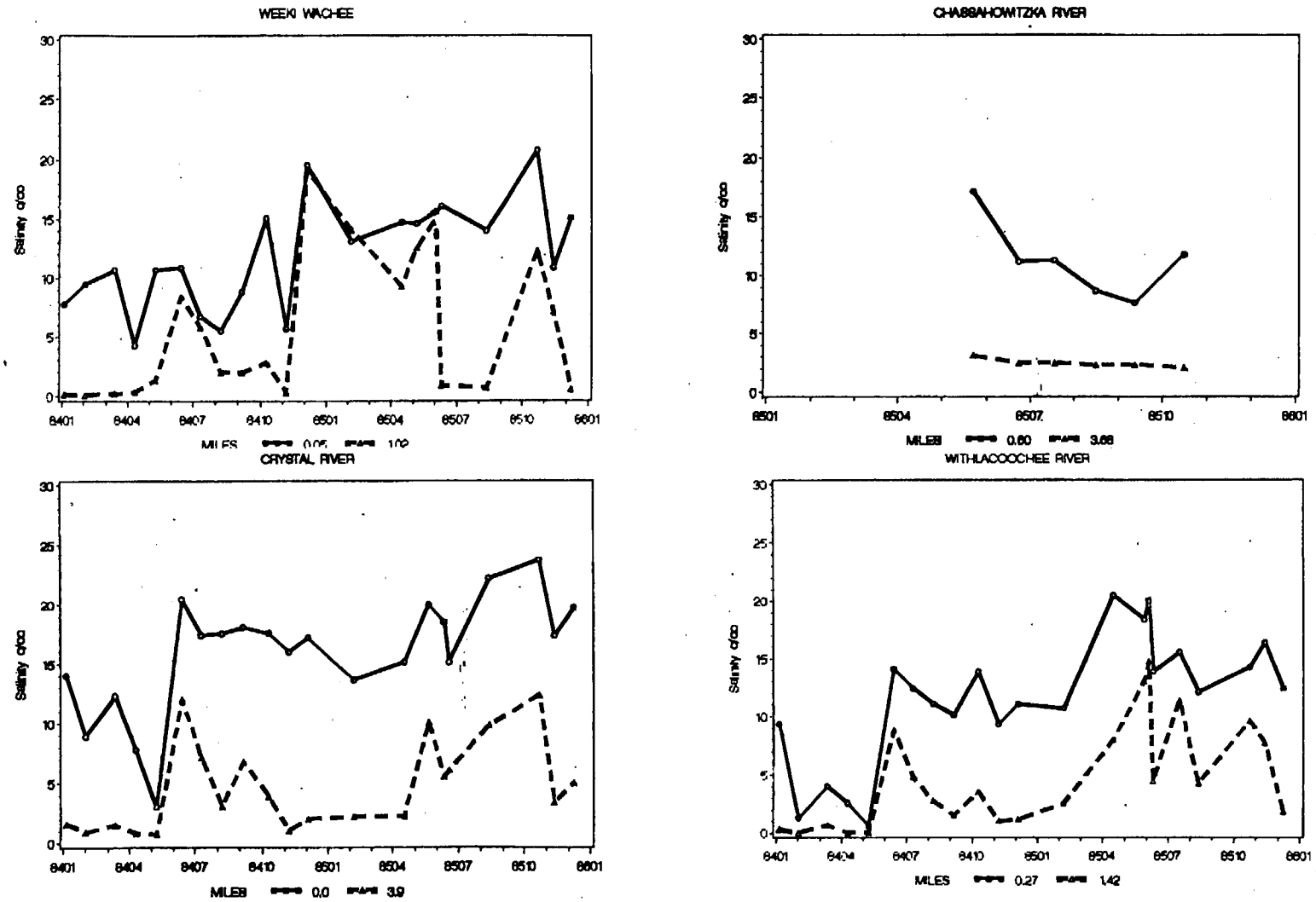


Figure 3.9. Time series for top meter salinity for two river mile locations on the Weeki Wachee (1984-1985), Chassahowitzka (1985), Crystal (1984-1985), and Withlacoochee (1984-1985) Rivers.

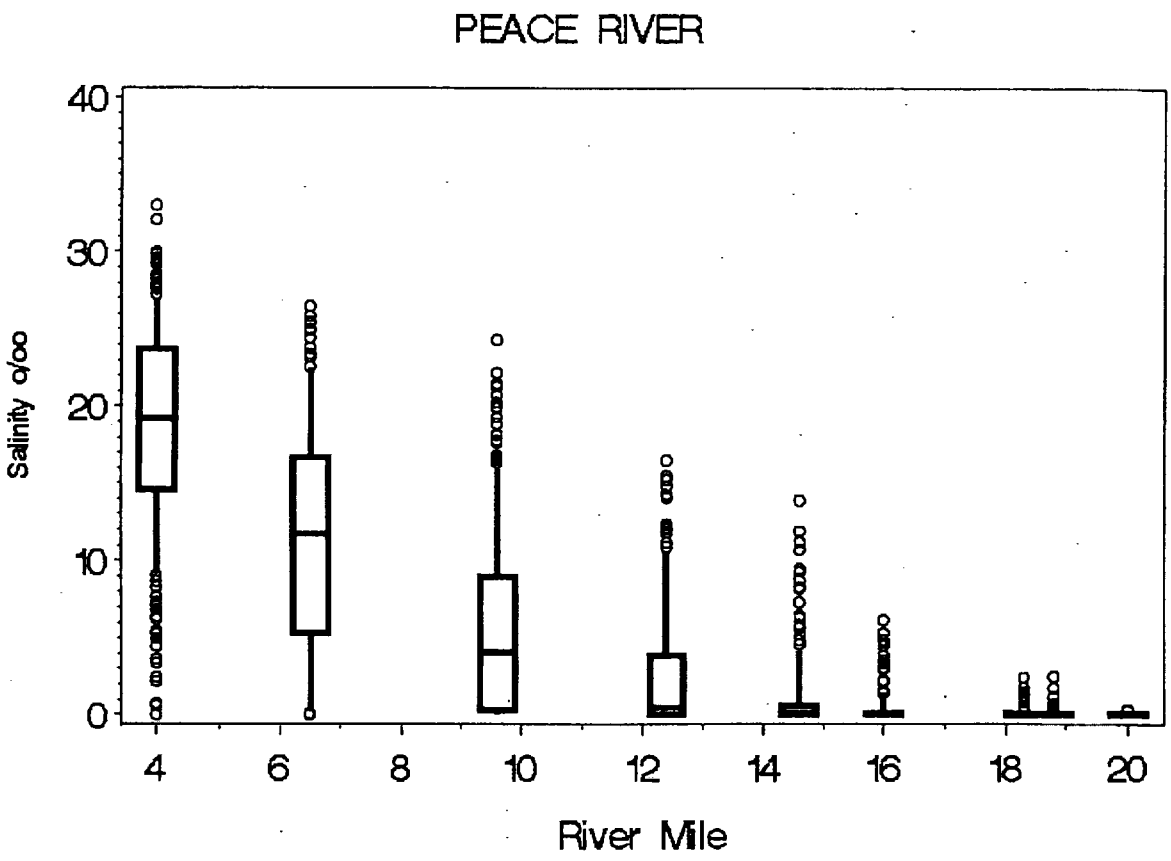


Figure 3.10 Box and whisker plot of top meter salinity in the Peace River

RIVER	MILES	n	MEAN	STD	CV	MIN	P10	Q1	MEDIAN	Q3	P90	MAX
PEACE	4	240	18.7	6.8	36.3	0	9.2	14.5	19.2	23.8	26.9	33
PEACE	6.5	144	11.5	7.6	66	0	0.2	5.3	11.8	16.7	22.5	26.5
PEACE	9.6	205	5.8	6.1	106	0	0	0.4	4.1	9	15.9	24.4
PEACE	12.4	144	2.8	4.3	151	0	0	0	0.5	3.9	10.6	16.5
PEACE	14.6	204	1.1	2.6	224	0	0	0	0.1	0.6	4.2	13.9
PEACE	16	144	0.4	1.1	256	0	0	0	0.1	0.1	1.4	6.2
PEACE	18.3	144	0.1	0.3	235	0	0	0	0.1	0.1	0.3	2.5
PEACE	18.8	204	0.1	0.3	214	0	0	0	0.1	0.1	0.2	2.6
PEACE	20	144	0.1	0.1	112	0	0	0	0.1	0.1	0.2	0.4

Table 3.3. Statistics for top meter salinity at river mile locations on the Peace River.

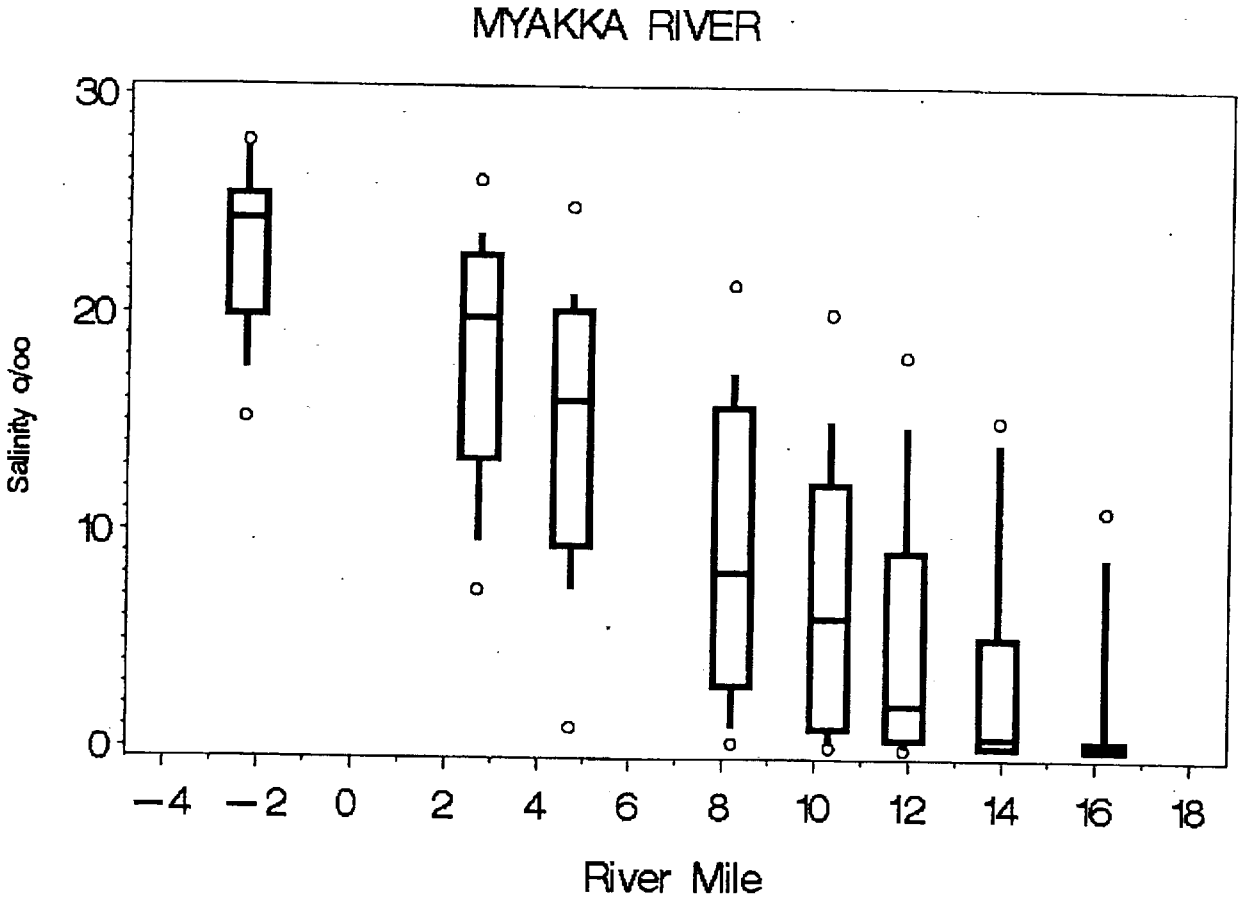


Figure 3.11. Box and whisker plot of top meter salinity in the Myakka River

RIVER	MILES	n	MEAN	STD	CV	MIN	P10	Q1	MEDIAN	Q3	P90	MAX
MYAK	-2.3	19	23	3.6	15.8	15.2	17.4	19.9	24.3	25.5	27.6	27.9
MYAK	2.7	19	18.2	5.2	28.8	7.4	9.6	13.4	19.8	22.7	23.7	26.1
MYAK	4.7	19	14.8	5.9	40	1	7.4	9.4	16	20.1	20.9	24.9
MYAK	8.2	19	9	6.6	73.5	0.3	1	2.9	8.2	15.8	17.3	21.4
MYAK	10.3	19	7	6.1	87.1	0.1	0.2	1	6	12.2	15.1	20.1
MYAK	11.9	19	4.9	5.6	114	0	0.1	0.5	2	9.1	14.9	18.1
MYAK	13.9	19	2.8	4.7	166	0	0	0.1	0.5	5.1	14.1	15.2
MYAK	16.2	19	1.2	3.1	256	0	0	0	0.1	0.4	8.9	11.1

Table 3.4. Statistics for top meter salinity at river mile locations on the Myakka River.

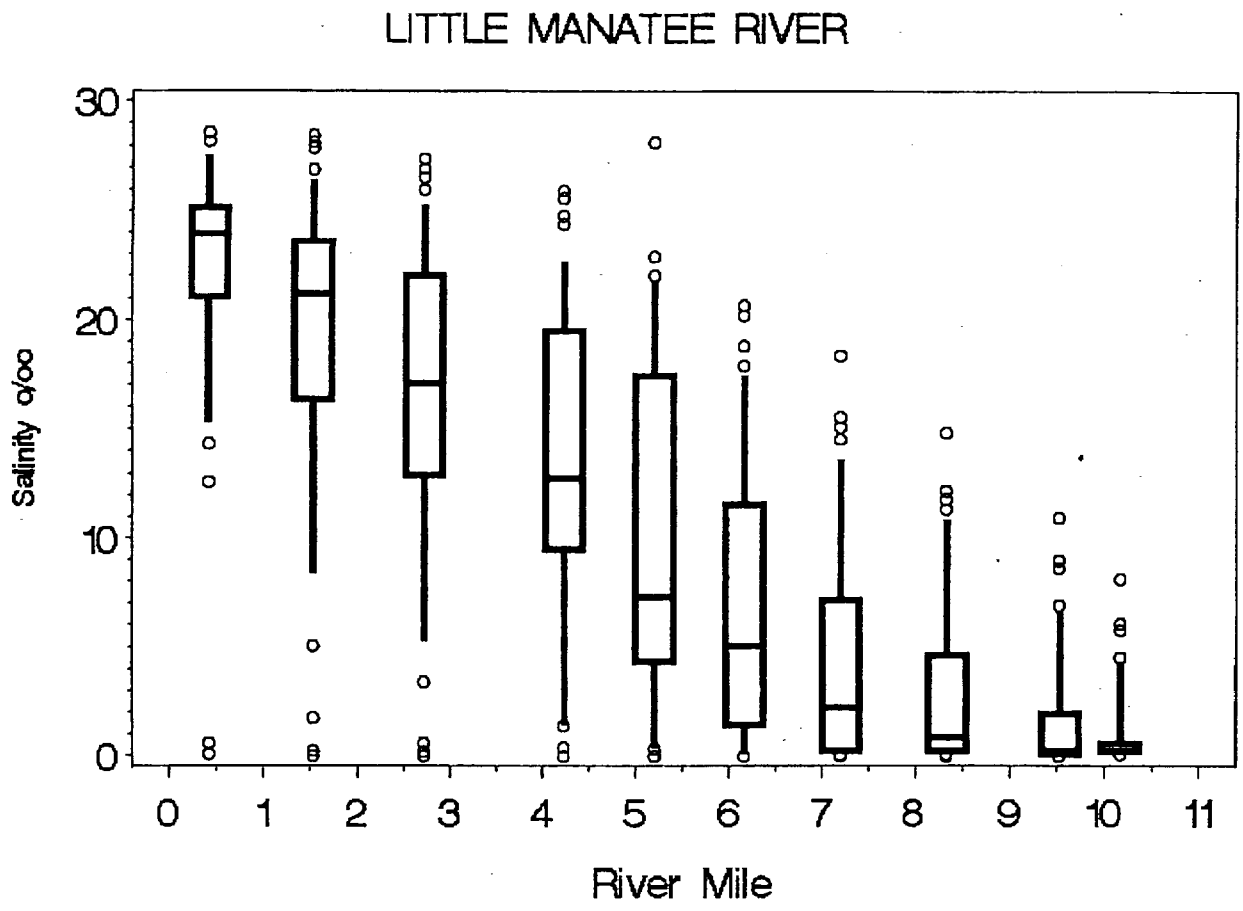


Figure 3.12. Box and whisker plot of top meter salinity in the Little Manatee River

RIVER	MILES	n	MEAN	STD	CV	MIN	P10	Q1	MEDIAN	Q3	P90	MAX
LMAN	0.42	41	22.2	6.3	28.4	0.1	15.3	21.1	24	25.2	27.6	28.6
LMAN	1.53	41	19	7.4	38.9	0	8.4	16.4	21.2	23.6	26.5	28.5
LMAN	2.72	41	16.1	7.6	47.1	0	5.3	12.9	17.1	22.1	25.3	27.4
LMAN	4.23	41	13.3	7.8	59	0	1.5	9.5	12.8	19.5	22.7	26
LMAN	5.2	39	10.1	7.9	78.3	0	0.4	4.4	7.3	17.5	21.9	28.2
LMAN	6.16	41	6.9	6.5	94.9	0	0.1	1.5	5.1	11.6	17.5	20.7
LMAN	7.19	41	4.6	5.3	116	0	0.1	0.2	2.2	7.2	13.6	18.4
LMAN	8.34	40	3.1	4.2	136	0	0.1	0.2	0.9	4.7	10.9	14.9
LMAN	9.53	40	1.7	2.9	168	0	0.1	0.1	0.3	1.9	6.7	11
LMAN	10.17	40	1.1	2	180	0.1	0.2	0.2	0.2	0.6	4.4	8.2

Table 3.5. Statistics for top meter salinity at river mile locations on the Little Manatee River.

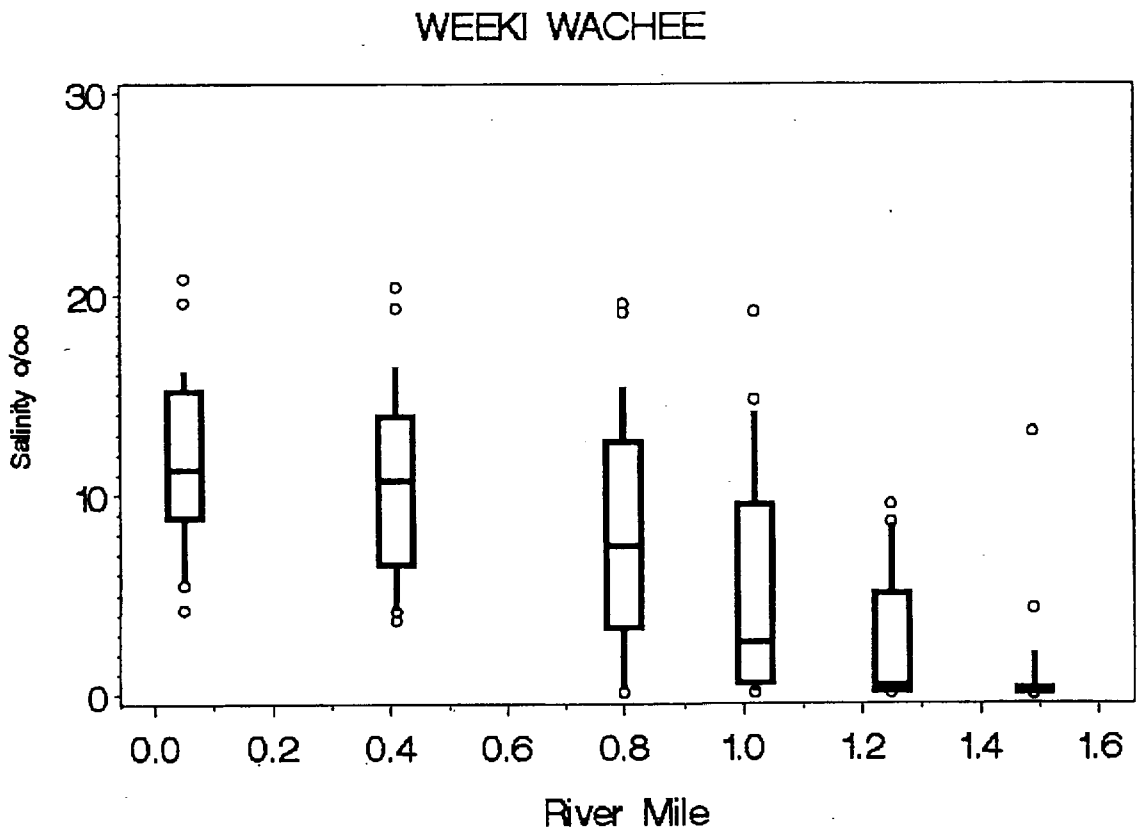


Figure 3.13. Box and whisker plot of top meter salinity in the Weeki Wachee River.

RIVER	MILES	n	MEAN	STD	CV	MIN	P10	Q1	MEDIAN	Q3	P90	MAX
WEEK	0.05	26	11.8	4.3	36.7	4.3	5.7	8.9	11.3	15.1	16.1	20.8
WEEK	0.41	26	10.7	4.7	44.1	3.8	4.3	6.6	10.7	13.9	16.4	20.4
WEEK	0.8	26	8.1	5.8	71.8	0.1	0.3	3.3	7.5	12.6	15.4	19.6
WEEK	1.02	26	5.6	5.8	104	0.1	0.2	0.6	2.7	9.5	14.1	19.2
WEEK	1.25	26	2.6	3.3	127	0.1	0.1	0.1	0.5	5	8.5	9.5
WEEK	1.49	26	1	2.6	264	0	0.1	0.1	0.2	0.3	2.1	13.1

Table 3.6. Statistics for top meter salinity at river mile locations on the Weeki Wachee River.

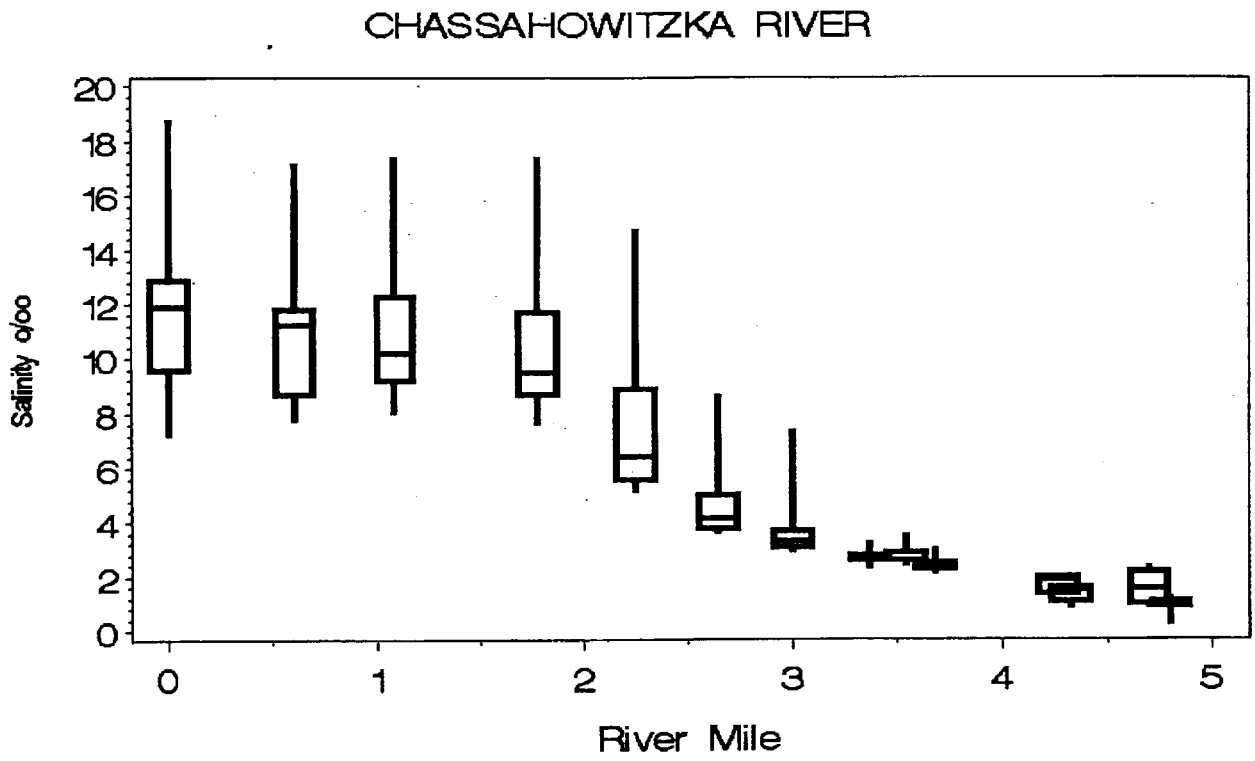


Figure 3.14 Box and whisker plot of top meter salinity in the Chassahowitzka River.

RIVER	MILES	n	MEAN	STD	CV	MIN	P10	Q1	MEDIAN	Q3	P90	MAX
CHAS	0	6	12.1	3.9	32.6	7.2	7.2	9.6	11.9	12.9	18.8	18.8
CHAS	0.6	6	11.3	3.3	29.3	7.7	7.7	8.7	11.3	11.8	17.2	17.2
CHAS	1.09	6	11.2	3.4	29.9	8	8	9.2	10.2	12.3	17.4	17.4
CHAS	1.78	6	10.7	3.5	33	7.6	7.6	8.7	9.5	11.7	17.4	17.4
CHAS	2.25	6	7.9	3.6	46.2	5.1	5.1	5.6	6.5	8.9	14.8	14.8
CHAS	2.64	6	4.9	1.9	39.2	3.6	3.6	3.8	4.2	5	8.7	8.7
CHAS	3	6	4	1.7	43.3	2.9	2.9	3.1	3.3	3.7	7.4	7.4
CHAS	3.37	5	2.7	0.4	13.6	2.3	2.3	2.6	2.6	2.8	3.3	3.3
CHAS	3.54	5	2.8	0.5	17.2	2.4	2.4	2.6	2.6	2.9	3.6	3.6
CHAS	3.68	6	2.5	0.3	14	2.1	2.1	2.3	2.4	2.5	3.1	3.1
CHAS	4.27	6	1.8	0.3	18.8	1.3	1.3	1.4	1.9	2	2.1	2.1
CHAS	4.33	5	1.3	0.4	28.2	0.8	0.8	1.1	1.5	1.6	1.7	1.7
CHAS	4.7	6	1.6	0.6	40.4	0.8	0.8	1	1.6	2.2	2.4	2.4
CHAS	4.8	5	0.9	0.4	46.5	0.2	0.2	0.9	1	1.1	1.3	1.3

Table 3.7 Statistics for top meter salinity at river mile locations on the Chassahowtizka River.

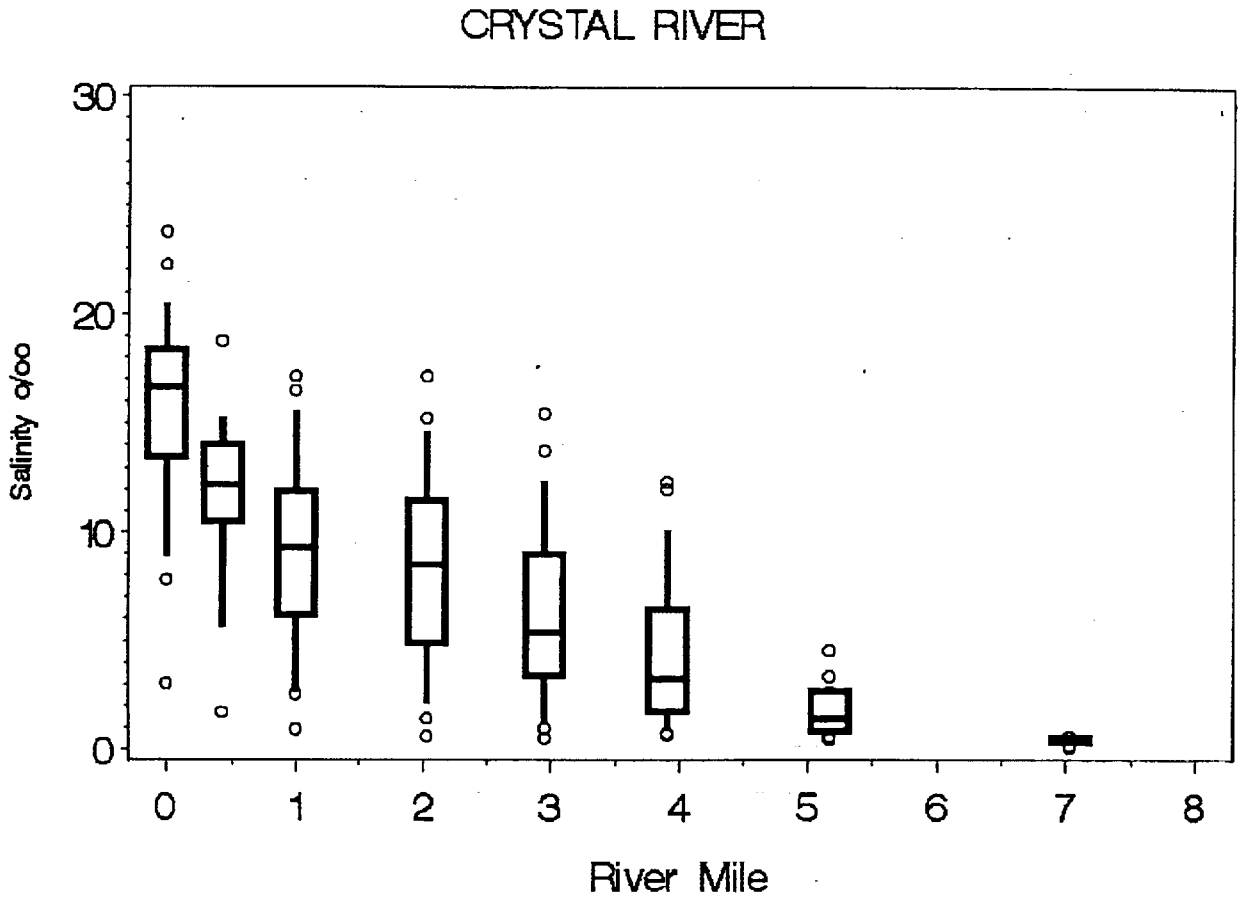


Figure 3.15. Box and whisker plot of top meter salinity in the Crystal River

RIVER	MILES	n	MEAN	STD	CV	MIN	P10	Q1	MEDIAN	Q3	P90	MAX
CRYS	0	24	15.7	4.7	29.7	3	8.9	13.5	16.6	18.3	20.5	23.8
CRYS	0.43	17	11.4	4.2	36.8	1.7	5.6	10.5	12.2	14	15.3	18.8
CRYS	1	24	9.3	4.4	47	1	2.6	6.2	9.3	11.9	15.6	17.2
CRYS	2.03	24	8.3	4.5	54.1	0.6	2.1	4.9	8.5	11.5	14.7	17.2
CRYS	2.95	24	6.3	4.2	65.7	0.6	1.2	3.4	5.4	9	12.4	15.5
CRYS	3.9	24	4.6	3.6	78.3	0.7	0.9	1.8	3.3	6.4	10.1	12.4
CRYS	5.17	23	1.7	1	60.1	0.5	0.8	0.8	1.4	2.7	2.9	4.6
CRYS	7.03	20	0.5	0.1	29.3	0.1	0.3	0.4	0.5	0.6	0.6	0.7

Table 3.8. Statistics for top meter salinity at river mile locations on the Crystal River.

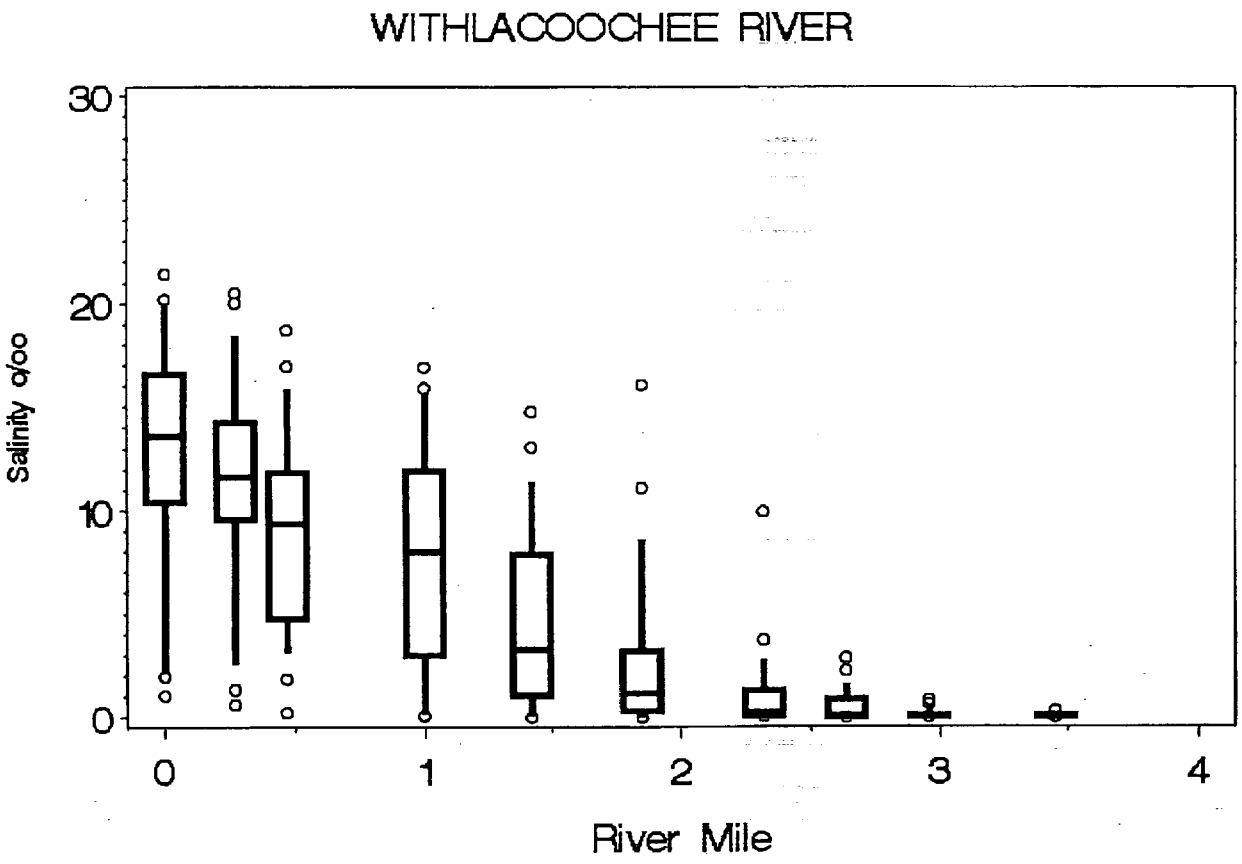


Figure 3.16. Box and whisker plot of top meter salinity in the Withlacoochee River

RIVER	MILES	N	MEAN	STD	CV	MIN	P10	Q1	MEDIAN	Q3	P90	MAX
WITH	0	24	12.9	5.8	44.7	1.1	2.2	10.4	13.6	16.6	19.9	21.4
WITH	0.27	24	11.4	5.3	46.3	0.6	2.6	9.6	11.6	14.2	18.4	20.5
WITH	0.47	20	8.9	5	56.6	0.3	3.2	4.8	9.4	11.8	15.9	18.7
WITH	1	23	7.5	5.3	71	0.1	0.2	3	8	11.9	15.6	16.9
WITH	1.42	24	4.7	4.4	92.9	0	0.1	1.1	3.3	7.8	11.4	14.8
WITH	1.85	24	2.9	4.1	139	0	0.1	0.3	1.2	3.2	8.6	16.1
WITH	2.32	21	1.2	2.2	183	0.1	0.1	0.1	0.2	1.3	2.7	10
WITH	2.64	23	0.5	0.8	163	0	0	0	0.1	0.9	1.6	2.9
WITH	2.96	23	0.2	0.2	141	0	0	0	0.1	0.1	0.6	0.9
WITH	3.45	20	0.1	0.1	108	0	0	0	0	0.1	0.3	0.3

Table 3.9. Statistics for top meter salinity at river mile locations on the Withlacoochee River.

CHAPTER FOUR
FLORISTIC CHARACTERIZATION OF THE RIVERS

4.1 Overview

The coastal region of the northeastern Gulf of Mexico, including peninsular Florida, is comprised largely of an extensive, low-gradient plain. This plain extends far into the Gulf in places, particularly in Florida's "Big Bend." Frictional drag of moving water across these shallows tempers waves and protects the shoreline from erosion (Tanner 1960). Tidal marsh establishment is favored by this environment. In subtropical areas, mangrove thickets and forests share the tidelands with marshes.

Coastal vegetation is limited by salinity and soil moisture regimes. Land that lies below the high tide line is subject to daily oscillations in salinity and inundation in response to astronomical tides. Plant roots may experience hypoxic conditions in water-logged soils. With increasing land elevation, tidal inundation occurs less frequently, sometimes only once a year at the highest spring tide. Land that is elevated above mean high tide is better drained and subjected to desiccation from evapotranspiration between periods of tidal inundation. Soils at such sites may become hypersaline from prolonged periods of evaporation. Variable salinity and moisture cause extreme physiological stress in plants. Contributing to this variability are the effects of direct rainfall and of wind generated tides, that can negate or greatly amplify the expected salinity and moisture regimes of astronomical tides. Toward the interior margins of tidal marshes, runoff from adjacent uplands ameliorates the extremes in soil moisture and salinity. Groundwater levels can also influence soil salinity. In areas with aretesian pressure, upward groundwater leakage can limit the depths that tidal waters affect soil salinity.

Those few plant species that can tolerate these harsh conditions are favored by the near lack of interspecific competition. These species form zones that reflect differences in soil moisture and salinity which occur with increasing elevation and distance from the Gulf. Most stands are either monotypic or they consist of chance assemblages of species that resist formalization into recognizable plant communities.

Kurz and Wagner (1957) largely determined plant species composition and zonation in response to salinity, soil moisture, and other site factors in Florida. Kruczynski et al. (1978) elaborated with quantitative descriptions of the vegetation at St. Marks in Wakulla County, where Kurz and Wagner (1957) conducted much of their work. Subsequently, most work on Gulf coastal tidal marsh vegetation in Florida has been limited to qualitative descriptions, e.g., Stout (1984), Clewell (1986, 1997), and Montague and Wiegert (1990).

Florida's Gulf-coastal tidal marshes are interrupted frequently by streams (McPherson and Hammett 1990). Most are small black-water rivers and spring-runs that carry fresh water from the interior of Florida. The Suwannee River is the largest river of peninsular, Gulf-coastal Florida and displays the most pronounced geomorphic features associated with alluvial transport, such as high levees, meandering channels, chutes, and oxbows

(Clewell 1990). Intertidal vegetation along the Suwannee River is well known in terms of species composition and abundance, zonation, and the relationship of zones to salinity and soil factors (Clewell et al. 1999, Clewell 2000, Coultas and Lasley 2001).

Other Gulf-coastal rivers, including those under investigation, have much less discharge than the Suwannee. They are low-gradient and carry overflow from headwater marshes and swamps, groundwater seepage, and sometimes discharge from deep springs. These sources yield modest quantities of perennial flow. They do not produce the dramatic seasonal pulses in flow of continental rivers that derive from snowmelt and seasonal rainfall and that traverse steep gradients. As a consequence, alluvial processes and geomorphology are much less pronounced in Florida than elsewhere.

Even so, these small streams disrupt the landform and vegetation zones in tidal marshes. In those rivers that transport significant amounts of suspended sediment, natural levees accrete alongside the river channels in the lower river reaches. The levees form corridors through which saline water flows that is diluted by freshwater discharge. River velocity is retarded upon reaching the Gulf, causing sediments to be deposited and form bars and deltaic features. These, in turn, cause the formation of new distributaries. The resulting network of channels divides the land into islands, each bordered by levees. Plant species respond by forming irregular mosaics, each patch of which is dominated by one or very few species that are favored by particular combinations of site conditions which differ subtly from place to place.

A unique area encompassed by this study is the highly-digitate, irregularly shaped coast from Pasco County to Crystal River. This is a sediment-starved coastline with poor or no supply of quartz-rich sands (Hine and Belknap 1988). Coastal and riverine geomorphological characteristics in this region are shaped by the interaction of tidal forces with an exposed, karst bedrock. Much of the streamflow in the region results from groundwater discharges from coastal springs. Expansive, broad, flat marshes are found along this coast, which has a particular scarcity of alluvial sediments. Natural levees that can be found along rivers in other areas of Florida are particularly scarce or small in this region.

Stability of the vegetation in any given location is threatened by the ever-changing landform and also by normal processes of erosion and deposition that are ubiquitous along riverbanks. In addition, wrack (rafts of deposited detritus, Fig. 4.8) smothers existing vegetation and makes the exposed land available for colonization by opportunist species, e.g., *Phragmites australis* (Fig. 4.9). Rafts of tidal wrack commonly occur in narrow strips on levees and along riverbanks of all Gulf-coastal rivers. The wrack consists largely of dislodged aquatic seagrasses *(e.g. Halodue wrightii, Thalassia testudinum,* etc.) and submerged freshwater species *(Vallisneria americana,* etc.). Storm wrack is deposited much less frequently by hurricanes and other major storms. It consists largely of the dead stalks of emergent tidal marsh plants that are rafted and can be deposited anywhere in tidal marshes. These rafts kill all vegetation beneath them and may cover several acres. Storm wrack is a major perturbation in Suwannee River tidal marshes owing to eddying caused by the high volume of river discharge as it

encounters storm tides (Clewell et al. 1999). Other Gulf-coastal rivers lack sufficient discharge to cause much rafting, and storm wrack deposition is apparently much less consequential than it is along the Suwannee River.

4.2 Communities mapped by photo-interpretation and GIS.

Figures 4.1 through 4.7 are GIS maps of the major vegetation communities along the tidal reaches of the Peace, Myakka, Little Manatee, Weeki Wachee, Chassahowitzka, Crystal, and Withlacoochee rivers, respectively. As with all the tables and figures in this report, the maps are presented in an order from south to north. Distances in the channels upstream from the mouths of the rivers are shown in miles. Mapping polygons portray land usage and the complex and irregular mosaic of major plant communties. Geomorphic complexity is more pronounced in those rivers having greater discharge. For example, the corridor of the Peace River (Figure 4.1) contains obvious meander loops, chutes, and oxbows. Mapping polygons next to the Peace and other rivers are commonly elongated, indicating the positions of natural levees and sometimes the narrow zones of vegetation lying next to them. Numerous islands exist, especially near the Gulf where deltaic deposition and distributary formation has been greatest.

The predominant vegetation cover type in Figures 4.1-4.7 is designated as *Juncus sp.* and consists of dense stands of *Juncus roemerianus* (needlerush, Fig. 4.10). *Juncus roemerianus* is the most abundant and characteristic tidal marsh plant species on the Gulf coast of Florida. It tolerates a wide range of salinity and soil moisture content, and, once established, it offers considerable competition to other species by its densely intertwined rhizomes and by the shade imparted by its closely-spaced shoots. It commonly grows in monotypic stands, particularly in the mesohaline zone (salinity 5-18 ppt). It occasionally shares space with other species. In such circumstances, needlerush may be colonizing newly formed land, it may be recovering from wrack deposition, or it may be occupying an oligohaline zone (< 5ppt) where the salinity is low enough for other species to compete with it.

The *Juncus* zone is commonly fringed by a narrow zone of *Spartina alterniflora* (cordgrass, Fig. 4.11) on riverbanks where the salinity is high. This zone was too narrow to be mapped separately in Figures 4.1 - 4.7 Along the northern four rivers, the *Juncus* zone and its fringe of *Spartina alterniflora* extend to the Gulf of Mexico. This zone seemingly wraps around without interruption from the river mouth and continues as the principal tidal marsh cover facing the Gulf.

Along the southern three rivers (Peace, Myakka, Little Manatee) the *Juncus* zone is truncated by mangrove thickets that occupy the shoreline of the Gulf and comprise the dominant vegetation up river into the more saline reaches of the mesohaline zone. Mangrove trees and shrubs consist largely of *Rhizophora mangle* (red mangrove), *Avicennia germinans* (black mangrove), and *Laguncularia racemosa* (white mangrove) (Fig. 4.12). Small fringes of cordgrass can be found associated with downstream stands of *Juncus* that are just upstream or interspersed with mangroves. In general,

however, cordgrass is less widely distributed on the sourthern rivers due to the presence of mangroves in the higher salinity zones.

Upstream of the *Juncus* zone, species composition becomes quite variable, diverse, and difficult to categorize. Along the northern four rivers (Weeki Wachee, Chassahowitzka, Crystal, Withlacoochee) *Cladium jamaicense* (sawgrass, Fig. 4.13) is generally the predominant species that replaces *Juncus* upstream (Figs. 4.4 – 4.7). *Cladium* also occurs in this position along the southern three rivers (Peace, Myakka, Little Manatee) but not in sufficient abundance to warrant its mapping as a distinct cover type. *Cladium* generally extends upstream to the point where forest replaces tidal marsh. However, it sometimes becomes mixed with, or entirely replaced by, a number of other emergent marsh species that tolerate oligohaline conditions.

Typha domingensis (cattail) is another marsh species that is tolerant of oligohaone conditions and much has the same zonation as *Cladium,* although less widely distributed . This species, which more salt tolerant than the common inland cattail species *Typha latifolia*, commonly occurs in low-salinity marshes on the Gulf coast. Stands of *Typha domingensis* were mapped in the four northern study rivers (Figs. 4.4 – 4.7), being most common on the Crystal and Withlacoochee. In some marshes, *Typha* is the predominant plant forming nearly monospecific stands, while in other marshes it is extensively inter-mixed with *Cladium* or other species tolerant of brackish conditions. Similar to *Cladium*, *Typha* was present, but much less abundant, on the southern rivers.

The interior tidal forest was largely mapped as bottomland hardwood forest in Figures 4.1-4.7. This forest (Fig. 4.14) is quite variable in species composition and may include a considerable coniferous element of cypress *(Taxodium distichum, T. ascendens)* and/or pine *(Pinus elliottii, P. taeda)* and also cabbage palms *(Sabal palmetto,* Fig. 4.2*)*. The interface between bottomland hardwood forest and herbaceous marsh may be abrupt or gradual (Fig. 4.15). Upland forest closely flanked the well entrenched upper intertidal reach of the Myakka River (Fig. 4.2).

Patches of tidal freshwater marsh occupied narrow flats and riverbanks in front of the tidal bottomland hardwood forest (Fig. 4.16). The forests and marshes in this zone occupy predominantly freshwater habitat, although they may become slightly brackish during storm tides and extended dry periods. They remain under tidal influence, because incoming tides serve as tidal dams that retard river discharge. Fresh water backs up and causes flooding. Where flooding is too prolonged for trees to become established, freshwater tidal marsh occurs. The flood plain is forested where soils are sufficiently oxygenated, at least seasonally, to allow deep enough rooting for tree anchorage and to facilitate metabolism in their roots.

Some interior marsh zones were colonized with scrub, extensively so along the Peace River (Figure 4.1). The scrub largely consisted of saplings and small trees of bottomland hardwood forests that were colonizing these marshes. The trees potentially could overtake these sites and create new tidal forest at the expense of tidal marsh. However, this woody growth is susceptible to both salinity shock and fire. Salinity shock

can be caused by drought that increases ionic concentration in soil water and also by Gulf water driven inland by hurricanes. Wildfires can move across dense growths of sawgrass and needlerush.

Maps of the two most southern rivers (Peace, Myakka; Figures 4.1, 4.2) showed large areas of *Acrostichum danaeifolium* (leather fern, Fig. 4. 17). Smaller stands were mapped on the third southern river, the Little Manatee (Fig. 4.3). This conspicuous and coarse fern grew mainly on, or shoreward from, natural levees in *Juncus* marshes. It also grew on levees along the Weeki Wachee and Crystal Rivers, but not in sufficient abundance to warrant mapping by photo-interpretation.

4.3 Species Presence by River.

The presence of plant species on the riverbanks was documented by field sampling a number of shoreline sites on each of the rivers (see Chapter 2). The location of these vegetation sites are shown in Appendix A. Appendix G presents all species that were recorded at each site for each river, along with the location by river mile and the median and P95 salinity values for each site. The sites in Appendix G are listed from upstream to downstream for each river. Appendix H presents the same data, but the sites are grouped separately by the individual plant species that were recorded there. These data provide the basis for generating the subsequent tables and appendices in this chapter. Salinity/vegetation relationships are discussed in Chapter 5.

One hundred nineteen plant species were recorded at the study sites (Table 4.1). The number of species ranged from 19 at the Weeki Wachee River to 57 at the Withlacoochee River. Rivers with high discharge (Withlacoochee, Peace) had the most species. Small spring-runs (Weeki Wachee, Crystal) had the fewest species. Table 4.1 is not a comprehensive list of species that occurred in the tidal marshes associated with each river or of the species that occurred along the banks of each river. Instead, this table lists those species that were recorded in or near quadrats at study sites. Nonetheless, Table 4.1 is reasonably comprehensive and includes all of the more common species for each river, as was evident from reconnaissance in 1997.

The most abundant species sampled was *Juncus roemerianus* (needlerush). This species appeared at 242 sites and in one or both quadrats at 224 of those sites, as recorded in Table 4.2. This table presents an overview of the species occurring along intertidal rivers on Florida's Gulf coast. It also indicates the relative abundance of those species without regard to salinity, which varies considerably within the tidal reaches of the seven study rivers. The next most abundant species are *Cladium jamaicense* (sawgrass), *Spartina alterniflora* (cordgrass), *Typha domingensis* (cattail), and *Rhizophora mangle* (red mangrove). Red mangrove is somewhat over-represented, owing to its propensity to establish seedlings on riverbanks where the salinity is too low for their survival much beyond the seedling stage. As discussed in Chapter 2, the study areas for this project were located upstream of mature mangrove forests.

Appendix C is an alphabetical checklist of scientific names of plants, which gives the common name and the family name for each. Each species is characterized by its salinity preference and by its life form (herb, shrub, tree, etc.). Tropical species that essentially reach their northern limit of distribution in the southernmost rivers in this study are so noted, as are exotic species. Most species were indigenous. The only exotic species listed in Appendix C were *Alternanthera philoxeroides, Colocasia esculenta, Crotalaria incana, Paspalum repens, Schinus terebinthifolius,* and *Urochloa mutica.*

Salinity preference is represented by glycophytes and halophytes. Glycophytes are plants of freshwater wetlands where the salinity rarely if ever exceeds 0.5 ppt. Halophytes are plants of brackish or saline wetlands where the salinity commonly exceeds 0.5 ppt. Halophytes grow in intertidal zones that are identified by their normal range in salinity: oligohaline zone (0.5-5.0 ppt), mesohaline zone (5-18 ppt), and polyhaline zone (18-30 ppt). The salinity ranges denoted by these terms conform to the Venice System, which was established by a group of ecologist in 1957 based largely on benthic organisms (reference). These are zones of convenience for purposes of general communication and cannot be accurately applied to vegetation or mapped with precision. The term *brackish* can apply to the mesohaline zone, but is perhaps more appropriately used for denoting the oligohaline zone

In this report, we recognize halophytes that are largely confined to the oligotrophic zone as oligohalophytes. Likewise, halophytes typical of the mesohaline zone are called mesohalophytes. A polyhaline zone occurs near the mouths of some but not all Gulf-coastal rivers. The few species that are sometimes exposed to salinity in this range are treated as mesohalophytes in this report. Many species listed in Appendix C tolerate a wide range of salinity and can live both as glycophytes and oligohalophytes or as oligo- and mesohalophytes. Species are recognized as glycophytes, oligohalophytes, and mesohalophytes for convenience of general communication, and these designations denote tendencies rather than fixed attributes.

Appendix D provides brief summaries of autecological information for twelve species that were frequently recorded at sites in this study. Information is presented on salinity tolerances, habitat requirements for seedling establishment, and responses of interspecific competetion to the extent that such information is available.

Each species occupied a particular reach of riverbank that is measurable according to the distance (river miles) from the coast. Appendix E gives river mileage by species for each river. Three values are given: the minimum and maximum river mileage for a species and its center of abundance. The center of abundance is a mean river mile location that incorporates plant coverage at the different quadrat sites as a weighting factor in the calculation of the mean location. The number of sites at which each species occurred is given as an indication of confidence for mileage values, assuming that confidence is a function of the number of sites.

The seven rivers span a distance of more than 150 miles of latitude within both warm temperate and subtropical climatic zones. This raises the question of whether or not the study area is floristically homogeneous. The geographic ranges of distribution for each species in Table 4.1 were ascertained from floristic sources, mainly Wunderlin (1998). Mangroves and several tropical species that are commonly associated with mangroves comprised the only important group of species that were not distributed throughout the entire study area. Mangroves included *Avicennia germinans, Conocarpus erectus* (buttonwood), *Laguncularia racemosa, and Rhizophora mangle*. Tropical associates were *Acrostichum aureum* (golden leather fern), *Dalbergia ecastophyllum* (coinvine), *Ficus aurea* (strangler fig), and *Rhabdadenia biflora* (mangrovevine). These species were restricted to the three southern rivers (Peace, Myakka, Little Manatee) and to a small thicket of white mangroves that occurred along the Crystal River.

Scirpus americanus (American bulrush) was the only important temperate species of saline tidal marshes that did not extend to the southern rivers. It was recorded on the Chassahowitzka River (Table 4.1) and was common along the Suwannee River (Clewell et al. 1999). A few other species with temperate distributions appeared in Table 4.1, e.g., *Chasmanthium nitidum* and *Decumaria barbara*. All were uncommon and were essentially restricted to freshwater habitats at the upstream areas of the tidal reaches. In summary, the flora of the seven rivers is essentially homogeneous, except for mangroves and several associated species.

Table 4.3 presents the percentage of sites that each species occupied along each river. Like the species presence data in Table 4.1, these data suggest that each river has its own signature with respect to its patterns of species abundance. Some rivers show considerable similarity in both species composition and species abundance, such as the Weeki Wachee and Crystal rivers which are both small and spring-fed. Submersed species are particularly abundant in these clear-water streams, such as *Ruppia maritima* and *Sagittaria subulata*. *Spartina alterniflora* is much more important in northern rivers, where does not suffer competition from mangroves. Table 4.3 suggests that *Scirpus californicus* and *Acrostichum danaeifolium* are progressively less abundant from south to north. However, both, especially *S. californicus,* are abundant further north along the intertidal Suwannee River (Clewell et al. 1999).

4.4 Within-River Species Distributions

The patterns of species presence and species dominance are more clearly seen from quadrat data. Appendix F presents percent cover values for every species by river in terms of means, medians, minima, and maxima. Twelve more abundant species were selected and are graphically portrayed for each river from quadrat data in Figures 4.20 through 4.26. These figures revealed considerable diversity across the seven rivers, and no two rivers were closely similar. However, certain patterns in species presence and abundance were apparent. *Rhizophora mangle* occupied terrain that was nearest the Gulf, relative to the other species (Figs 4.20-4.23). Sampling began upstream near the interior edge of mangrove swamps along the southern three rivers. This point occurred at river mile 8 along the Peace River (Fig. 4.20) and much nearer the Gulf at

river miles 3 and 2.5 along the Myakka (Fig. 4.21) and Little Manatee rivers (Fig. 4.22). This discrepancy in distance reflected a narrowing of the mangrove zone with increasing proximity to the northern limit of mangroves. *Spartina alterniflora* was much more abundant along the northern four rivers than along the southern three rivers where its habitat was largely pre-empted by *Rhizophora mangle* and other mangroves.

All seven figures (Figs. 4.20-4.27) revealed the importance of *Juncus roemerianus* in terms of distribution and cover, especially in the outer marsh areas nearest the Gulf. Figures 4.23-4.26 showed the importance of *Cladium jamaicense* in the northern four rivers and its lesser importance in the southern three rivers, particularly the Myakka and Little Manatee rivers (Figs. 4.21-4.22). Figure 4.20-4.26 showed how *Cladium jamaicense* overlapped considerably with *Juncus roemerianus* and how it increased in cover and eventually replaced *Juncus roemerianus* inland.

The aforementioned importance of *Acrostichum danaeifolium* along the three southern rivers was apparent, particularly on the Peace River (Fig. 4.20). The figures showed a corresponding importance of *Scirpus californicus* (Fig. 4.18) along the three southern rivers; however, its near-absence along the four northern rivers may have reflected its unpredictable distribution as an opportunistic species that colonizes tidal wrack. It was common along the more saline riverbanks of the Suwannee River (Clewell et al. 1999), and it occurs throughout the Gulf states (Godfrey and Wooten 1979). *Sagittaria subulata* grows on riverbanks between the elevations of high and low tide. It was more abundant along the largely spring-fed Weeki Wachee and Crystal rivers (Figs. 4.23, 4.25) than along the other rivers. Water clarity likely favored this species. The other species *(Typha domingensis* (Fig. 4.19), *Crinum americanum, Pontederia lancifolia, Polygonum hydropiperoides)* were most abundant upstream in oligohaline and freshwater habitats. *Typha domingensis,* which is another opportunistic species that follows wrack deposition, extended further downstream, although with not as much cover as it exhibited upstream.

Table 4.1 Species presence at riverbank study sites at each river.

	Peace	Myakka	Little Manatee	Weeki Wachee	Chassa-howitzka	Crystal	Withla-coochee
Acer rubrum	X				X		X
Acrostichum aureum	X	X					
Acrostichum danaeifolium	X	X	X	X	X		
Alternanthera philoxeroides	X	X	X		X		X
Amaranthus australis	X						X
Ampelopsis arborea		X			X		
Ardisia escallonoides	X						
Aster carolinianus	X	X	X		X	X	X
Aster subulatus				X			X
Aster tenuifolius					X	X	
Avicennia germinans		X	X				
Baccharis angustifolia				X		X	X
Baccharis halimifolia	X		X	X	X	X	X
Bacopa monnieri	X	X					
Bidens laevis						X	
Blechnum serrulatum	X		X				
Blutaparon vermiculare		X					
Boehmeria cylindrica					X		
Borrichia frutescens		X					
Carex lupulina		X					
Carya aquatica					X		X
Cephalanthus occidentalis	X	X					X
Chasmanthium nitidum							X
Cicuta maculata	X	X			X		X
Cladium jamaicense	X	X	X	X	X	X	X
Colocasia esculenta	X						X
Conocarpus erectus	X	X					
Cornus foemina					X		X
Crinum americanum	X	X	X	X	X		X
Crotalaria incana			X				
Cyperus distinctus							X
Dalbergia ecastophyllum	X		X				
Decumaria barbara							X
Diodia virginiana		X					
Distichlis spicata	X	X		X	X	X	X
Echinochloa muricata							X
Eclipta prostrata			X				
Eleocharis fallax							X
Eleocharis flavescens		X					
Ficus aurea	X	X					
Fraxinus caroliniana						X	X
Gratiola virginiana		X					
Hydrocotyle umbellata		X					
Hypericum mutilum		X					
Ilex cassine				X	X		X
Iris hexagona		X			X		
Isoetes flaccida		X					X

Table 4.1 continued

	Peace	Myakka	Little Manatee	Weeki Wachee	Chassa-howitzka	Crystal	Withla-coochee
Itea virginica					X		X
Iva frutescens		X				X	X
Juncus effusus							X
Juncus megacephalus		X					
Juncus roemerianus	X	X	X	X	X	X	X
Juniperus virginiana							X
Laguncularia racemosa	X	X	X			X	
Limonium carolinianum			X				
Lobelia cardinalis						X	X
Lobelia feayana		X					
Ludwigia repens	X	X					X
Lycium carolinianum					X		
Lythrum alatum		X	X		X		
Magnolia virginiana				X	X	X	X
Mikania scandens	X	X					X
Myrica cerifera	X		X		X	X	X
Nuphar luteum	X						
Ophioglossum petiolatum							X
Osmunda regalis			X				
Panicum anceps							X
Panicum rigidulum		X					
Parthenocissus quinquefolia			X				
Paspalidium geminatum					X		
Paspalum vaginatum			X				
Persea palustris	X			X	X		X
Phragmites australis	X		X		X		X
Phyla nodiflora		X					
Pluchea odorata	X	X	X		X		X
Polygonum hydropiperoides	X	X				X	X
Pontederia cordata	X	X	X		X	X	X
Quercus geminata					X		
Quercus virginiana							X
Rhabdadenia biflora	X						
Rhizophora mangle	X	X	X				
Rhynchospora colorata		X					
Rumex verticillatus	X	X	X		X		X
Ruppia maritima			X	X		X	X
Sabal palmetto	X	X	X	X	X	X	X
Sabatia calycina		X					
Sagittaria lancifolia	X	X		X	X	X	X
Sagittaria subulata	X	X		X	X	X	X
Salix caroliniana	X	X					X
Sambucus canadensis	X						
Samolus valerandi	X	X			X		
Saururus cernuus					X		X
Schinus terebinthifolius	X	X	X				
Scirpus americanus					X		
Scirpus californicus	X	X		X			

Table 4.1 continued

	Peace	Myakka	Little Manatee	Weeki Wachee	Chassa-howitzka	Crystal	Withla-coochee
Scirpus robustus					X		
Scirpus tabernaemontani		X	X				
Senecio glabellus	X	X			X		
Sesuvium portulacastrum	X	X					
Smilax bona-nox							X
Smilax laurifolia							X
Smilax walteri							X
Solidago sempervirens	X						
Solidago stricta	X	X			X		X
Spartina alterniflora		X		X	X	X	X
Spartina bakeri	X	X					
Spartina patens		X					
Stenotaphrum secundatum	X						X
Taxodium distichum	X						X
Teucrium canadense	X	X					
Tilia Americana					X		
Triglochin striata	X						
Typha domingensis	X	X	X	X	X	X	X
Ulmus Americana					X		
Urochloa mutica		X	X				
Vallisneria Americana				X		X	X
Viburnum obovatum							X
Vitis rotundifolia			X				
Zizania aquatica	X						X
TOTAL NUMBER OF SPECIES RECORDED	**52**	**58**	**31**	**19**	**42**	**23**	**59**
NUMBER OF SITES SAMPLED	**60**	**73**	**72**	**41**	**84**	**67**	**67**

Table 4.2 Number of sites and number of quadrats in which each species occurred for all seven rivers combined.

	Sites	Quadrats
Juncus roemerianus	242	224
Cladium jamaicense	132	122
Spartina alterniflora	108	98
Typha domingensis	118	96
Rhizophora mangle	75	50
Sagittaria subulata	68	44
Sagittaria lancifolia	43	33
Scirpus californicus	35	28
Crinum americanum	37	24
Ruppia maritima	45	20
Acrostichum danaeifolium	53	19
Pontederia cordata	29	19
Polygonum hydropiperoides	28	19
Alternanthera philoxeroides	22	14
Scirpus tabernaemontani	15	14
Fraxinus caroliniana	18	12
Laguncularia racemosa	33	11
Eleocharis flavescens	16	11
Urochloa mutica	15	10
Rumex verticillatus	21	9
Samolus valerandi	19	9
Distichlis spicata	15	9
Mikania scandens	15	9
Aster carolinianus	21	8
Eleocharis fallax	11	8
Colocasia esculenta	10	8
Saururus cernuus	10	8
Ludwigia repens	10	7
Magnolia virginiana	21	6
Senecio glabellus	17	6
Pluchea odorata	13	6
Phragmites australis	10	6
Lobelia cardinalis	9	6
Gratiola virginiana	8	5
Avicennia germinans	16	4
Cicuta maculata	15	4
Bacopa monnieri	12	4
Scirpus americanus	4	4
Chasmanthium nitidum	3	3
Isoetes flaccida	3	3
Solidago stricta	17	2
Sabal palmetto	13	2
Iva frutescens	12	2
Lythrum alatum	9	2
Spartina bakeri	9	2
Cephalanthus occidentalis	8	2
Amaranthus australis	6	2
Blechnum serrulatum	6	2
Conocarpus erectus	6	2

Table 4.2 continued

	Sites	Quadrats
Cornus foemina	6	2
Acrostichum aureum	5	2
Iris hexagona	5	2
Itea virginica	5	2
Panicum anceps	5	2
Diodia virginiana	3	2
Hydrocotyle umbellata	3	2
Sambucus canadensis	3	2
Aster subulatus	2	2
Juncus effusus	2	2
Paspalidium geminatum	2	2
Scirpus robustus	2	2
Stenotaphrum secundatum	2	2
Myrica cerifera	22	1
Taxodium distichum	7	1
Panicum rigidulum	5	1
Zizania aquatica	5	1
Aster tenuifolius	3	1
Baccharis angustifolia	3	1
Borrichia frutescens	3	1
Nuphar luteum	3	1
Sesuvium portulacastrum	3	1
Ampelopsis arborea	2	1
Echinochloa muricata	2	1
Osmunda regalis	2	1
Smilax walteri	2	1
Spartina patens	2	1
Triglochin striata	2	1
Juncus megacephalus	1	1
Phyla nodiflora	1	1
Smilax bona-nox	1	1
Baccharis halimifolia	18	0
Persea palustris	17	0
Ficus aurea	10	0
Vallisneria americana	9	0
Acer rubrum	8	0
Schinus terebinthifolius	7	0
Dalbergia ecastophyllum	6	0
Ilex cassine	6	0
Salix carolinlana	6	0
Lobelia feayana	3	0
Lycium carolinianum	3	0
Carya aquatica	2	0
Crotalaria incana	2	0
Decumaria barbara	2	0
Rhabdadenia biflora	2	0
Teucrium canadense	2	0
Ardisia escallonoides	1	0
Bidens laevis	1	0
Blutaparon vermiculare	1	0
Boehmeria cylindrica	1	0

Table 4.2 concluded

	Sites	Quadrats
Carex lupulina	1	0
Cyperus distinctus	1	0
Eclipta prostrate	1	0
Hypericum mutilum	1	0
Juniperus virginiana	1	0
Limonium carolinianum	1	0
Ophioglossum petiolatum	1	0
Parthenocissus quinquefolia	1	0
Paspalum vaginatum	1	0
Quercus geminata	1	0
Quercus virginiana	1	0
Rhynchospora colorata	1	0
Sabatia calycina	1	0
Smilax laurifolia	1	0
Solidago sempervirens	1	0
Tilia caroliniana	1	0
Ulmus americanus	1	0
Viburnum obovatum	1	0
Vitis rotundifolia	1	0

Table 4.3 Percentage of sites along each river at which each species occurred.

	Southern Rivers			*Northern Rivers*			
	Peace	Myakka	Little Manatee	Weeki Wachee	Chassa-howitzka	Crystal	Withla-coochee
Juncus roemerianus	36	52	65	67	48	57	45
Cladium jamaicense	19	3	7	37	74	22	36
Typha domingensis	14	16	17	30	36	35	30
Spartina alterniflora	0	11	0	49	5	71	39
Rhizophora mangle	36	28	48	0	0	0	0
Sagittaria subulata	2	12	0	14	11	35	28
Acrostichum danaeifolium	32	13	14	9	13	0	0
Ruppia maritime	0	0	1	53	0	19	9
Sagittaria lancifolia	19	9	0	7	14	7	9
Crinum americanum	7	12	10	2	15	0	6
Scirpus californicus	25	25	0	2	0	0	0
Laguncularia racemosa	8	23	14	0	0	1	0
Pontederia cordata	15	15	6	0	1	3	3
Polygonum hydropiperoides	12	21	0	0	0	1	6
Myrica cerifera	7	0	6	0	11	3	4
Alternanthera philoxeroides	7	3	12	0	5	0	4
Magnolia virginiana	0	0	0	14	6	1	13
Rumex verticillatus	5	11	4	0	8	0	1
Aster carolinianus	12	1	1	0	9	3	3
Samolus valerandi	14	8	0	0	6	0	0
Baccharis halimifolia	3	0	4	2	11	3	1
Fraxinus caroliniana	0	0	0	0	0	1	25
Persea palustris	8	0	0	2	8	0	7
Senecio glabellus	10	5	0	0	9	0	0
Solidago stricta	2	1	0	0	6	0	15
Avicennia germinans	0	9	13	0	0	0	0
Eleocharis flavescens	0	21	0	0	0	0	0
Cicuta maculata	15	3	0	0	4	0	1
Mikania scandens	3	16	0	0	0	0	1
Scirpus tabernaemontani	0	17	3	0	0	0	0
Urochloa mutica	0	11	10	0	0	0	0
Distichlis spicata	3	3	0	5	6	3	1
Pluchea odorata	7	8	1	0	1	0	1
Sabal palmetto	5	1	1	5	4	1	3
Bacopa monnieri	15	4	0	0	0	0	0
Iva frutescens	0	9	0	0	0	4	3
Eleocharis fallax	0	0	0	0	0	0	15
Ficus aurea	12	4	0	0	0	0	0
Ludwigia repens	3	7	0	0	0	0	4
Saururus cernuus	0	0	0	0	4	0	10
Colocasia esculenta	12	0	0	0	0	0	3
Lythrum alatum	0	4	3	0	5	0	0
Phragmites australis	2	0	4	0	1	0	6
Spartina bakeri	5	8	0	0	0	0	0
Vallisneria Americana	0	0	0	7	0	6	3
Acer rubrum	2	0	0	0	3	0	7
Cephalanthus occidentalis	2	3	0	0	0	0	7
Gratiola virginiana	0	11	0	0	0	0	0

Table 4.3 continued

	Peace	Myakka	Little Manatee	Weeki Wachee	Chassa-howitzka	Crystal	Withla-coochee
Lobelia cardinalis	0	0	0	0	0	1	10
Schinus terebinthifolius	3	4	3	0	0	0	0
Taxodium distichum	2	0	0	0	0	0	9
Blechnum serrulatum	5	0	4	0	0	0	0
Conocarpus erectus	3	5	0	0	0	0	0
Cornus foemina	0	0	0	0	3	0	6
Dalbergia ecastophyllum	2	0	7	0	0	0	0
Ilex cassine	0	0	0	2	1	0	6
Salix caroliniana	2	3	0	0	0	0	4
Acrostichum aureum	3	4	0	0	0	0	0
Amaranthus australis	3	0	0	0	0	0	4
Iris hexagona	0	4	0	0	3	0	0
Itea virginica	0	0	0	0	3	0	4
Panicum anceps	0	0	0	0	0	0	7
Panicum rigidulum	0	7	0	0	0	0	0
Zizania aquatica	3	0	0	0	0	0	4
Scirpus americanus	0	0	0	0	5	0	0
Aster tenuifolius	0	0	0	0	1	3	0
Baccharis angustifolia	0	0	0	2	0	1	1
Borrichia frutescens	0	4	0	0	0	0	0
Chasmanthium nitidum	0	0	0	0	0	0	4
Diodia virginiana	0	4	0	0	0	0	0
Hydrocotyle umbellata	0	4	0	0	0	0	0
Isoetes flaccida	0	1	0	0	0	0	3
Lobelia feayana	0	4	0	0	0	0	0
Lycium carolinianum	0	0	0	0	4	0	0
Nuphar luteum	5	0	0	0	0	0	0
Sambucus canadensis	5	0	0	0	0	0	0
Sesuvium portulacastrum	2	3	0	0	0	0	0
Ampelopsis arborea	0	1	0	0	1	0	0
Aster subulatus	0	0	0	2	0	0	1
Carya aquatica	0	0	0	0	1	0	1
Crotalaria incana	0	0	3	0	0	0	0
Decumaria barbara	0	0	0	0	0	0	3
Echinochloa muricata	0	0	0	0	0	0	3
Juncus effusus	2	0	0	0	0	0	1
Osmunda regalis	0	0	3	0	0	0	0
Paspalidium geminatum	0	0	0	0	3	0	0
Rhabdadenia biflora	3	0	0	0	0	0	0
Scirpus robustus	0	0	0	0	3	0	0
Smilax walteri	0	0	0	0	0	0	3
Spartina patens	0	3	0	0	0	0	0
Stenotaphrum secundatum	2	0	0	0	0	0	1
Teucrium canadense	2	1	0	0	0	0	0
Triglochin striata	3	0	0	0	0	0	0
Ardisia escallonoides	2	0	0	0	0	0	0
Bidens laevis	0	0	0	0	0	1	0
Blutaparon vermiculare	0	1	0	0	0	0	0

Table 4.3 concluded

	Peace	Myakka	Little Manatee	Weeki Wachee	Chassa-howitzka	Crystal	Withla-coochee
Boehmeria cylindrica	0	0	0	0	1	0	0
Carex lupulina	0	1	0	0	0	0	0
Cyperus distinctus	0	0	0	0	0	0	1
Eclipta prostrate	0	0	1	0	0	0	0
Hypericum mutilum	0	1	0	0	0	0	0
Juncus megacephalus	0	1	0	0	0	0	0
Juniperus virginiana	0	0	0	0	0	0	1
Limonium carolinianum	0	0	1	0	0	0	0
Ophioglossum petiolatum	0	0	0	0	0	0	1
Parthenocissus quinquefolia	0	0	1	0	0	0	0
Paspalum vaginatum	0	0	1	0	0	0	0
Phyla nodiflora	0	1	0	0	0	0	0
Quercus geminata	0	0	0	0	1	0	0
Quercus virginiana	0	0	0	0	0	0	1
Rhynchospora colorata	0	1	0	0	0	0	0
Sabatia calycina	0	1	0	0	0	0	0
Smilax bona-nox	0	0	0	0	0	0	1
Smilax laurifolia	0	0	0	0	0	0	1
Solidago sempervirens	2	0	0	0	0	0	0
Tilia caroliniana	0	0	0	0	1	0	0
Ulmus americanus	0	0	0	0	1	0	0
Viburnum obovatum	0	0	0	0	0	0	1
Vitis rotundifolia	0	0	1	0	0	0	0

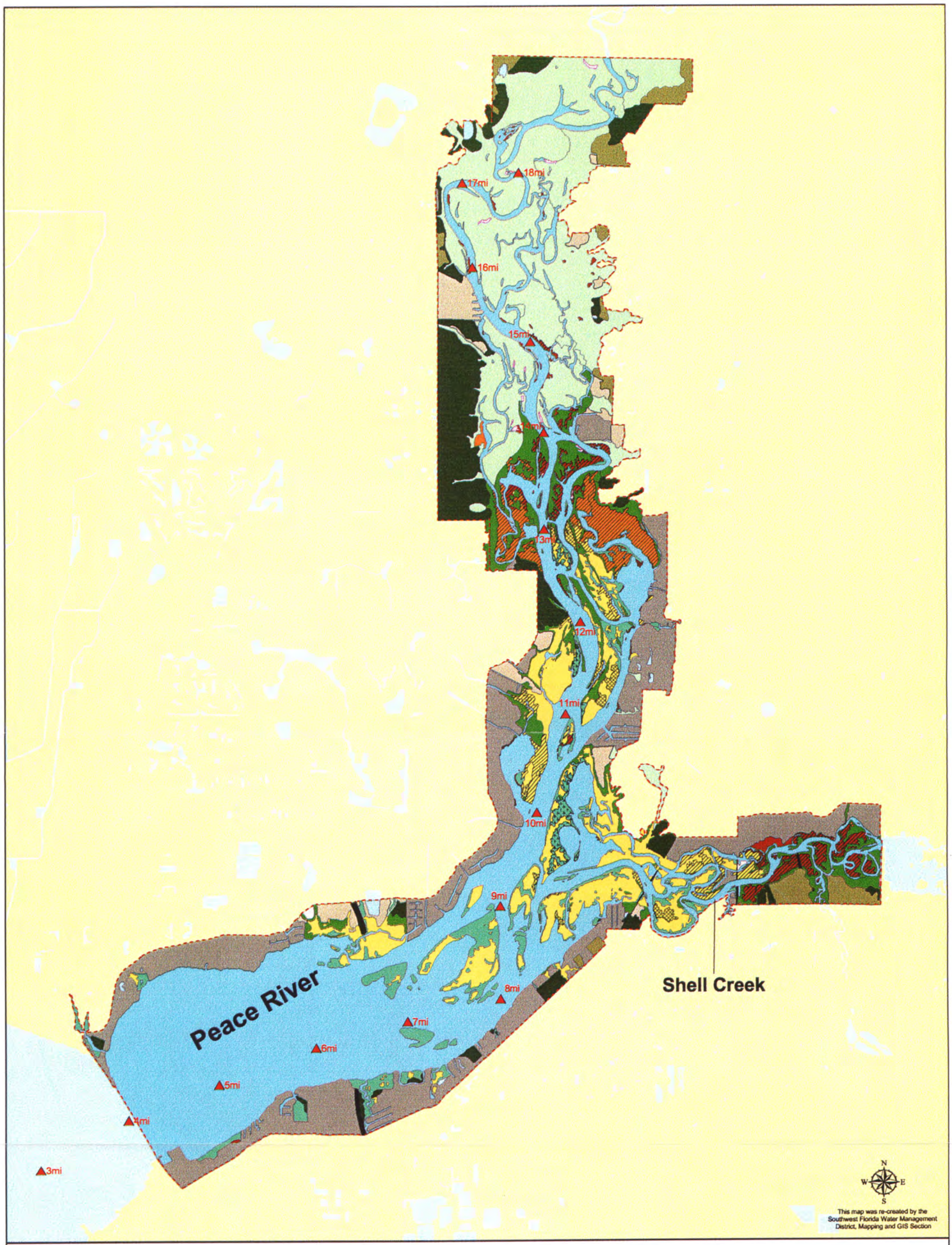


Figure 4.1 Peace River



Figure 4.2 Myakka River

- Land (outside of area mapped)
- Urban
- Agriculture
- Rangeland
- Upland Forest
- Coniferious Forest - Pines
- Pinus spp.
- Planted Pine
- Hardwood Forest
- Dead Forest
- Water (outside of area mapped)
- Streams and Rivers
- Ponds < 10 acres
- Embayments/Open to Gulf
- Mangroves
- Bottomland Hardwoods
- Sabal Palmetto
- Wetland Coniferious Forest
- Southern Red Cedar
- Cypress
- Coastal Hammock
- Wetland Marsh
- Freshwater Marsh
- Cladium
- Typha
- Echinochloa
- Saltwater Marsh
- Spartina sp.
- Juncus sp
- Sporobolus sp
- Acrostichum
- Amaranthus
- Wet Prairie
- Water Hyacinth
- Tidal Flats
- Beaches
- Oyster Bars
- Barren Land
- Utility

MODIFIERS

- Cladium
- Typha
- Juncus sp
- Sporobolus sp
- Acrostichum
- Scrub

▲ Distance Up River (miles)

The Landuse/Landcover data depicted in the map were created in 1997 using data from 1990. It was created by the Florida Marine Research Institute under contract to the Southwest Florida Water Management District (SWFWMD).

Kilometers

0 0.75 1.5

Miles

0 0.75 1.5



This map was re-created by the Southwest Florida Water Management District, Mapping and GIS Section

Figure 4.3 Little Manatee River

- Land (outside of area mapped)
- Urban
- Agriculture
- Rangeland
- Upland Forest
- Coniferious Forest - Pines
- Pinus spp.
- Planted Pine
- Hardwood Forest
- Dead Forest
- Water (outside of area mapped)
- Streams and Rivers
- Ponds < 10 acres
- Embayments/Open to Gulf
- Mangroves
- Bottomland Hardwoods
- Sabal Palmetto
- Wetland Coniferious Forest
- Southern Red Cedar
- Cypress
- Coastal Hammock
- Wetland Marsh
- Freshwater Marsh
- Cladium
- Typha
- Echinochloa
- Saltwater Marsh
- Spartina sp.
- Juncus sp
- Sporobolus sp
- Acrostichum
- Amaranthus
- Wet Prairie
- Water Hyacinth
- Tidal Flats
- Beaches
- Oyster Bars
- Barren Land
- Utility

MODIFIERS

- Cladium
- Typha
- Juncus sp
- Sporobolus sp
- Acrostichum
- Scrub

▲ Distance Up River (miles)

The Landuse/Landcover data depicted in the map were created in 1997 using data from 1990. It was created by the Florida Marine Research Institute under contract to the Southwest Florida Water Management District (SWFWMD).

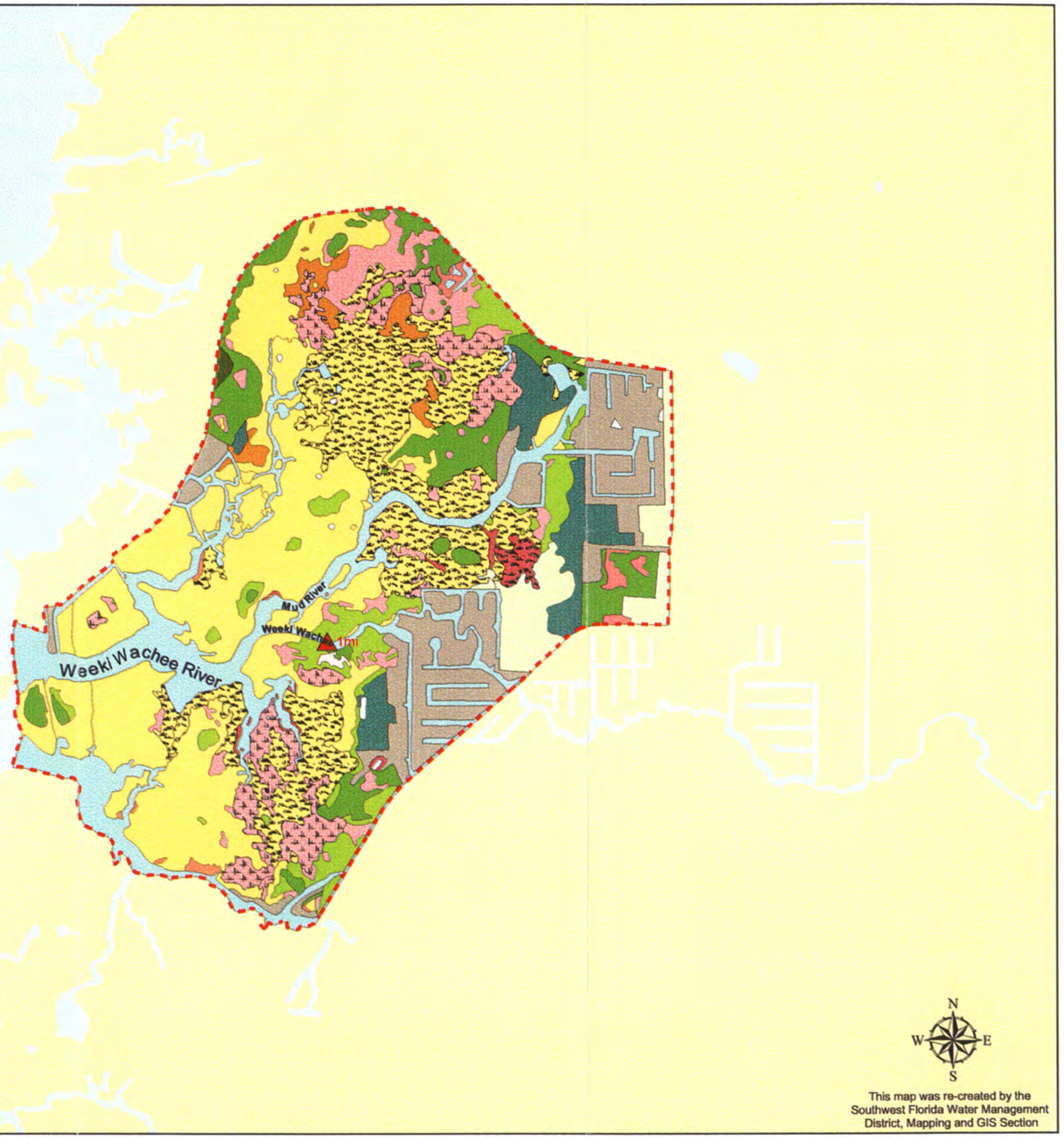
Kilometers

0 0.5 1

Miles

0 0.5 1

Figure 4.4 Weeki Wachee River



This map was re-created by the Southwest Florida Water Management District, Mapping and GIS Section

- Land (outside of area mapped)
- Urban
- Agriculture
- Rangeland
- Upland Forest
- Coniferious Forest - Pines
- Pinus spp.
- Planted Pine
- Hardwood Forest
- Dead Forest
- Water (outside of area mapped)
- Streams and Rivers
- Ponds < 10 acres
- Embayments/Open to Gulf
- Mangroves
- Bottomland Hardwoods
- Sabal Palmetto
- Wetland Coniferious Forest
- Southern Red Cedar
- Cypress
- Coastal Hammock
- Wetland Marsh
- Freshwater Marsh
- Cladium
- Typha
- Echinochloa
- Saltwater Marsh
- Spartina sp.
- Juncus sp
- Sporobolus sp
- Acrostichum
- Amaranthus
- Wet Prairie
- Water Hyacinth
- Tidal Flats
- Beaches
- Oyster Bars
- Barren Land
- Utility

MODIFIERS

- Cladium
- Typha
- Juncus sp
- Sporobolus sp
- Acrostichum
- Scrub

▲ Distance Up River (miles)

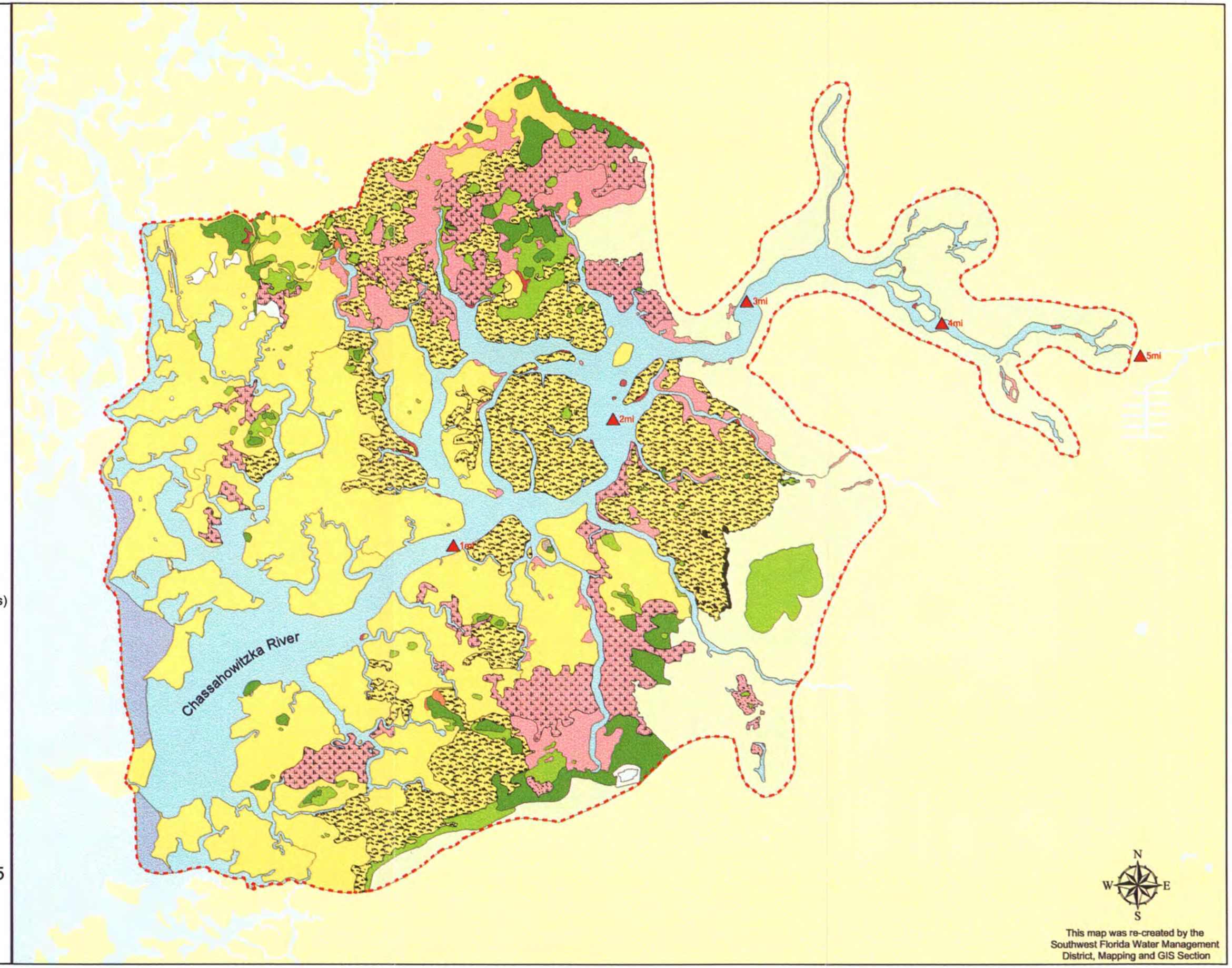
The Landuse/Landcover data depicted in the map were created in 1997 using data from 1990. It was created by the Florida Marine Research Institute under contract to the Southwest Florida Water Management District (SWFWMD).

Kilometers

0 0.75 1.5

Miles

0 0.75 1.5



N
W E
S

This map was re-created by the Southwest Florida Water Management District, Mapping and GIS Section

Figure 4.5 Chassahowitzka River

- Land (outside of area mapped)
- Urban
- Agriculture
- Rangeland
- Upland Forest
- Coniferious Forest - Pines
- Pinus spp.
- Planted Pine
- Hardwood Forest
- Dead Forest
- Water (outside of area mapped)
- Streams and Rivers
- Ponds < 10 acres
- Embayments/Open to Gulf
- Mangroves
- Bottomland Hardwoods
- Sabal Palmetto
- Wetland Coniferious Forest
- Southern Red Cedar
- Cypress
- Coastal Hammock
- Wetland Marsh
- Freshwater Marsh
- Cladium
- Typha
- Echinochloa
- Saltwater Marsh
- Spartina sp.
- Juncus sp
- Sporobolus sp
- Acrostichum
- Amaranthus
- Wet Prairie
- Water Hyacinth
- Tidal Flats
- Beaches
- Oyster Bars
- Barren Land
- Utility

MODIFIERS

- Cladium
- Typha
- Juncus sp
- Sporobolus sp
- Acrostichum
- Scrub

▲ Distance Up River (miles)

The Landuse/Landcover data depicted in the map were created in 1997 using data from 1990. It was created by the Florida Marine Research Institute under contract to the Southwest Florida Water Management District (SWFWMD).

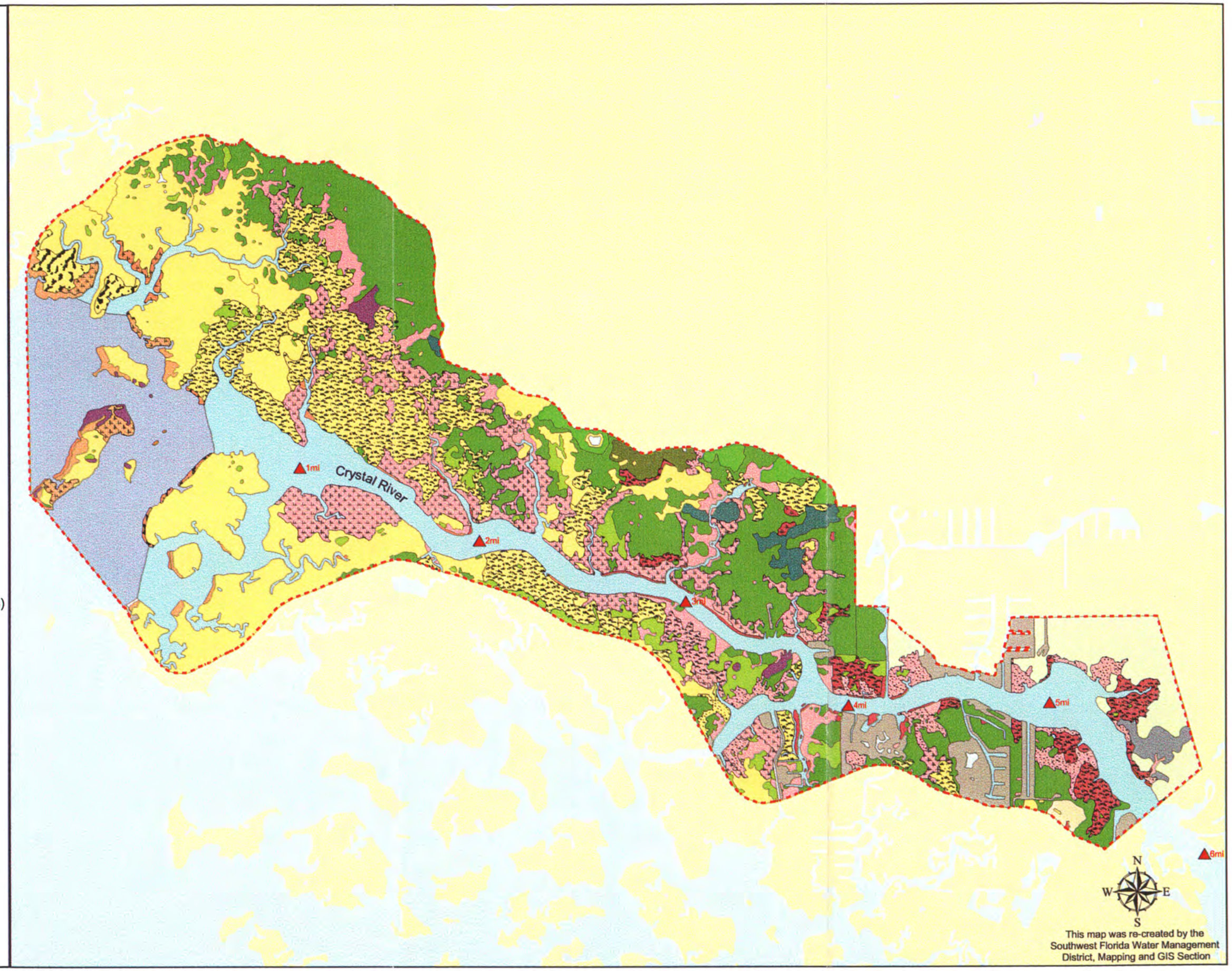
Kilometers

0 0.75 1.5

Miles

0 0.75 1.5

Figure 4.6 Crystal River



This map was re-created by the Southwest Florida Water Management District, Mapping and GIS Section

- Land (outside of area mapped)
- Urban
- Agriculture
- Rangeland
- Upland Forest
- Coniferious Forest - Pines
- Pinus spp.
- Planted Pine
- Hardwood Forest
- Dead Forest
- Water (outside of area mapped)
- Streams and Rivers
- Ponds < 10 acres
- Embayments/Open to Gulf
- Mangroves
- Bottomland Hardwoods
- Sabal Palmetto
- Wetland Coniferious Forest
- Southern Red Cedar
- Cypress
- Coastal Hammock
- Wetland Marsh
- Freshwater Marsh
- Cladium
- Typha
- Echinochloa
- Saltwater Marsh
- Spartina sp.
- Juncus sp
- Sporobolus sp
- Acrostichum
- Amaranthus
- Wet Prairie
- Water Hyacinth
- Tidal Flats
- Beaches
- Oyster Bars
- Barren Land
- Utility

MODIFIERS

- Cladium
- Typha
- Juncus sp
- Sporobolus sp
- Acrostichum
- Scrub

▲ Distance Up River (miles)

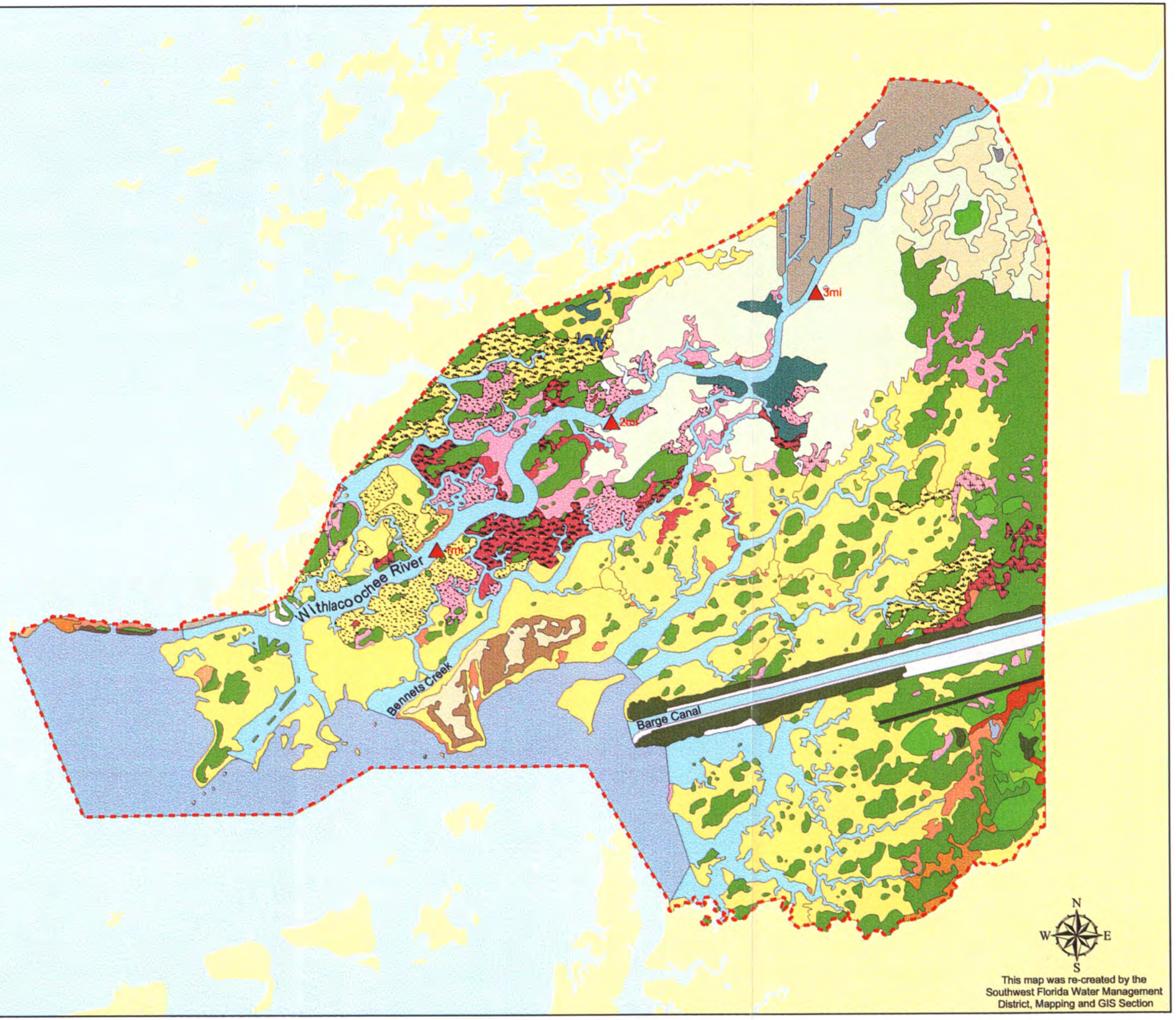
The Landuse/Landcover data depicted in the map were created in 1997 using data from 1990. It was created by the Florida Marine Research Institute under contract to the Southwest Florida Water Management District (SWFWMD).

Kilometers

0 0.5 1

Miles

0 0.5 1



This map was re-created by the Southwest Florida Water Management District, Mapping and GIS Section

Figure 4.7 Withlacoochee River

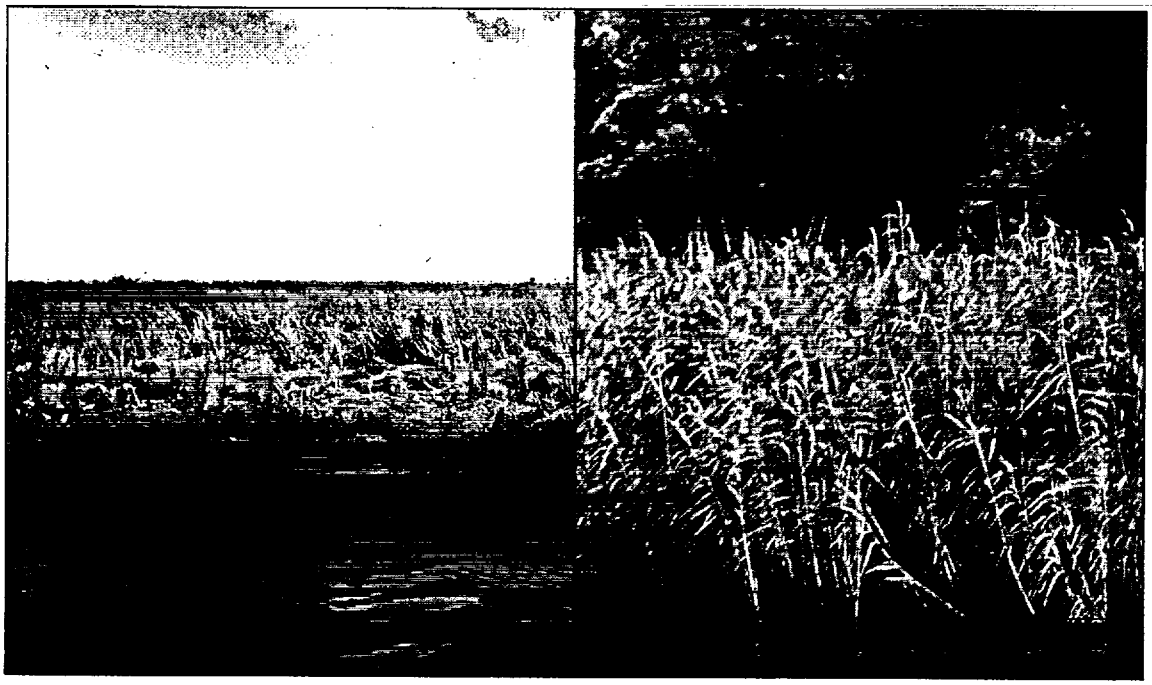


Figure 4.8. Tidal wrack on riverbank in sawgrass marsh. Chassahowitzka River, Site 37.

Figure 4.9. Reed, *Phragmites australis*. Chassahowitzka River, Site 85.

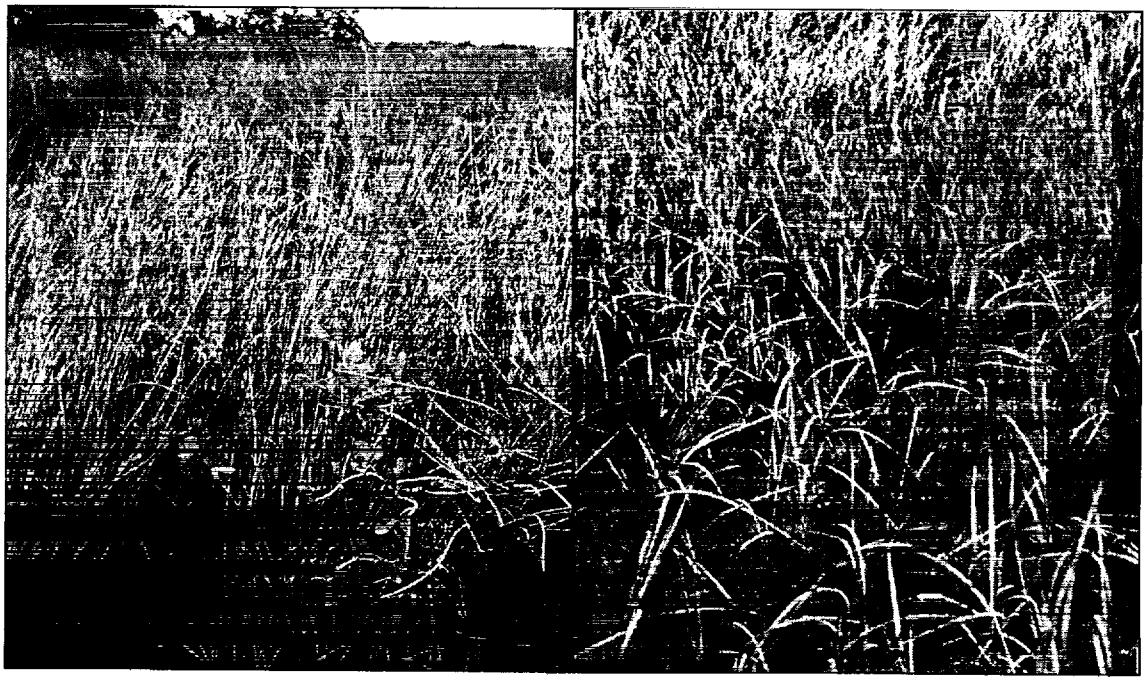


Figure 4.10. Needlerush, *Juncus roemerianus*, and small mangroves. Peace River, Site 9.

Figure 4.11. Cordgrass, *Spartina alterniflora*. Withlacoochee River, Site 46.



Figure 4.12. Red mangrove, *Rhizophora mangle*. Peace River, Site 7.

Figure 4.13. Sawgrass, *Cladium jamaicense*. Withlacoochee River, Site 46.



Figure 4.14. Freshwater swamp. Crystal River Site 73.

Figure 4.15. Transition between sawgrass marsh and cabbage palm *(Sabal palmetto)* hammock. Weeki Wachee River, Site 36.

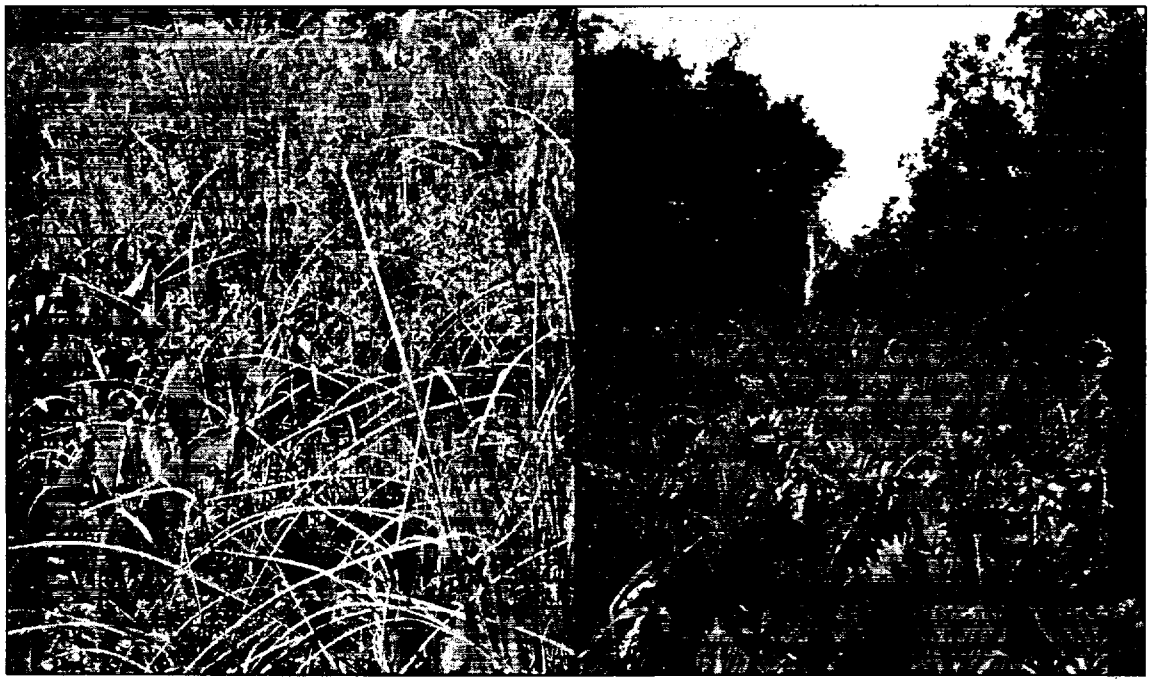


Figure 4.16. Tidal freshwater marsh. Withlacoochee River, Site 49.

Figure 4.17. Leatherfern, *Acrostichum danaeifolium,* growing on a levee. Peace River, Site 3.

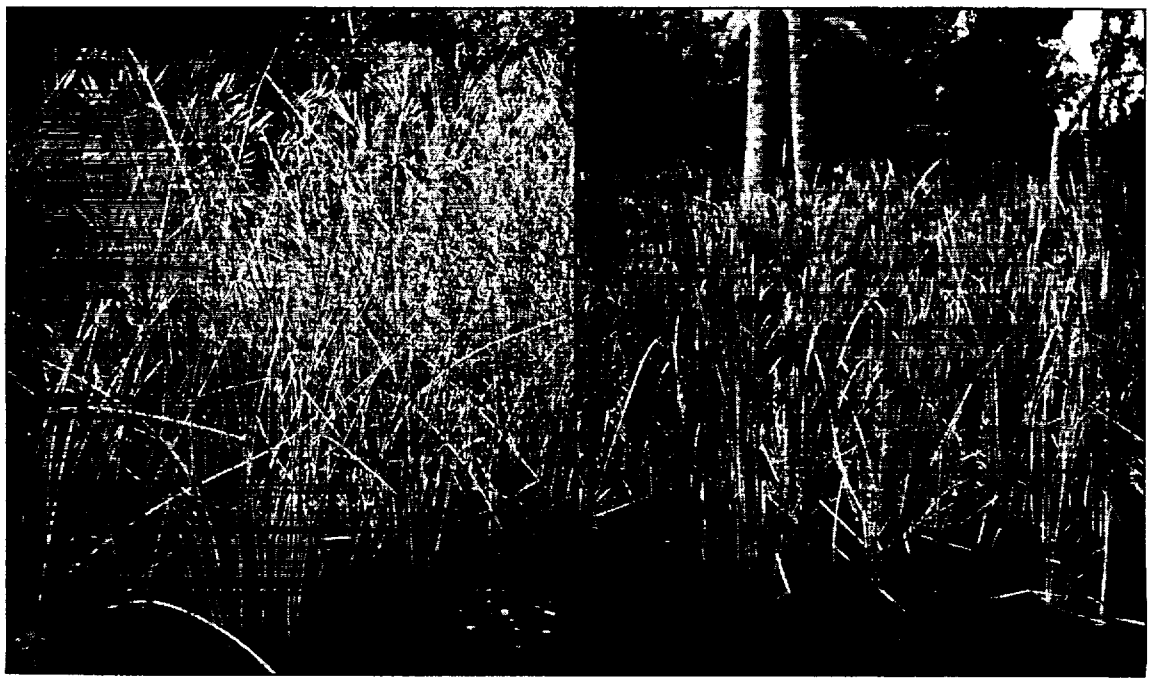


Figure 4.18. Bulrush, *Scirpus californicus.* Myakka River, Site T61.

Figure 4.19. Cattails, *Typha domingensis.* Weeki Wachee River, Site 31.

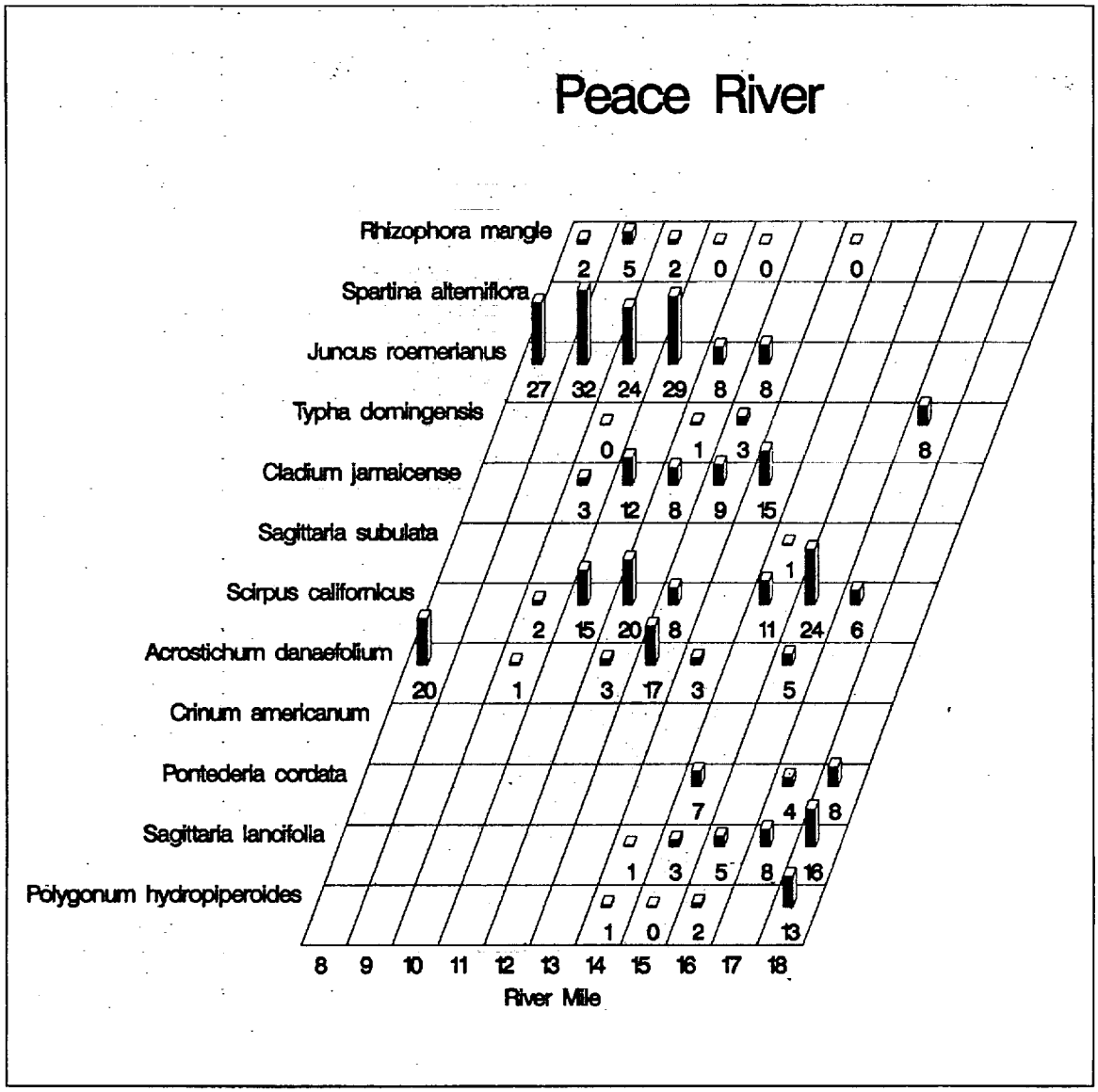


Figure 4.20. Distribution by river mile and percent cover (numerical value, height of glyph) for 12 species along the Peace River.

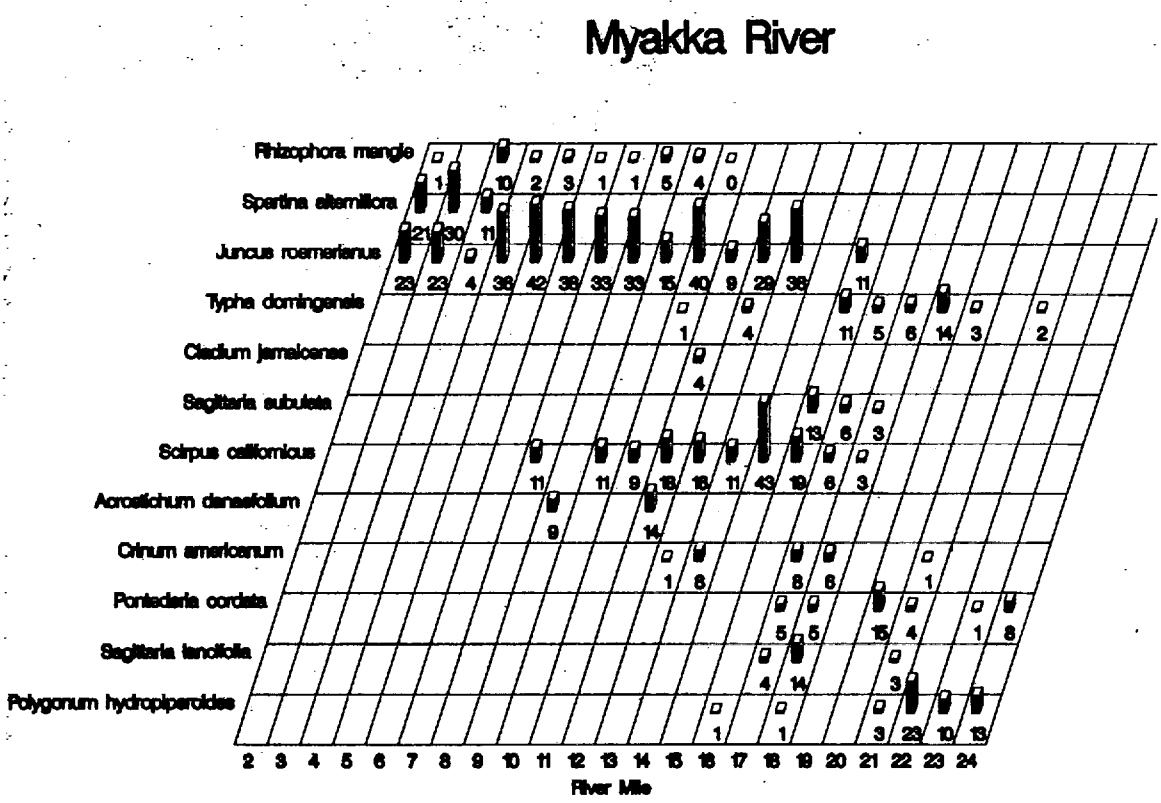


Figure 4.21. Distribution by river mile and percent cover (numerical value, height of glyph) for 12 species along the Myakka River.

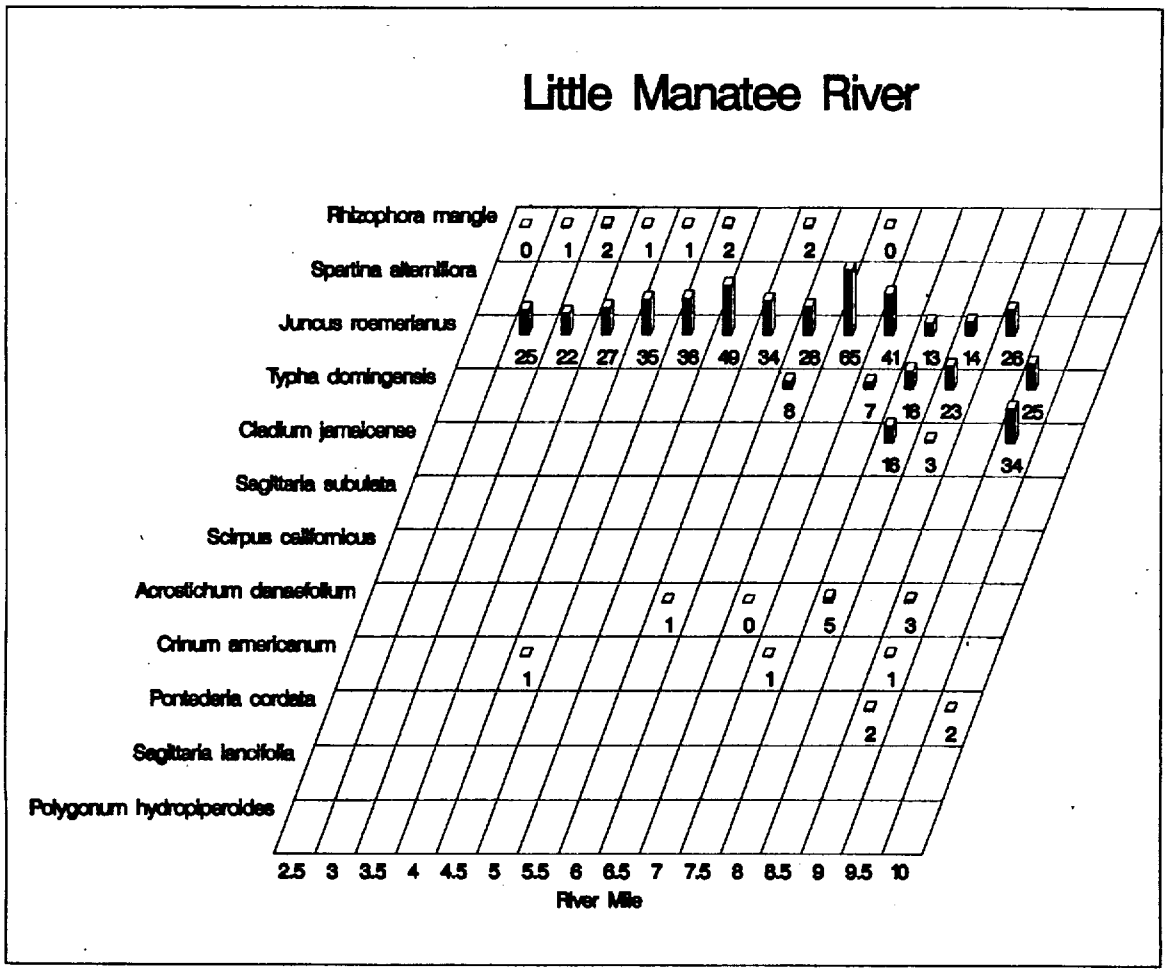


Figure 4.22. Distribution by river mile and percent cover (numerical value, height of glyph) for 12 species along the Little Manatee River.

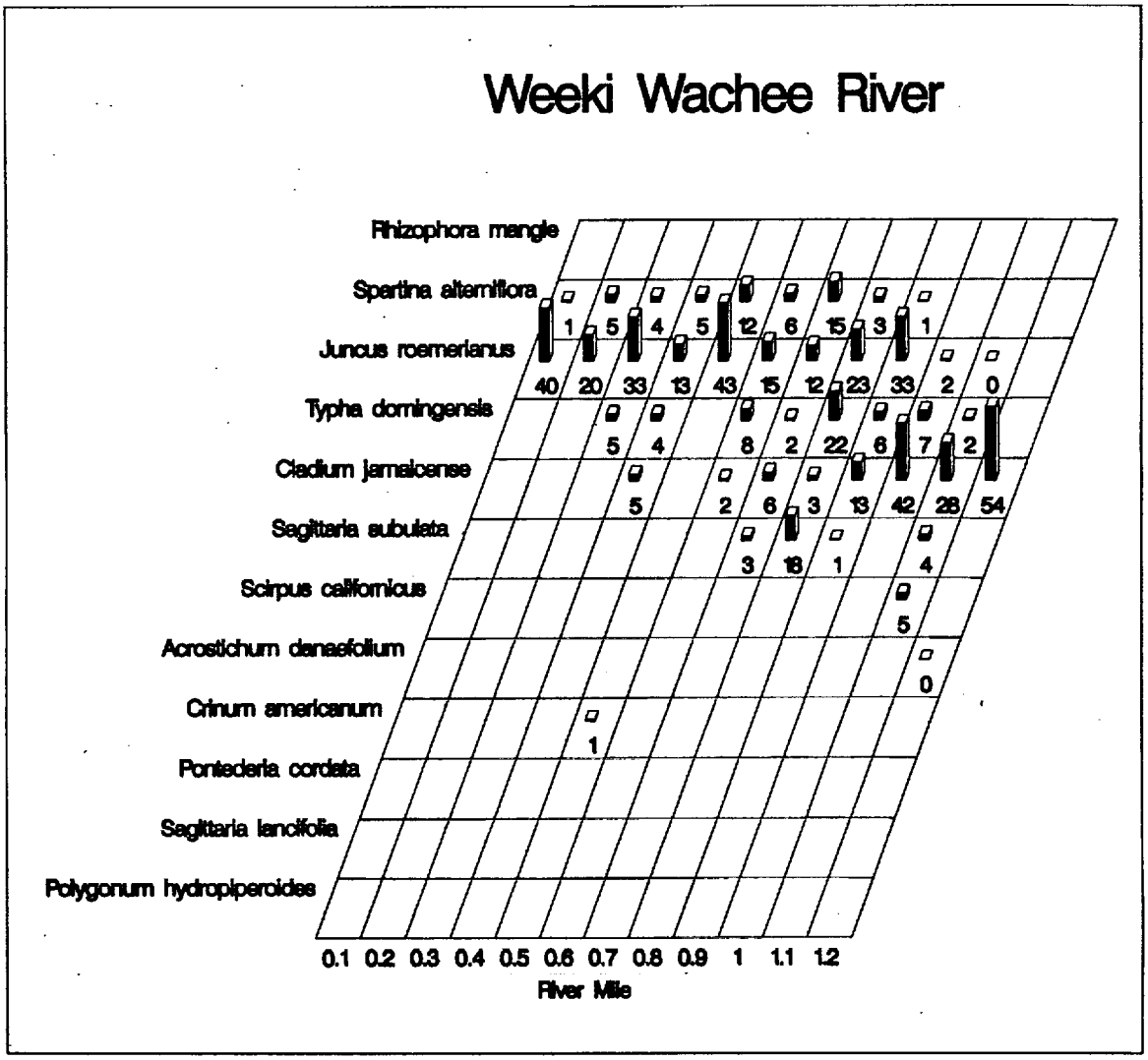


Figure 4. 23. Distribution by river mile and percent cover (numerical value, height of glyph) for 12 species along the Weeki Wachee River.

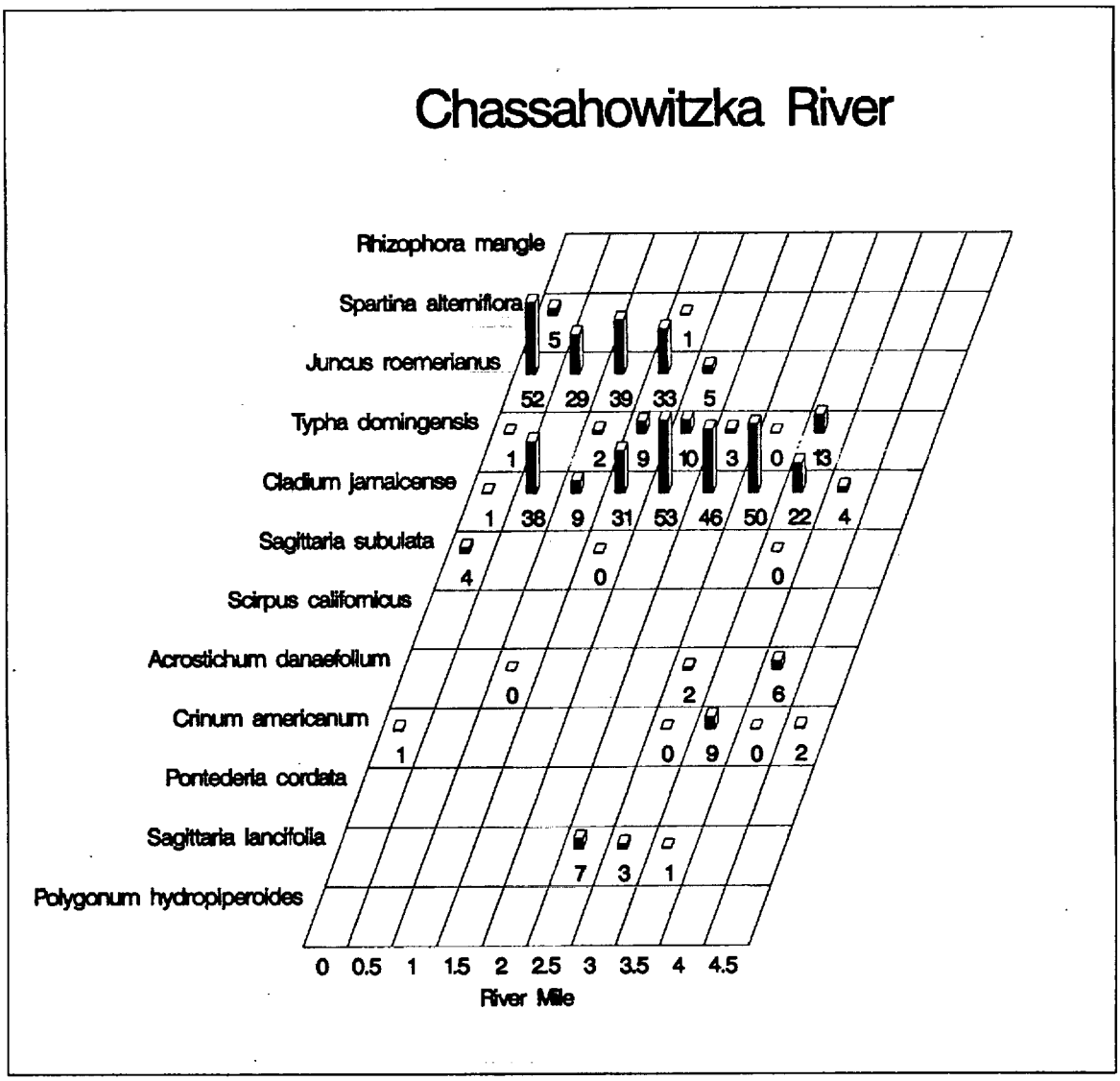


Figure 4.24. Distribution by river mile and percent cover (numerical value, height of glyph) for 12 species along the Chassahowitzka River.

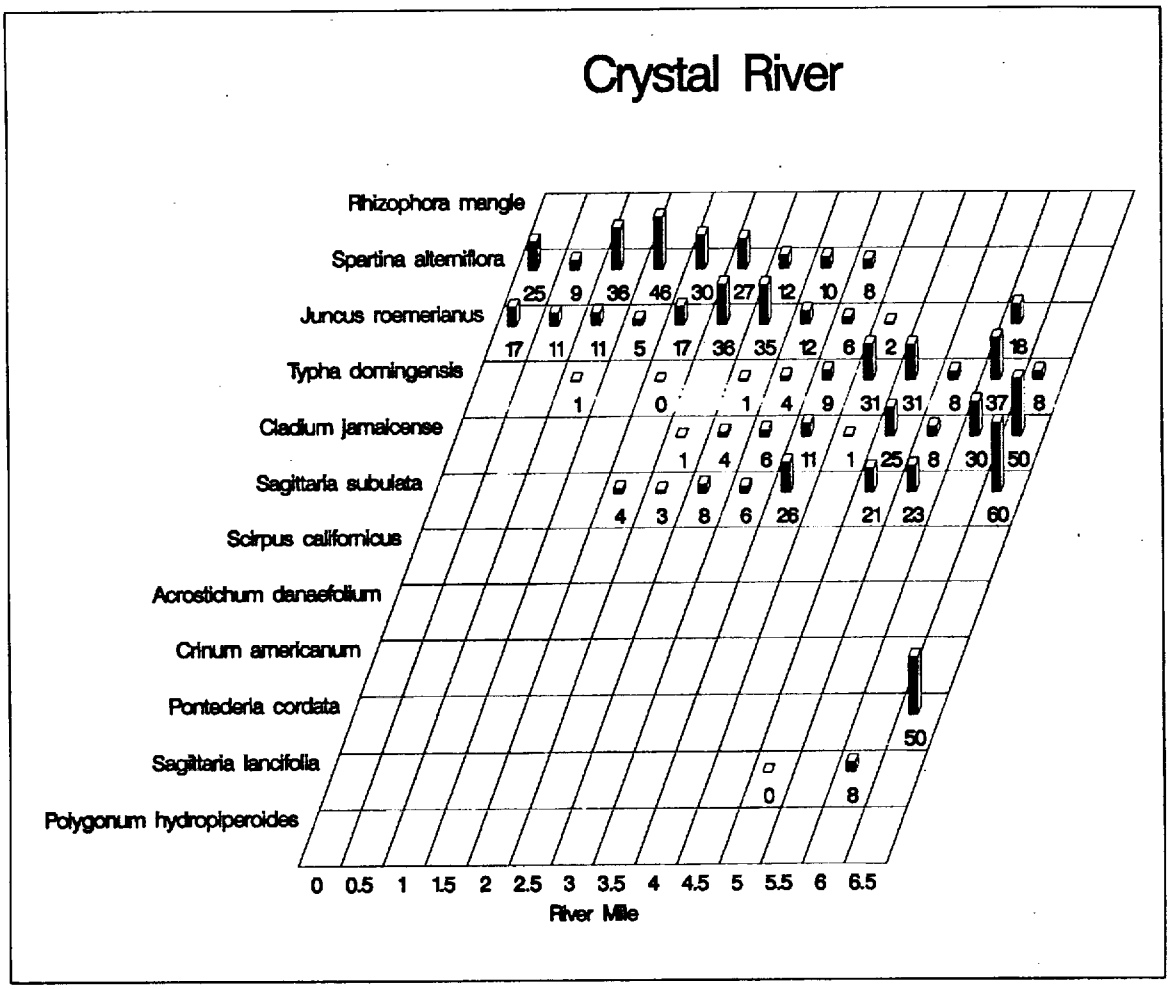


Figure 4.25. Distribution by river mile and percent cover (numerical value, height of glyph) for 12 species along the Crystal River.

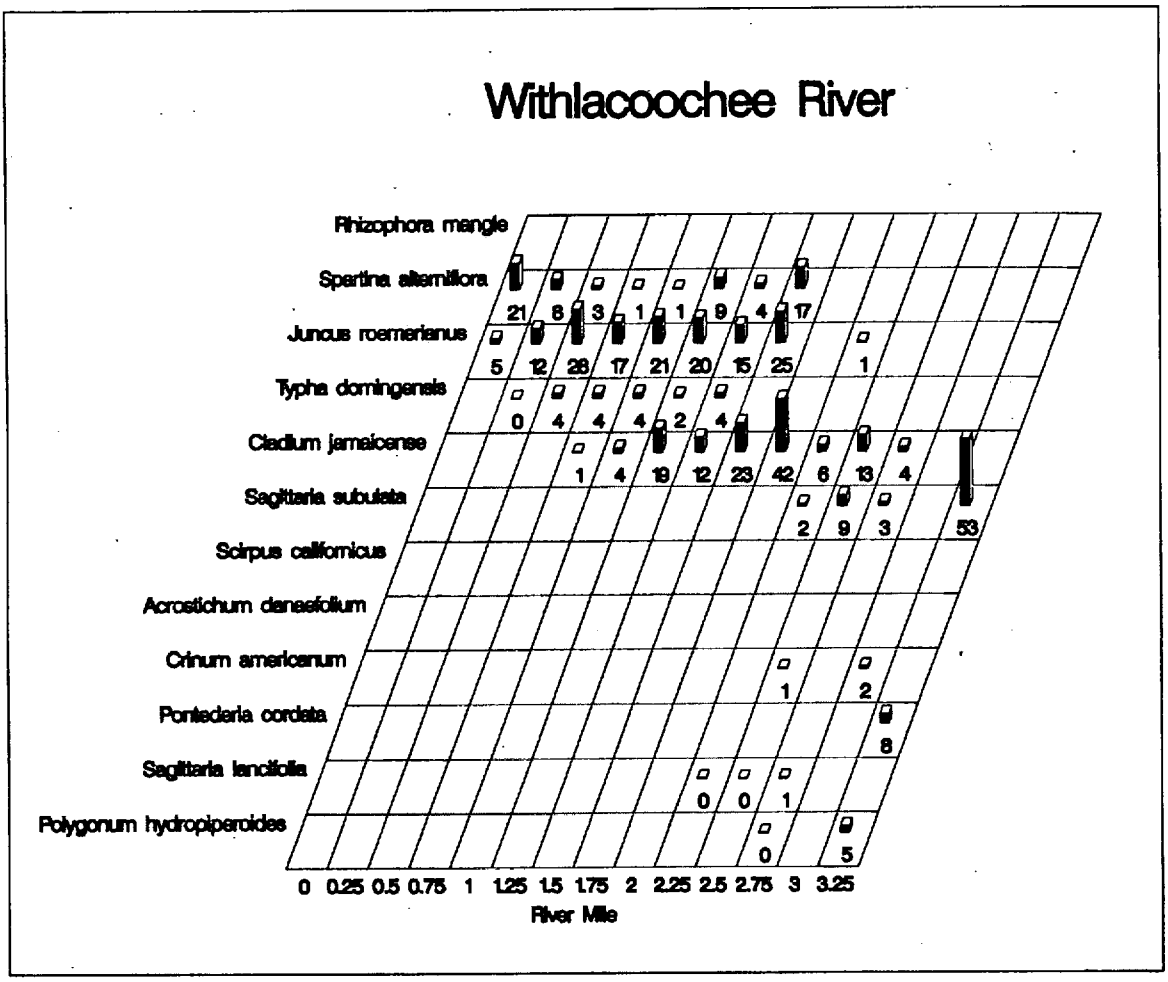


Figure 4.26. Distribution by river mile and percent cover (numerical value, height of glyph) for 12 species along the Withlacoochee River.

CHAPTER FIVE
SALINITY-VEGETATION RELATIONSHIPS

5.1 Overview

The principal intent of this chapter is to identify salinity tolerances and the normal salinity regimes of plant species that inhabit the banks of the tidal rivers. The basic assumption is that vegetation responds to salinity in terms of species distribution and species abundance. Temporal changes in either can signal a change in the salinity regime. This change could be long-term and unidirectional, or it could be a short-term, temporary response to an extraordinary event, such as a hurricane, a severe drought, or a period of exceedingly high rainfall.

Although all tidal marsh species respond to the salinity regime, their distribution and abundance are determined in concert with other factors, such as their response to interspecific competition and their resilience following scouring and the deposition of wrack. Some species may be distributed in tidal marshes as much in response to these other factors as they are to salinity (Woerner and Hackney 1997). If their susceptibility to distribution by other factors goes unrecognized, erroneous conclusions could be drawn when using vegetation as an indicator of the salinity regime. For that reason, factors in addition to salinity are also evaluated in this chapter.

5.2. Salinity-vegetation relationships

Salinity data are available for the water column in the channel for each of the study rivers. As described in Senctions 2.4 and 3.3, data were collected at a number of fixed location stations that were arrayed along the length of each tidal river. The number of dates when salinity was measured varied greatly among rivers, as did the degree that these measurements were distributed over the flow regimes (Section 3.3). Given these limitations, salinity regimes were characterized from multiple salinity measurements to account for temporal variations attributable to seasonality and other factors. The median salinity value and 95th percentile salinity value (P95) were estimtated for each site across all seven rivers (see Section 2.4). These values are listed by site and river along with all species recorded at each site in Appendix G. Tables and most appendices presented later in this chapter were prepared from data in Appendix G, which, in turn, is identical to data presented in Appendix H, in which the data are arranged by plant species. Appendix H is most useful for evaluating the salinity regimes of individual species.

Median salinity can be considerd the typical salinity experienced by a species population. The range in median salinity values at sites where a given species occurs describes the normal salinity regime for that species. The 95th percentile (P95) salinity value represents higher than normal salinity that is equaled or exceeded only 5% of the time. The P95 salinity may be critical ecologically, because it represents the highest salinity that a species population is apt to experience on a regular basis. The range in P95 salinity values at sites where a given species occurs describes the approximate maximum salinity

regime for that species, although that range may be exceeded on rare occasions. The corresponding 5th percentile (P5) minimum salinity value was not presented in Appendices G or H, because it is a much less meaningful statistic ecologically. Nearly all tidal marsh halophytes survive in fresh water, although in time they may be replaced by more competitive glycophytes. As seedlings, halophytes generally become successfully established during periods of low salinity, as, for example, during rainy periods (Noe and Zedler 2001).

The normal and maximum salinity ranges for the more common species, based on median salinity values at more than 10 sites across rivers, is shown in Table 5.1. For example, Table 5.1 shows that *Juncus roemerianus* occurred at 240 sites and that the median salinity for 90% of these sites did not exceed 12 ppt. The maximum salinity value (P95) for 50% of these sites did not exceed 17 ppt for *Juncus roemerianus*. The values in Table 5.1 support the designation of species listed in Table 4.1 as glycophytes, oligohalophytes, and mesohalophytes. Uncommon species—those that occurred in < 10 sites across rivers—are listed in Table 5.2 along with the minimum and maximum salinity of the sites at which they occurred for both median and P95 salinity values. Percentile distributions of these uncommon species were not calculated for lack of sufficient data.

In Table 5.3, median salinity values are divided into salinity classes with each class representing an interval of 2 ppt (0-2, 2-4, 4-6 ppt, etc.). The number of sites is at which each species occurred within each of the salinity classes across all seven rivers. For example, *Cladium jamaicense* occurred in 49 (out of 131) sites, where the median salinity of the water column ranged from 0 to 2 ppt and in 10 sites where the median salinity ranged from 6 to 8 ppt. Table 5.4 provides the same kind of information only for the P95 salinity values.

The data from Tables 5.3 and 5.4 are presented visually as histograms for 24 species in Figures 5.1 through 5.24. Each figure contains two histograms: the upper, labeled (A), represents median salinity and the lower, labeled (B), represents 95th percentile (P95) salinity. The species are arranged in descending order of salt tolerance from strong halophytes to glycophytes. These histograms emphasize that that halophytic species (Figures 5.1 to 5.8) are all tolerant of several median salinity classes. None of them are strongly grouped into one or two adjacent salinity classes. Instead, they are more nearly distributed with equanimity among several classes. In other words, halophytes lack clearly defined centers of abundance that can be identified precisely with a particular salinity regime. In contrast, glycophytic species (Figures 5.21 to 5.24) are generally clustered in the lowest salinity class, because they are intolerant of saline water. Weak halophytes (Figs. 5.9 to 5.20) prefer fresh water but tolerate relatively low salinity.

Histograms for the 95th percentile salinity (Figures 5.1B-5-24B) show that the species represented are able to tolerate episodes of salinity that are distinctly greater than their respective median salinity ranges. This observation is not unexpected. Salinity was measured in the water column of rivers and not in the soil where water absorption occurs in roots. High salinity events are likely too brief for the soil water to become elevated with lethal concentrations of salt. However, prolonged high salinity in the water column, as

could occur durint the end of the dry season or a drought, could increase soil saliity in shoreline and intertidal areas.

Bar heights of histograms for the median salinity regime may indicate influences other than salinity. For example, low bar heights for *Spartina alterniflora* (Fig. 5.4A) for higher salinity classes probably represent its competitive exclusion by mangroves rather than its intolerance of high salinity. Likewise, the anomalous occurrence of more nearly freshwater species in saline environments, e.g., *Baccharis halimifolia* at the 12-14 ppt salinity class in Figure 5.15A, is not readily explained on the basis of median salinity tolerance. A more likely explanation is that weak halophytes like *Baccharis halimifolia* become established in strongly saline zones during years with high rainfall and concomitantly reduced salinity. Seedlings are more labile to salinity than are more mature plants. Once established, these plants persist indefinitely after the resumption of normal salinity conditions. For these reasons, central tendencies are more reliable than are extremes for the interpretation of normal salinity regimes of individual species. The percentile distributions of species shown in Table 5.1 are particularly helpful in this regard.

Clewell et al. (1999) discovered a close correlation between river salinity and the ratio of the abundance of *Juncus roemerianus* to that of *Cladium jamaicense* where they grew together along the banks of the Suwannee River. The river location where the two species were equally abundant was readily mapped, and any change in its map position over time would signify a corresponding change in the salinity regime in the river. This finding stimulated an attempt in the present study to try to locate a similarly critical position. To do so, sites where *Juncus roemerianus* and *Cladium jamaicense* co-occurred were recorded in Table 5.5 and plotted as histograms in Figure 5.25. If the histograms revealed a pronounced spike associated with a narrow range of salinity, the position of this spike could be mapped from salinity data for any given river. Movement in this position at a subsequent monitoring event would indicate a change in the salinity regime. Since two species contributed to the location of this position, its use would engender more confidence than would a position that was based from a single species. For that reason, co-occurrence histograms were also generated for *Juncus roemerianus* and three other species: *Typha domingensis* (Figure 26), *Scirpus californicus* (Figure 27), and *Rhizophora mangle* (Figure 28).

Spikes that may prove useful in detecting temporal changes in salinity regimes of rivers were apparent for *Juncus-Cladium* at the 16-18 ppt salinity class for P95 values (Figure 5.25b), for *Juncus-Typha* at the 8-10 ppt salinity class for median values (Figure 5.26a) and for the 16-18 ppt salinity class for P95 values (Figure 5.26b), and for *Juncus-Scirpus* at the 14-16 ppt salinity class for P95 values (Figure 5.27b). Shifts in the position of spikes on histograms from one monitoring event to the next would signify a change in the salinity regime. Similar shifts of the same direction and general magnitude would also be expected for other species.

5.3 Cross-River Commonality

Using the highest median salinity recorded for a species at a single site on a river as an indicator, much variation was evident across rivers (Appendix H). For example, the highest median salinity for *Juncus roemerianus* ranged from a low of 7.3 ppt at a site on the Peace River to a high of 19.4 ppt at a site on Myakka River. For *Cladium jamaicense* (ignoring rivers with less than 10 sites) the highest median salinity ranged from 6.6 ppt at Crystal River to 11.7 ppt at Chassahowitzka River. For *Rhizophora mangle* the highest median salinity ranged from 6.9 ppt at Peace River to 19.4 ppt at Myakka River. For *Spartina alterniflora* the highest median salinity ranged from 11.2 ppt at Weeki Wachee River to 19.8 ppt at Myakka River. Nearly all other species were recorded at too few sites to continue this across-river analysis. Nonetheless, the highest median salinity tended to vary for halophytes and even for some glycophytes. These results confirm the importance of using central trends rather than extremes for interpolating river salinity regimes from riverbank species.

Juncus roemerianus displayed considerable cross-river differences when its salinity preference in the southern rivers was compared with its preference in the four northern rivers (Table 5.6, Figures 5.29 and 5.30). Although broad overlap occurred, *Juncus roemerianus* tended to prefer more saline environments in northern rivers and less saline environments in southern rivers. This trend was apparent for both median and P95 salinity values. The most obvious and perhaps sole explanation for this discrepancy is that mangroves have pre-empted habitat that of *Juncus roemerianus* would otherwise exploit.

5.4 Autecology

Cross-river variation in salinity responses for species suggests that factors other than salinity were affecting species distribution, as has been documented elsewhere (Clewell et al. 1999, Greiner La Peyre et al. 2001). Appendix D was prepared to help discern between species distributions that were readily attributable to salinity alone and those that could have been influenced by other environmental factors. The other factors pertain to the propensity of species to form new populations following disturbance and the individual abilities of those colonizing species to persist with the return of increasing interspecific competition. Riverbank environments are frequently subjected to stress from scouring by strong, flood-induced currents and to the deposition of wrack. If such stress events are sufficient to weaken or remove existing vegetation, other species may colonize. Species that were originally present prior to a stress event may return and recover at the expense of the colonizing species. However, the original species may not return at all and may be replaced by other competition-tolerant species. Alternatively, repeated stress events could keep a given site in a permanent state of flux with regard to its vegetation. The interpretation of salinity tolerance for individual species must be tempered with an understanding of such patch dynamics (Pickett and White 1985) for tidal riverbank habitats and with autecological knowledge for colonizing species.

The most persistent and competitive herbaceous species of saline environments are *Spartina alterniflora, Juncus roemerianus,* and in more nearly freshwater habitats, *Cladium jamaicense* (Clewell et al. 1999). Other herbaceous species can be considered colonizers that cannot compete indefinitely with these three species, assuming no disturbance.

However, disturbance is too frequent for the persistence, and usually even the development, of monotypic stands of vegetation on riverbanks.

5.5 Vegetation Breaks and Salinity

Perhaps the most readily apparent indicators of changing salinity regimes along tidal rivers are the breaks in conspicuous vegetation on riverbanks, either single species or plant assemblages. The most obvious and potentially useful breaks are as follows:

- Where either mangrove-canopied or cordgrass-dominated shoreline *(Spartina alterniflora)* yields to needlerush-dominated shoreline.
- Where needlerush-dominated shoreline yields to mixed halophytic-species, such as sawgrass and cattails.
- Where mixed halophytic species yield to mixed glycophytic species, such as *Pontederia cordata, Zizania aquatica.*

The question arises: Do these break points correlate with sufficient precision across rivers with regard to salinity to make them useful as ecological indicators of the salinity regime?

These vegetation breaks are generally apparent from vegetation maps (Figures 4.1-4.7) and from corresponding aerial photographs. They can also be predicted from histograms of species-groups representing different salinity regimes (Figures 5.1-5.24). However, the precise break points are difficult to ascertain from shoreline species data, as presented Appendix G. One reason is the narrow width of riverbank habitat, which does not allow the full expression of its potential botanical diversity at many sites. Another reason is the relatively high frequency of disturbance and resultant patch dynamics on riverbanks. The problem is mainly one of resolution, similar to the examination of a photograph that is clear from a distance but that dissolves into incoherent pixels with increasing proximity.

Another aspect is that the species composition of riverbank vegetation may differ considerably from adjacent marsh or forest assemblages located short distances inland. In many cases, dramatic shifts in species composition can occur over a length of a few meters depending on the morphology of the bank and adjacent riparian zone. The design of the field sampling for this project emphasized riverbank vegetation, as it was assumed these plants would be most susceptible to changes in river salinity. The vegetation maps prepared from photo-interpretation (Figs. 4-1 to 4-7) identified much broader vegetation patterns, and in many, cases did not characterize narrow vegetation communities along the river banks. For that reason, field data for riverbank vegetation may not conform to what is apparent from aerial photographs and vegetation maps that are prepared from them.

For these reasons, breaks in the vegetation that seem apparent as one travels by boat may be indicative of general salinity conditions but are not reliable as predictors of specific salinity regimes. As previously discussed, the examination of the overall distributions of plant species and assemblages, with emphasis on their central tendencies, offers more for identifying prevailing salinity regimes in overlapping reaches of a tidal river.

Table 5.1. Salinity (ppt) That Was Not Exceeded by Percentile Groups (10, 25, 50, 75, 90) of Common Species (N > 10 Sites across Rivers) for Median and P95 Salinity Values.

		Median Salinity Values					95% Salinity Values				
	N	10%	25%	50%	75%	90%	10 %	25 %	50%	75 %	90%
Acrostichum danaeifolium	50	0	0	2	6	11	3	7	14	18	20
Alternanthera philoxeroides	19	0	0	1	2	12	0	3	11	15	17
Aster carolinianus	17	0	0	0	2	3	2	3	7	8	11
Avicennia germinans	14	10	12	16	18	19	23	24	25	26	26
Baccharis halimifolia	17	0	2	2	3	4	2	3	6	10	16
Bacopa monnieri	12	0	0	1	3	4	10	11	13	17	18
Cicuta maculata	14	0	0	0	0	3	1	1	5	8	9
Cladium jamaicense	131	0	1	3	8	10	3	7	12	17	17
Crinum americanum	36	0	0	1	3	3	2	3	8	14	18
Distichlis spicata	14	3	10	12	12	15	16	17	19	19	24
Eleocharis flavescens	16	0	0	0	0	0	2	5	7	9	11
Fraxinus caroliniana	18	0	0	0	0	1	1	2	3	4	6
Iva frutescens	12	8	10	13	15	17	16	19	22	23	25
Juncus roemerianus	240	1	3	7	11	12	11	14	17	19	23
Laguncularia racemosa	32	4	7	12	15	17	18	20	23	25	26
Magnolia virginiana	21	0	0	1	2	3	2	2	3	8	13
Mikania scandens	14	0	0	0	0	1	0	0	4	14	16
Myrica cerifera	20	0	0	2	3	3	2	3	4	7	13
Persea palustris	16	0	0	1	3	3	2	3	7	10	11
Pluchea odorata	13	0	0	0	1	2	0	6	8	11	16
Polygonum hydropiperoides	27	0	0	0	0	0	0	1	3	7	10
Pontederia cordata	26	0	0	0	0	1	0	0	2	6	9
Rhizophora mangle	71	2	4	8	14	16	15	19	21	25	26
Rumex verticillatus	21	0	0	0	2	3	0	2	4	8	11
Ruppia maritima	43	1	3	6	9	11	10	13	15	19	19
Sabal palmetto	13	0	0	1	2	14	2	2	9	13	24
Sagittaria lancifolia	42	0	0	0	2	4	1	2	4	8	8
Sagittaria subulata	68	0	0	2	5	10	3	4	11	14	18
Samolus valerandi	18	0	0	0	2	3	0	3	6	9	16
Scirpus californicus	35	0	0	0	2	4	3	10	13	16	18
Scirpus tabernaemontani	14	0	0	0	0	1	0	0	4	8	10
Senecio glabellus	16	0	0	0	3	3	1	3	4	7	8
Solidago stricta	17	0	0	1	3	11	3	4	5	12	18
Spartina alterniflora	108	3	6	9	11	14	12	14	17	19	21
Typha domingensis	118	0	1	4	8	10	3	9	13	17	18
Urochloa mutica	13	0	0	0	0	1	0	1	7	10	12

Table 5.2. Range in Salinity (ppt) for Uncommon Species (N < 10 Sites across Rivers) for Median and 95% (P95) Salinity Values.

		Median Salinity Values		95% Salinity Values	
	N	Minimum	Maximum	Minimum	Maximum
Acer rubrum	8	0	3	2	8
Acrostichum aureum	5	5	17	19	25
Amaranthus australis	5	0	1	0	11
Ampelopsis arborea	2	0	3	5	11
Ardisia escallonoides	1	1	1	13	13
Aster subulatus	2	1	11	11	20
Aster tenuifolius	3	12	14	18	20
Baccharis angustifolia	3	3	15	15	21
Bidens laevis	1	1	1	2	2
Blechnum serrulatum	6	0	0	7	9
Blutaparon vermiculare	1	19	19	26	26
Boehmeria cylindrica	1	2	2	2	2
Borrichia frutescens	3	17	20	25	26
Carex lupulina	1	0	0	1	1
Carya aquatica	2	0	3	2	8
Cephalanthus occidentalis	7	0	0	0	5
Chasmanthium nitidum	3	0	0	2	3
Colocasia esculenta	9	0	0	0	9
Conocarpus erectus	6	2	17	15	25
Cornus foemina	5	0	3	1	4
Crotalaria incana	2	0	1	9	13
Cyperus distinctus	1	0	0	3	3
Dalbergia ecastophyllum	6	2	13	14	25
Decumaria barbara	2	0	0	2	2
Diodia virginiana	3	0	0	0	1
Echinochloa muricata	2	0	0	0	4
Eclipta prostrate	1	1	1	12	12
Eleocharis fallax	10	0	1	0	11
Ficus aurea	10	0	20	7	26
Gratiola virginiana	8	0	0	0	8
Hydrocotyle umbellata	3	0	0	0	11
Hypericum mutilum	1	0	0	2	2
Ilex cassine	6	0	3	2	15
Iris hexagona	5	0	3	2	5
Isoetes flaccida	3	0	0	1	10
Itea virginica	5	0	2	1	2
Juncus effusus	2	0	0	0	7
Juncus megacephalus	1	0	0	0	0
Juniperus virginiana	1	2	2	11	11
Limonium carolinianum	1	14	14	25	25

Table 5.2 Continued

		Median Salinity Values		95% Salinity Values	
	N	Minimum	Maximum	Minimum	Maximum
Lobelia cardinalis	8	0	1	0	2
Lobelia feayana	2	0	0	0	11
Ludwigia repens	10	0	2	0	17
Lycium carolinianum	3	10	11	17	17
Lythrum alatum	8	0	12	0	19
Nuphar luteum	3	0	0	1	1
Ophioglossum petiolatum	1	0	0	1	1
Osmunda regalis	2	0	0	7	8
Panicum anceps	5	0	0	1	3
Panicum rigidulum	5	0	0	5	9
Parthenocissus quinquefolia	1	0	0	9	9
Paspalum repens	2	1	2	2	2
Phragmites australis	9	0	11	2	24
Quercus geminate	1	2	2	2	2
Quercus virginiana	1	0	0	3	3
Rhabdadenia biflora	2	5	6	19	20
Rhynchospora colorata	1	0	0	11	11
Sabatia calycina	1	0	0	10	10
Salix caroliniana	5	0	2	0	12
Sambucus canadensis	3	0	0	7	8
Saururus cernuus	10	0	3	0	8
Schinus terebinthifolius	7	2	19	15	26
Scirpus americanus	4	8	10	16	17
Scirpus robustus	2	2	4	3	9
Sesuvium portulacastrum	3	3	15	16	24
Smilax bona-nox	1	0	0	2	2
Smilax laurifolia	1	0	0	1	1
Smilax walteri	2	0	0	3	3
Solidago sempervirens	1	0	0	11	11
Spartina bakeri	9	0	20	8	26
Spartina patens	2	14	15	24	24
Stenotaphrum secundatum	2	0	0	2	7
Taxodium distichum	7	0	2	2	12
Teucrium canadense	2	0	0	11	14
Triglochin striata	2	0	3	7	16
Ulmus americanus	1	2	2	3	3
Vallisneria americana	9	0	5	3	17
Viburnum obovatum	1	0	0	2	2
Vitis rotundifolia	1	0	0	7	7
Zizania aquatica	5	0	0	1	6

Table 5.3 Number of sites across rivers in which species occurred as distributed into median salinity classes at intervals of 2 ppt.

Species	Median Salinity Classes										Total
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	
Acer rubrum	7	1									8
Acrostichum aureum			1	1		1	1		1		5
Acrostichum danaeifolium	22	12	5	4		5	2				50
Alternanthera philoxeroides	13	2			1	3					19
Amaranthus australis	5										5
Ampelopsis arborea	1	1									2
Ardisia escallonoides	1										1
Aster carolinianus	11	6									17
Aster subulatus	1					1					2
Aster tenuifolius						2	1				3
Avicennia germinans					2	1	2	2	3	4	14
Baccharis angustifolia		1			1			1			3
Baccharis halimifolia	7	8	1				1				17
Bacopa monnieri	7	5									12
Bidens laevis	1										1
Blechnum serrulatum	6										6
Blutaparon vermiculare										1	1
Boehmeria cylindrica	1										1
Borrichia frutescens									1	2	3
Carex lupulina	1										1
Carya aquatica	1	1									2
Cephalanthus occidentalis	7										7
Chasmanthium nitidum	3										3
Cicuta maculata	12	2									14
Cladium jamaicense	49	29	9	10	14	19				1	131
Colocasia esculenta	9										9
Conocarpus erectus		1	1				1	1	2		6
Cornus foemina	4	1									5
Crinum americanum	24	9			2	1					36
Crotalaria incana	2										2
Cyperus distinctus	1										1
Dalbergia ecastophyllum	1	1	1		1	1	1				6
Decumaria barbara	2										2
Diodia virginiana	3										3
Distichlis spicata		2		1		9		2			14
Echinochloa muricata	2										2
Eclipta prostrate	1										1
Eleocharis fallax	10										10

Table 5.3 Continued

Species	Median Salinity Classes										Total
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	
Eleocharis flavescens	15	1									16
Ficus aurea	5		1	1	1					2	10
Fraxinus caroliniana	18										18
Gratiola virginiana	8										8
Hydrocotyle umbellata	3										3
Hypericum mutilum	1										1
Ilex cassine	4	2									6
Iris hexagona	3	2									5
Isoetes flaccida	3										3
Itea virginica	5										5
Iva frutescens	1				2	2	2	3	1	1	12
Juncus effusus	2										2
Juncus megacephalus	1										1
Juncus roemerianus	40	31	25	30	41	48	13	6	4	2	240
Juniperus virginiana	1										1
Laguncularia racemosa	1	3	1	4	2	4	7	4	4	2	32
Limonium carolinianum								1			1
Lobelia cardinalis	8										8
Lobelia feayana	2										2
Ludwigia repens	9	1									10
Lycium carolinianum						3					3
Lythrum alatum	5	1				2					8
Magnolia virginiana	17	3	1								21
Mikania scandens	14										14
Myrica cerifera	9	11									20
Nuphar luteum	3										3
Ophioglossum petiolatum	1										1
Osmunda regalis	2										2
Panicum anceps	5										5
Panicum rigidulum	5										5
Parthenocissus quinquefolia	1										1
Paspalidium geminatum	2										2
Persea palustris	11	5									16
Phragmites australis	3			1	4	1					9
Pluchea odorata	11	2									13
Polygonum hydropiperoides	27										27
Pontederia cordata	25		1								26
Quercus geminata	1										1
Quercus virginiana	1										1

Table 5.3 Continued

Species	Median Salinity Classes										Total
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	
Rhabdadenia biflora			2								2
Rhizophora mangle	8	9	9	9	7	5	8	8	7	1	71
Rhynchospora colorata	1										1
Rumex verticillatus	15	6									21
Ruppia maritima	8	6	8	5	7	8			1		43
Sabal palmetto	9	1			1		1		1		13
Sabatia calycina	1										1
Sagittaria lancifolia	31	9	1			1					42
Sagittaria subulata	33	15	7	4	3	6					68
Salix caroliniana	5										5
Sambucus canadensis	3										3
Samolus valerandi	13	5									18
Saururus cernuus	7	3									10
Schinus terebinthifolius		1	2				1	1	1	1	7
Scirpus americanus				1	3						4
Scirpus californicus	27	5		1	2						35
Scirpus robustus		1	1								2
Scirpus tabernaemontani	14										14
Senecio glabellus	10	6									16
Sesuvium portulacastrum		1						2			3
Smilax bona-nox	1										1
Smilax laurifolia	1										1
Smilax walteri	2										2
Solidago sempervirens	1										1
Solidago stricta	10	3			1	2				1	17
Spartina alterniflora	4	10	13	11	31	21	7	4	4	3	108
Spartina bakeri	6	1			1					1	9
Spartina patens							1	1			2
Stenotaphrum secundatum	2										2
Taxodium distichum	7										7
Teucrium canadense	2										2
Triglochin striata	1	1									2
Typha domingensis	39	21	12	11	21	14					118
Ulmus americanus		1									1
Urochloa mutica	13										13
Vallisneria americana	7		2								9
Viburnum obovatum	1										1
Vitis rotundifolia	1										1
Zizania aquatica	5										5

Table 5.4. Number of sites across rivers in which species occurred as distributed into the 95th percentile (P95) salinity classes at intervals of 2 ppt.

Species	95th Percentile Salinity Classes														Total
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	
Acer rubrum	2	3	2	1											8
Acrostichum aureum										2		2	1		5
Acrostichum danaeifolium		6	3	6	4	2	3	5	9	6	4		2		50
Alternanthera philoxeroides	4	2	1		3	1	3	2	3	2					21
Amaranthus australis	1	1		1	1	1									5
Ampelopsis arborea			1			1									2
Ardisia escallonoides							1								1
Aster carolinianus	1	5	2	5	2	1		1							17
Aster subulatus						1				1					2
Aster tenuifolius										3					3
Avicennia germinans												3	8	3	14
Baccharis angustifolia								1	1		1				3
Baccharis halimifolia	1	5	3	1	2	1		2	1				1		17
Bacopa monnieri	1					3	3	1	3	1					12
Bidens laevis		1													1
Blechnum serrulatum				3	3										6
Blutaparon vermiculare													1		1
Boehmeria cylindrica		1													1
Borrichia frutescens													2	1	3
Carex lupulina	1														1
Carya aquatica	1			1											2
Cephalanthus occidentalis	3	3	2												8
Chasmanthium nitidum		3													3
Cicuta maculata	4	1	3	4	1	1									14
Cladium jamaicense	5	18	7	15	11	12	12	14	30	6				1	131
Colocasia esculenta	1	2	3	2	1										9
Conocarpus erectus								1		1		1	3		6
Cornus foemina	3	2													5
Crinum americanum	4	9	2	1	7	2	5	2		3		1			36
Crotalaria incana					1		1								2
Cyperus distinctus		1													1
Dalbergia ecastophyllum								1	1	1		1	2		6
Decumaria barbara	2														2
Diodia virginiana	3														3
Distichlis spicata								1	3	8			2		14
Echinochloa muricata	1	1													2
Eclipta prostrate						1									1
Eleocharis fallax	6	3				1									10
Eleocharis flavescens	2	1	2	4	4	2			1						16
Ficus aurea				1	1	3				1	2		1	1	10
Fraxinus caroliniana	5	10	1	1		1									18
Gratiola virginiana	2		1	3	2										8
Hydrocotyle umbellata	2					1									3
Hypericum mutilum		1													1

Table 5.4 Continued

Species	95th Percentile Salinity Classes														Total
	0-2	2-4	4-6	6-8	8-10	1012	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	
Ilex cassine	1	3	1					1							6
Iris hexagona	1	2	2												5
Isoetes flaccida	1	1				1									3
Itea virginica	3	2													5
Iva frutescens						1			2		2	5	1	1	12
Juncus effusus	1			1											2
Juncus megacephalus	1														1
Juncus roemerianus	3	3	1		6	13	24	39	55	45	22	13	15	1	240
Juniperus virginiana						1									1
Laguncularia racemosa							1	1	1	3	6	7	11	2	32
Limonium carolinianum													1		1
Lobelia cardinalis	6	2													8
Lobelia feayana	1					2									3
Ludwigia repens	5		1		1	2			1						10
Lycium carolinianum									3						3
Lythrum alatum	1	1			1	1	1	1		2					8
Magnolia virginiana	3	8	1	4	1		2	1	1						21
Mikania scandens	6	1	2		1	1	2	2							15
Myrica cerifera	3	7	4	3	1		1	2							21
Nuphar luteum	3														3
Ophioglossum petiolatum	1														1
Osmunda regalis				1	1										2
Panicum anceps	1	4													5
Panicum rigidulum			2	2	1										5
Parthenocissus quinquefolia					1										1
Paspalidium geminatum	1	1													2
Persea palustris	1	4	3	2	2	3		1							16
Phragmites australis		2						2	3			1	1		9
Phyla nodiflora	1														1
Pluchea odorata	2	1	1	2	2	2	1	1	1						13
Polygonum hydropiperoides	12	5	2	3	3	2	1								28
Pontederia cordata	14	4	3	3	2	1	1								28
Quercus geminata		1													1
Quercus virginiana		1													1
Rhabdadenia biflora										2					2
Rhizophora mangle				1		1	4	4	6	11	13	7	19	5	71
Rhynchospora colorata						1									1
Rumex verticillatus	5	4	5	2	2	2		1							21
Ruppia maritima	1	1		2		3	9	8	2	16				1	43
Sabal palmetto	2	3		1	1	2	1	1				1		1	13
Sabatia calycina						1									1
Sagittaria lancifolia	13	8	4	12	4					1					42
Sagittaria subulata	5	13	2	5	6	9	12	5	2	9					68
Salix caroliniana	3	1				2									6

Table 5.4 Continued

Species	95th Percentile Salinity Classes														Total
	0-2	2-4	4-6	6-8	8-10	1012	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	
Sambucus canadensis				3											3
Samolus valerandi	2	4	3	3	2		2	1		1					18
Saururus cernuus	4	4		2											10
Schinus terebinthifolius								1	1	1		1	3		7
Scirpus americanus								1	3						4
Scirpus californicus	2	3	1	1	2	5	5	7	5	2	2				35
Scirpus robustus		1			1										2
Scirpus tabernaemontani	6	1	1	2	3	2									15
Senecio glabellus	2	6	3	3	2										16
Sesuvium portulacastrum								1					2		3
Smilax bona-nox		1													1
Smilax laurifolia	1														1
Smilax walteri		2													2
Solidago sempervirens						1									1
Solidago stricta		7	3	2		1			3				1		17
Spartina alterniflora					2	7	13	19	21	29	8	3	5	1	108
Spartina bakeri				1		1	1	3	1		1			1	9
Spartina patens												1	1		2
Stenotaphrum secundatum		1		1											2
Taxodium distichum	1	2	1	1		2									7
Teucrium canadense						1	1								2
Triglochin striata				1				1							2
Typha domingensis	7	7	8	3	14	7	14	14	32	12					118
Ulmus americanus		1													1
Urochloa mutica	5	1	1	2	3	2	1								15
Vallisneria americana		2	2	2		1	1		1						9
Viburnum obovatum	1														1
Vitis rotundifolia				1											1
Zizania aquatica	1	3	1												5

Table 5.5. Salinity Distribution for Co-occurrence of *Juncus roemerianus* with Other Species.

Table A. Number of Sites Across Rivers Where *Juncus roemerianus* Occurred with Another Species, as Distributed Among Salinity Classes (2 ppt Intervals) for Median Salinity Values.

Salinity Class-ppt	Juncus & Cladium	Juncus & Typha	Juncus & Scirpus californicus	Juncus & Rhizophora
0-2	13	8	5	5
2-4	7	9	2	8
4-6	5	8	0	6
6-8	10	10	0	8
8-10	12	15	1	7
10-12	14	11	0	5
12-14	0	0	0	7
14-16	0	0	0	4
16-18	0	0	0	2
18-20	0	0	0	1
20-22	0	0	0	0
22-24	0	0	0	0
24-26	0	0	0	0
26-28	0	0	0	0

Table B. Number of Sites Across Rivers Where *Juncus roemerianus* Occurred with Another Species, as Distributed Among Salinity Classes (2 ppt Intervals) for 95th Percentile (P95) Salinity Values.

Salinity Class-ppt	Juncus & Cladium	Juncus & Typha	Juncus & Scirpus californicus	Juncus & Rhizophora
0-2	2	2	0	0
2-4	2	0	0	0
4-6	1	1	0	0
6-8	0	0	0	0
8-10	1	3	0	0
10-12	4	2	0	1
12-14	9	8	1	2
14-16	14	14	4	4
16-18	23	21	2	5
18-20	5	10	0	7
20-22	0	0	1	13
22-24	0	0	0	7
24-26	0	0	0	13
26-28	0	0	0	1

Table 5.6 Number of sites with *Juncus roemerianus* arranged by salinity classes (2 ppt intervals) for median and 95th percentile (P95) salinity in northern and southern rivers.

		Salinity Class (ppt)														
Statistic	**Rivers**	**0-2**	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**	**12-14**	**14-16**	**16-18**	**18-20**	**20-22**	**22-24**	**24-26**	**26-28**	**Tot**
P95	North	3	3	1		2	5	14	26	42	35	5				136
P95	South					4	8	10	13	13	10	17	13	15	1	104
median	North	11	11	15	19	34	40	4	1	1						136
median	South	29	20	10	11	7	8	9	5	3	2					104

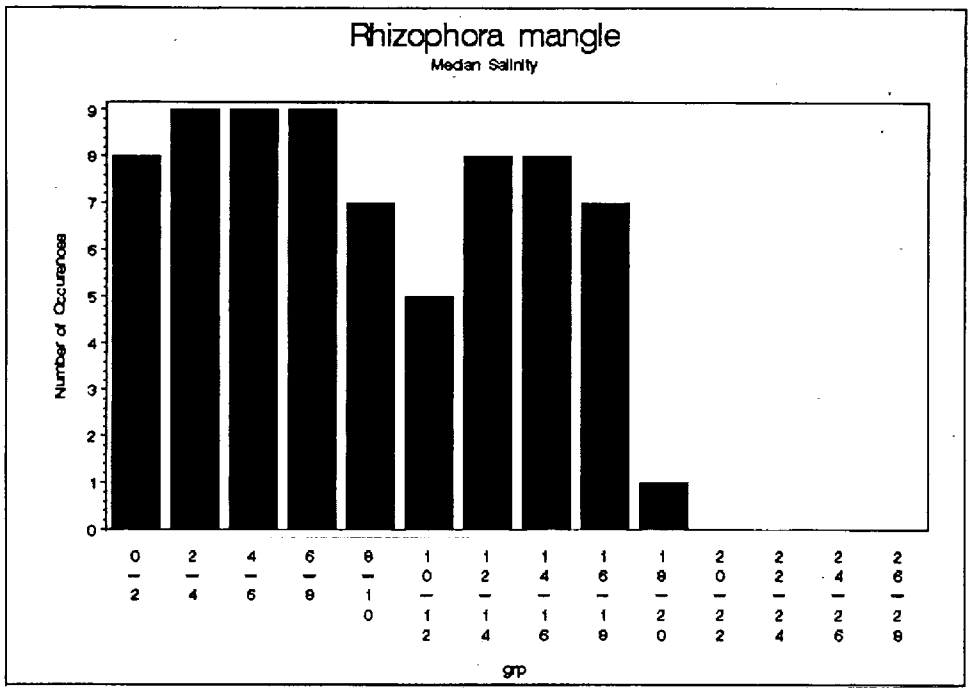


Figure5.1A. Histogram of median salinity values at sites where *Rhizophora mangle* was recorded.

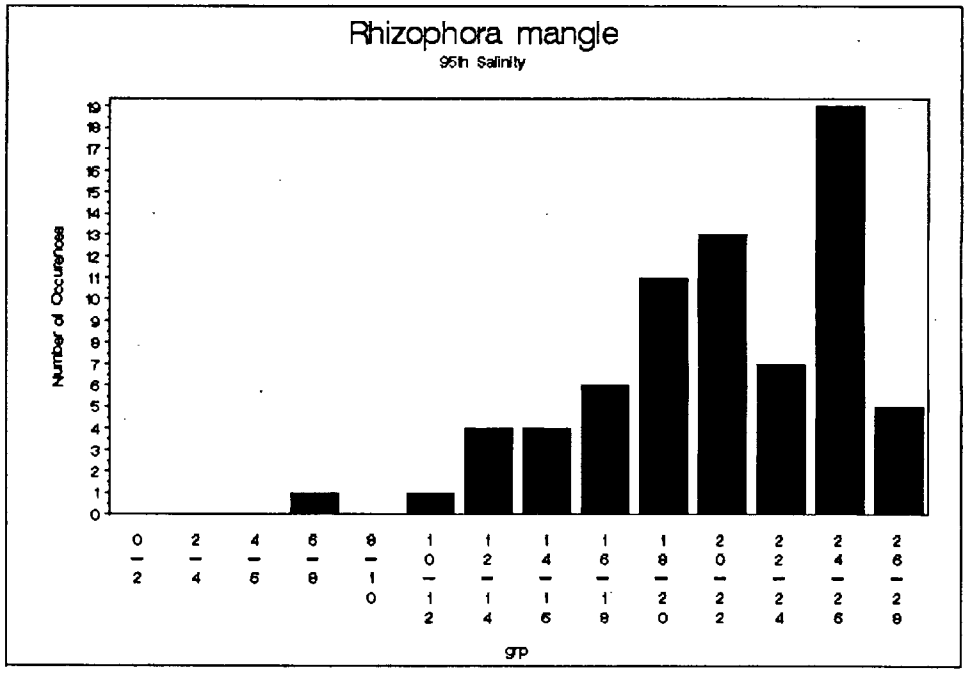


Figure 5.1B. Histogram of 95th percentile salinity values at sites where *Rhizophora mangle* was recorded.

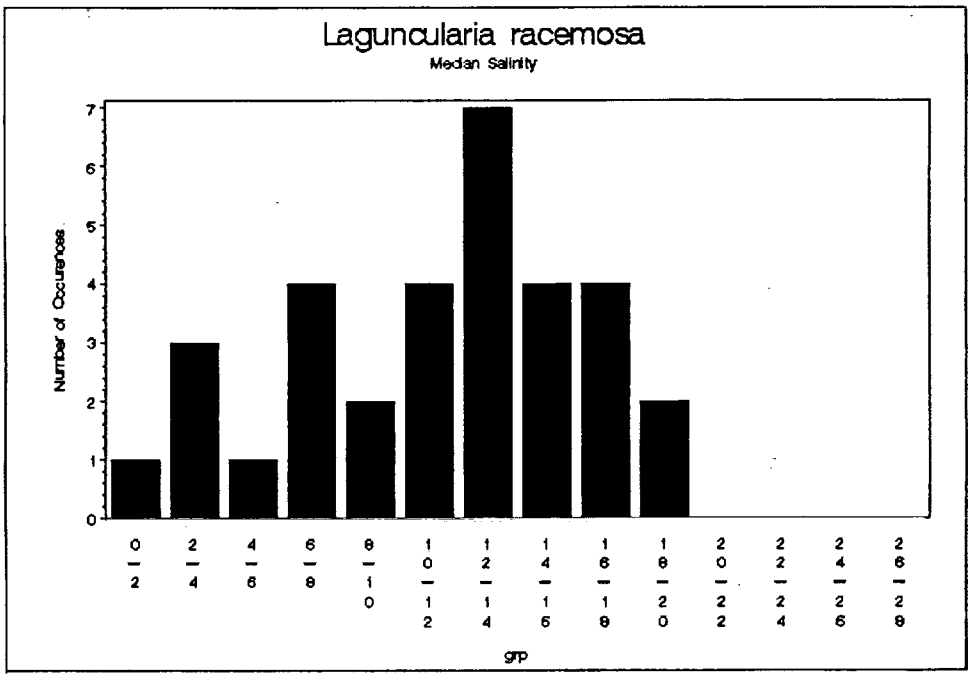


Figure 5.2A. Histogram of median salinity values at sites where *Laguncularia racemosa* was recorded.

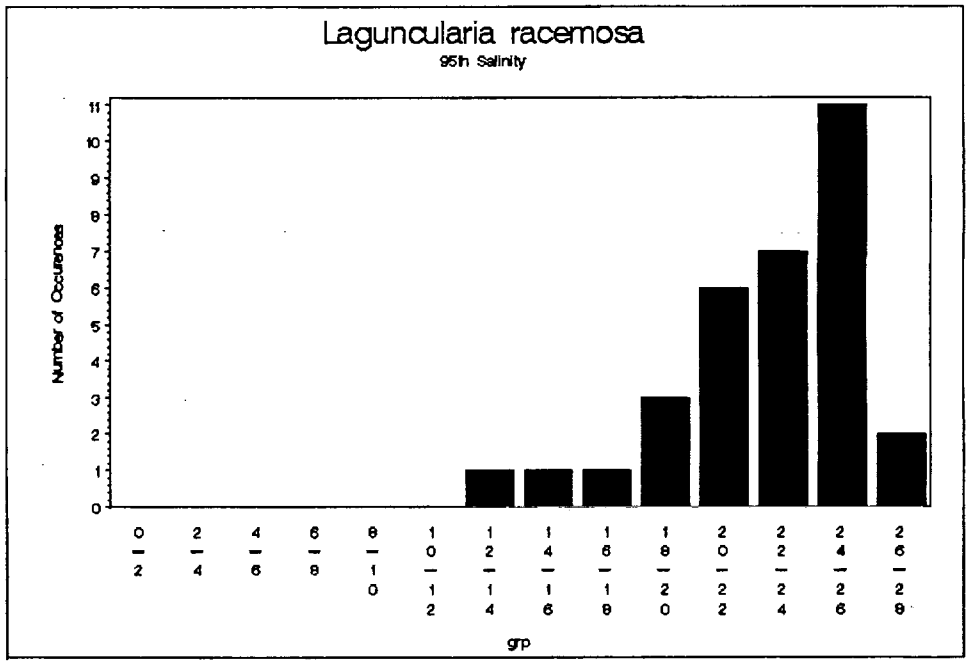


Figure 5.2B. Histogram of 95th percentile salinity values at sites where *Laguncularia racemosa* was recorded.

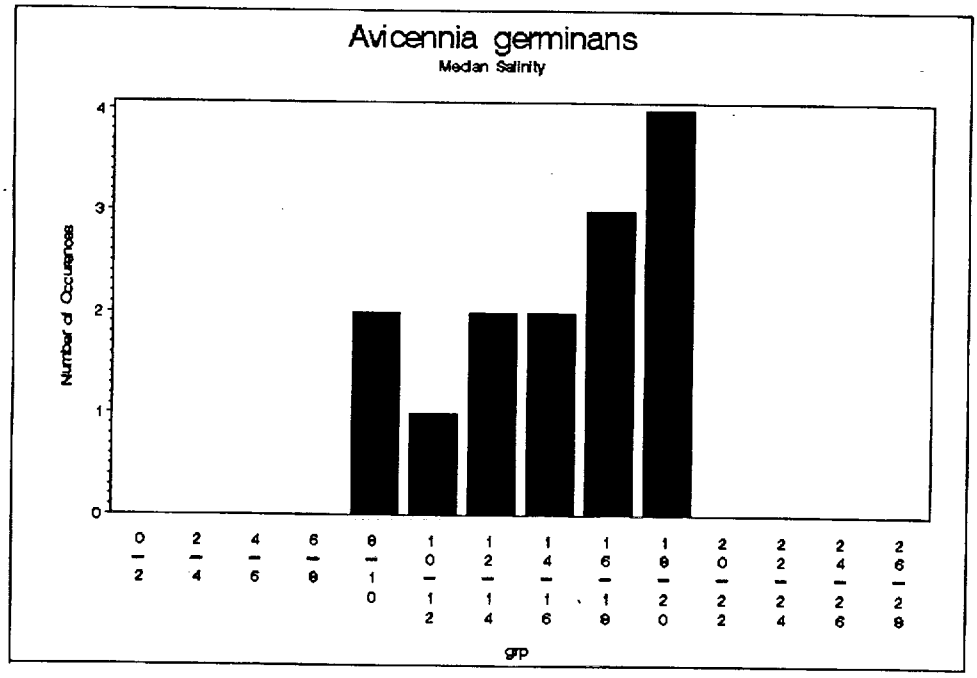


Figure 5.3A. Histogram of median salinity values at sites where *Avicennia germinans* was recorded.

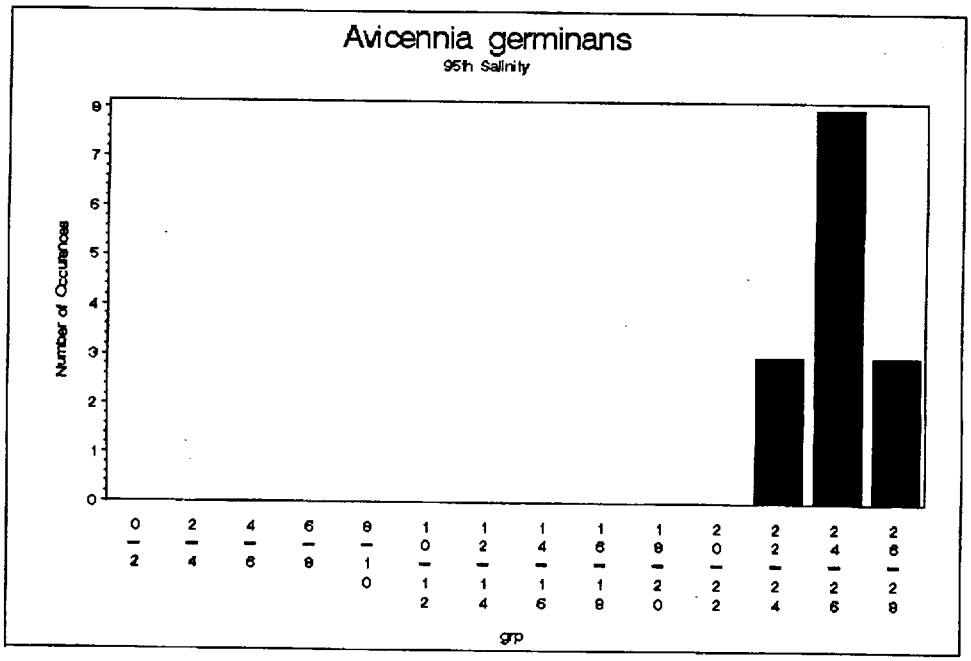


Figure 5.3B Histogram of 95th percentile salinity values at sites where *Avicennia germinans* was recorded.

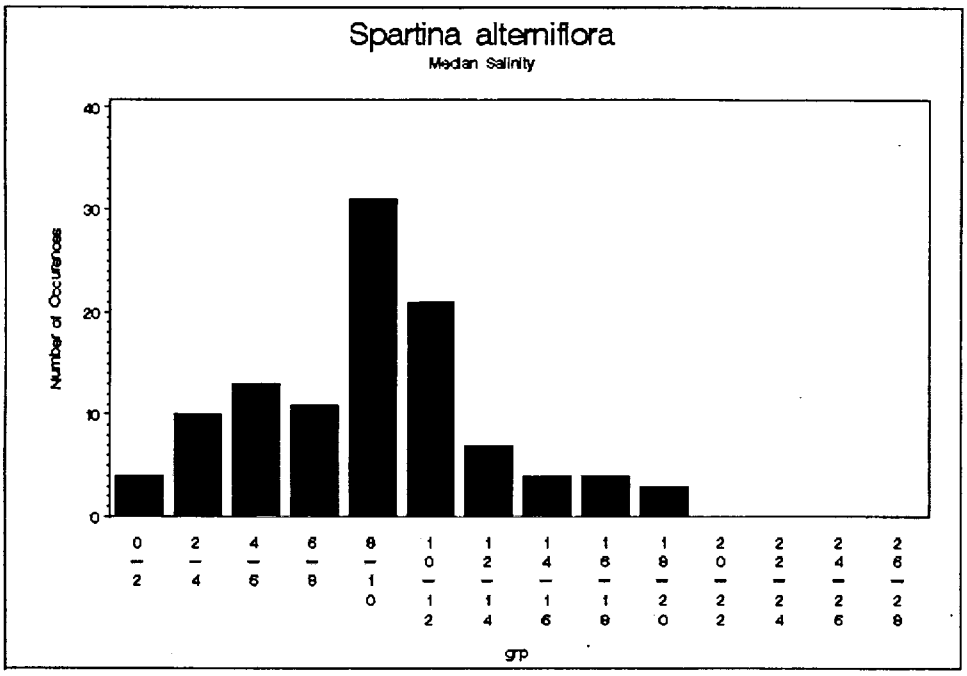


Figure 5.4A. Histogram of median salinity values at sites where *Spartina alterniflora* was recorded.

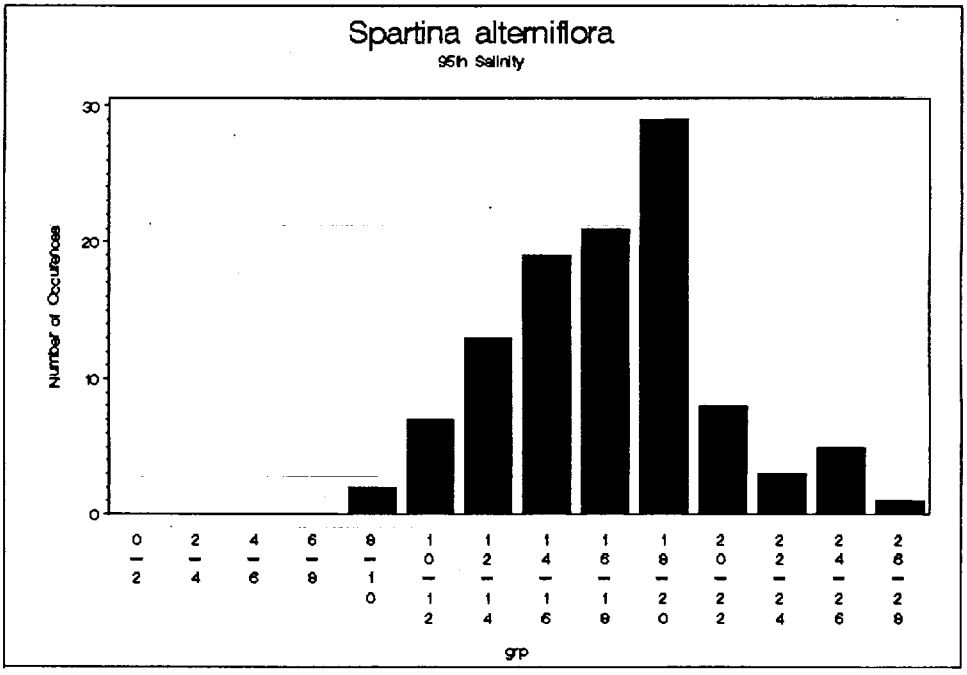


Figure 5.4B. Histogram of 95th percentile salinity values at sites where *Spartina alterniflora* was recorded.

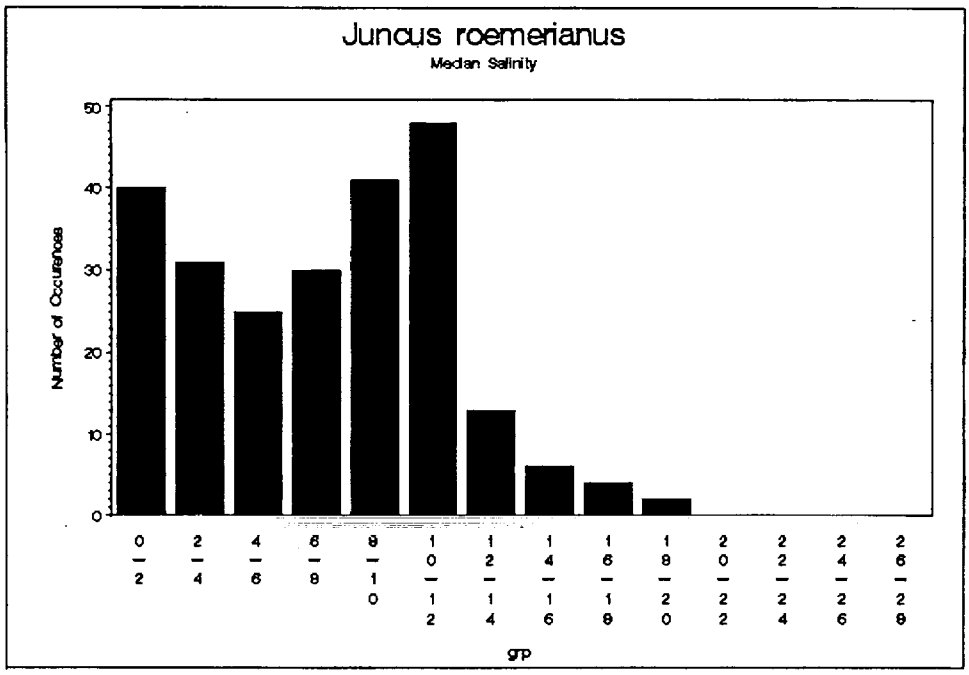


Figure 5.5A. Histogram of median salinity values at sites where *Juncus roemerianus* was recorded.

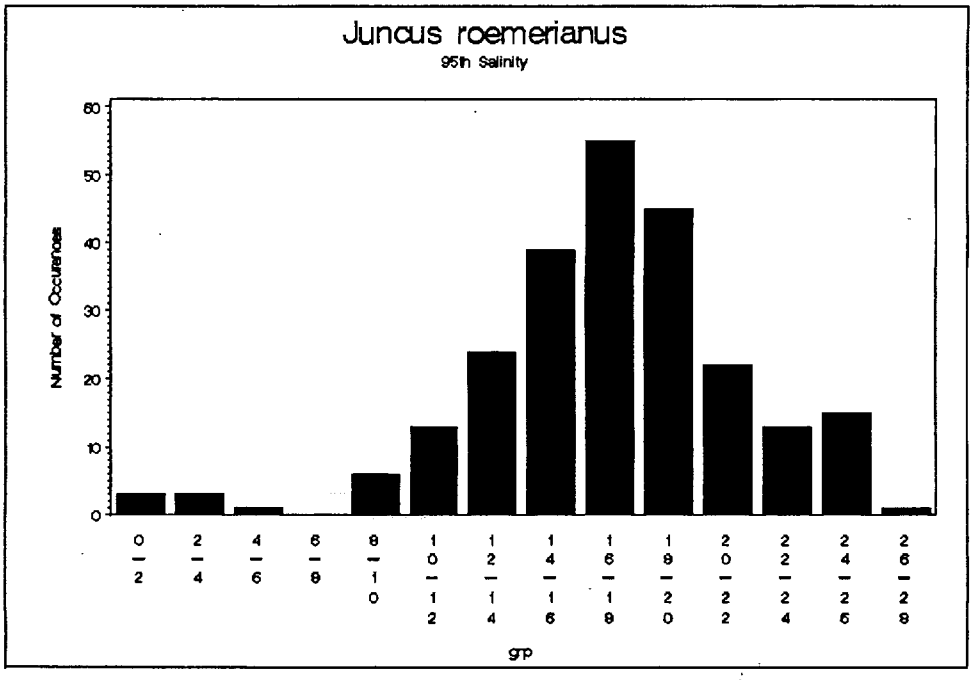


Figure 5.5B. Histogram of 95th percentile salinity values at sites where *Juncus roemerianus* was recorded.

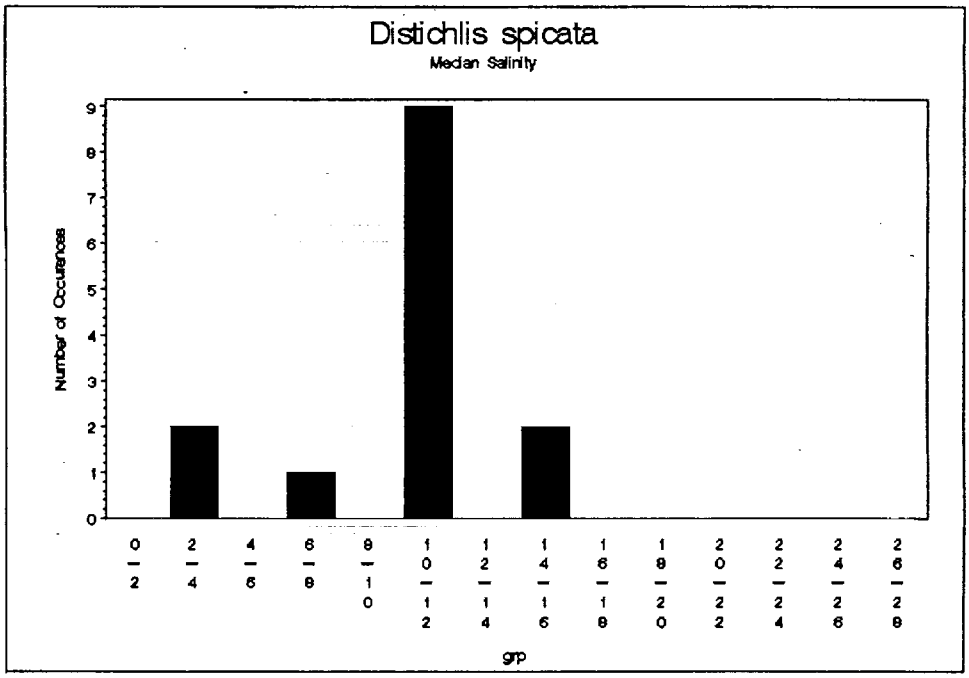


Figure 5.6A. Histogram of median salinity values at sites where *Distichlis spicata* was recorded.

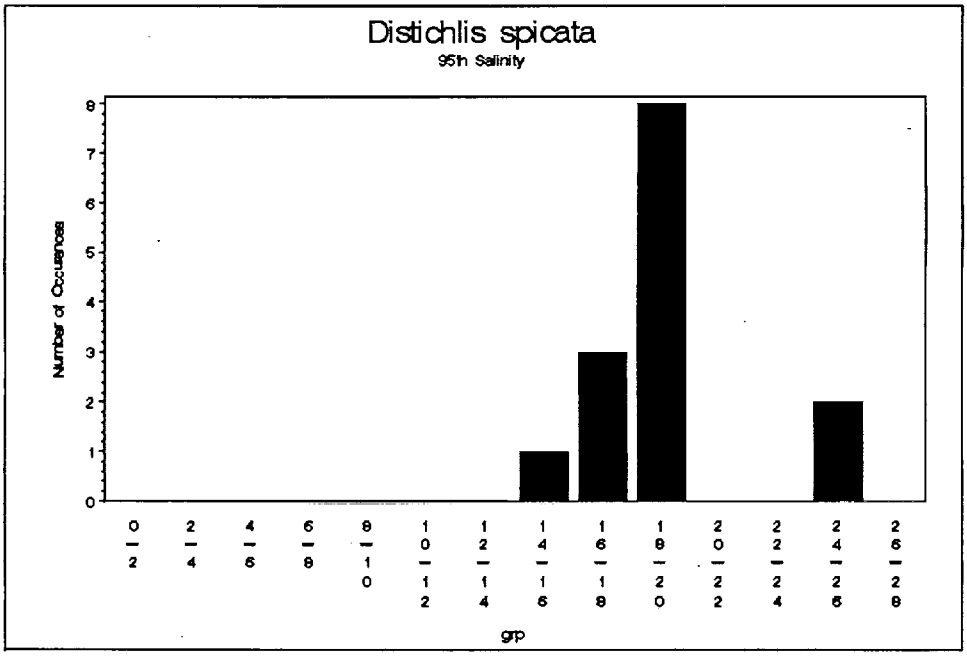


Figure 5.6B Histogram of 95th percentile salinity values at sites where *Distichlis spicata* was recorded.

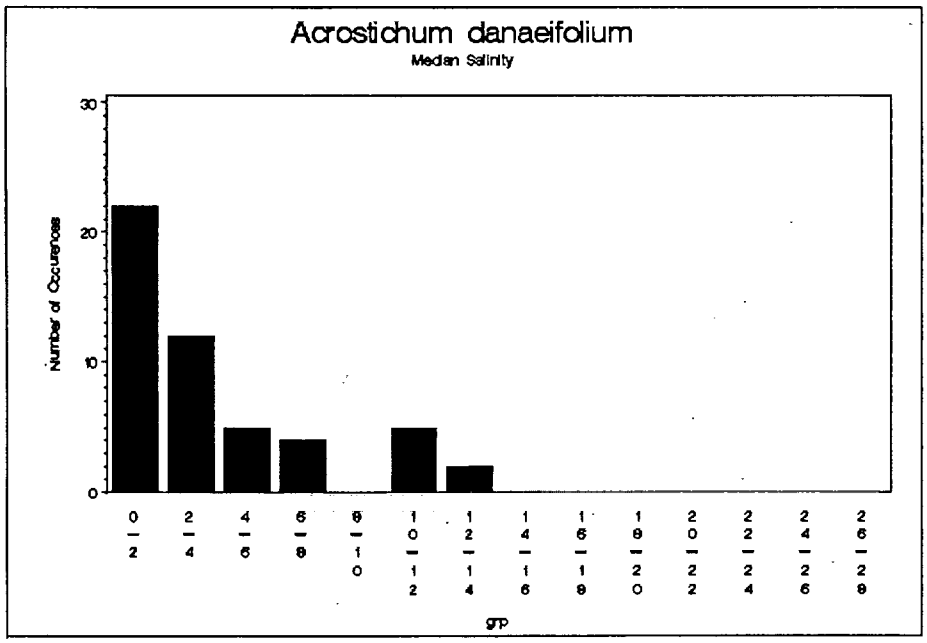


Figure 5.7A Histogram of median salinity values at sites where *Acrostichum danaefolium* was recorded.

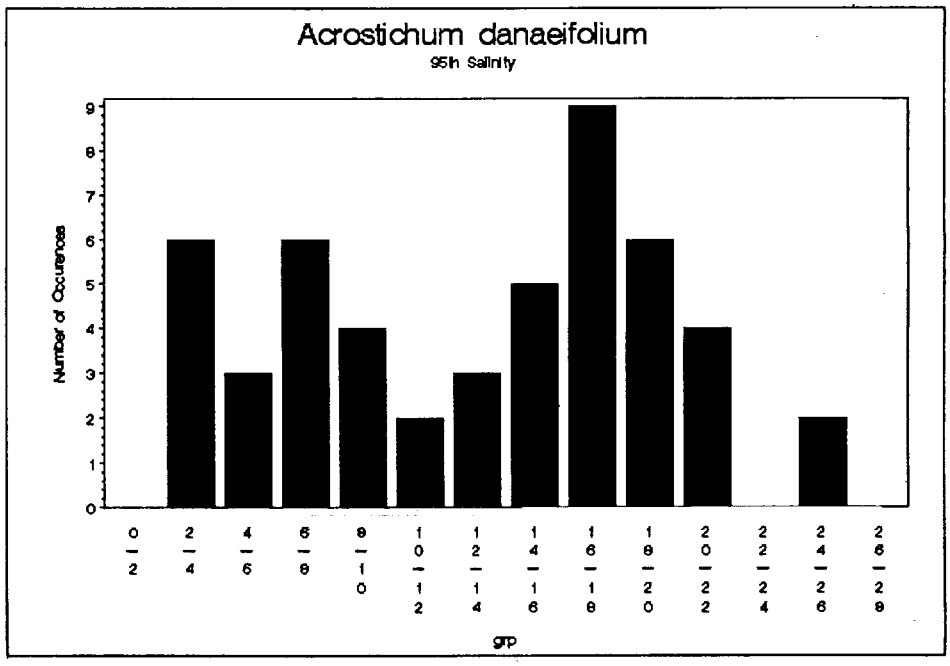


Figure 5.7B. Histogram of 95th percentile salinity values at sites where *Acrostichum danaefolium* was recorded.

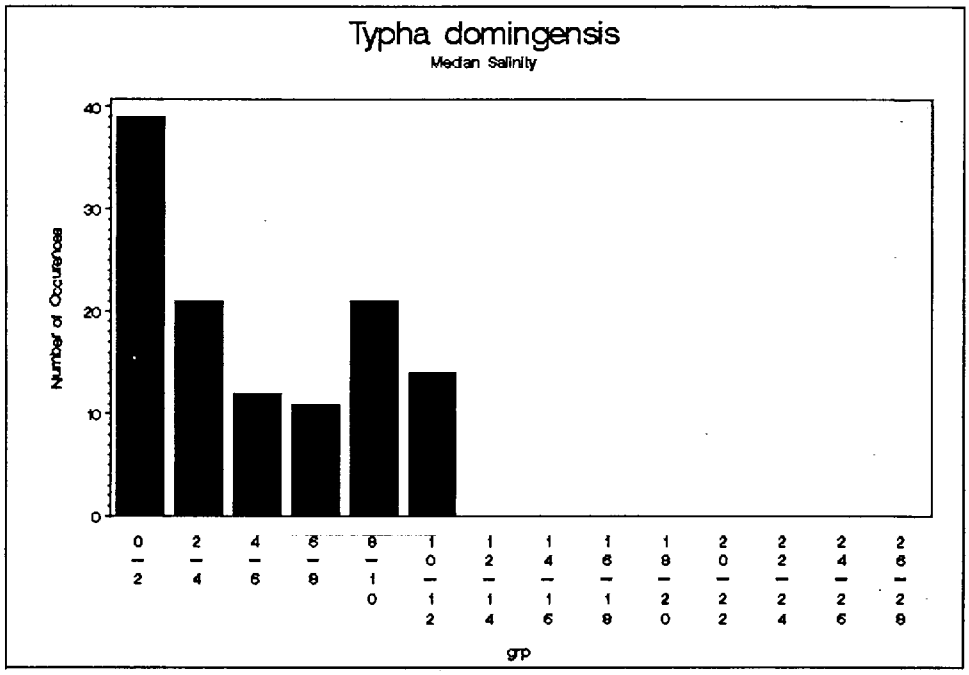


Figure 5.8A. Histogram of median salinity values at sites where *Typha domingensis* was recorded.

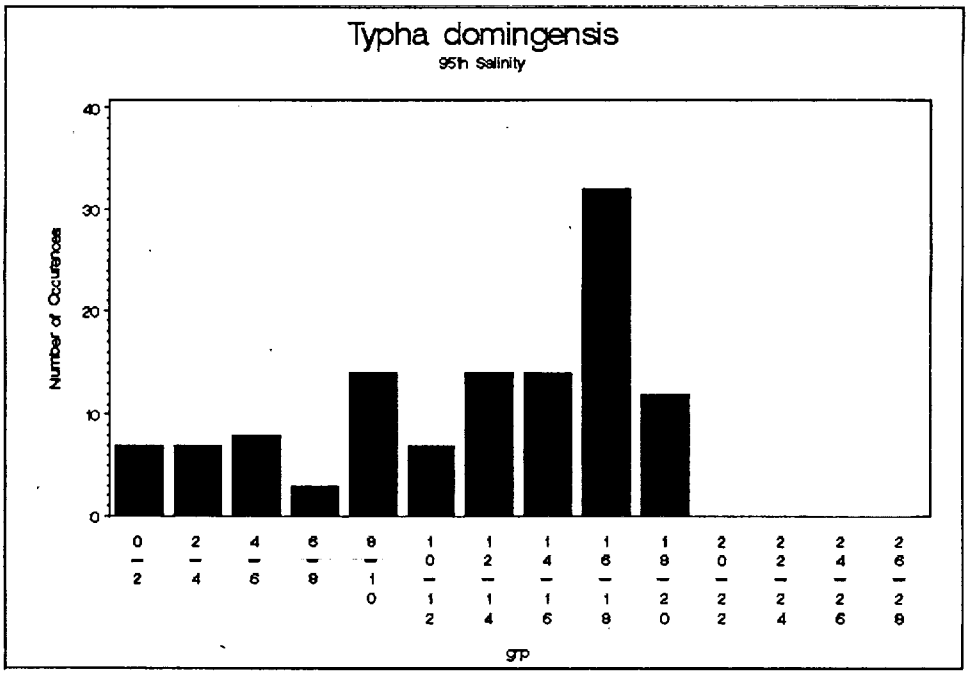


Figure 5.8B. Histogram of 95th percentile salinity values at sites where *Typha domingensis* was recorded.

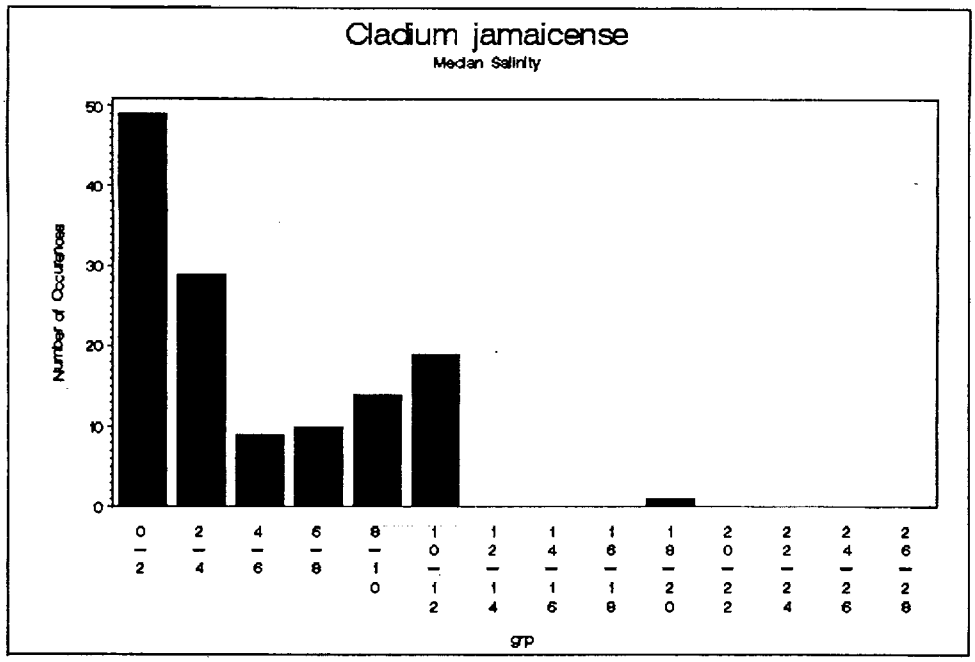


Figure 5.9A. Histogram of median salinity values at sites where *Cladium jamaicense* was recorded.

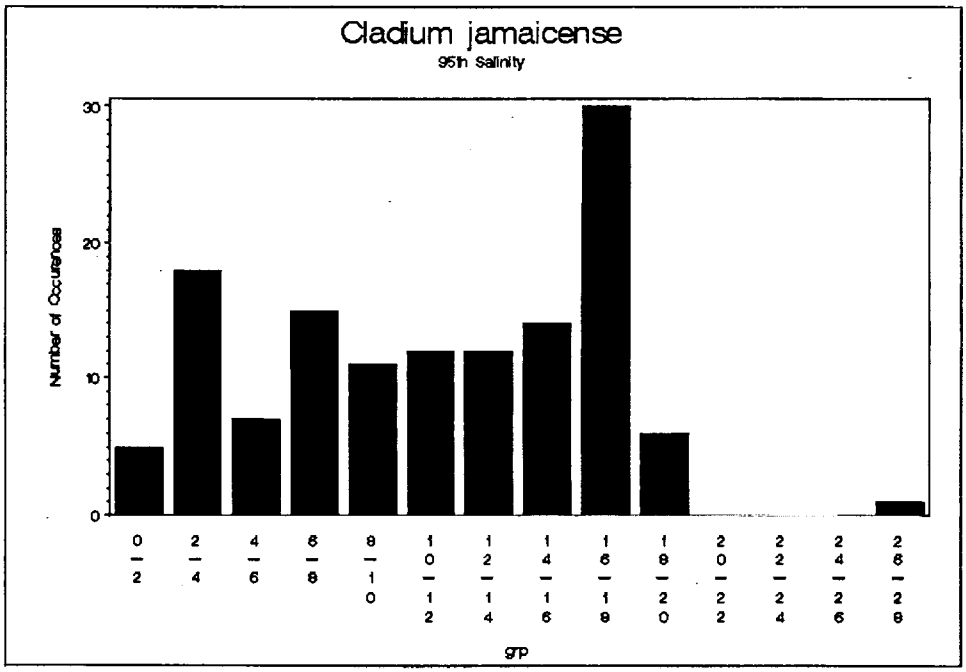


Figure 5.9B. Histogram of 95th percentile salinity values at sites where *Cladium jamaicense* was recorded.

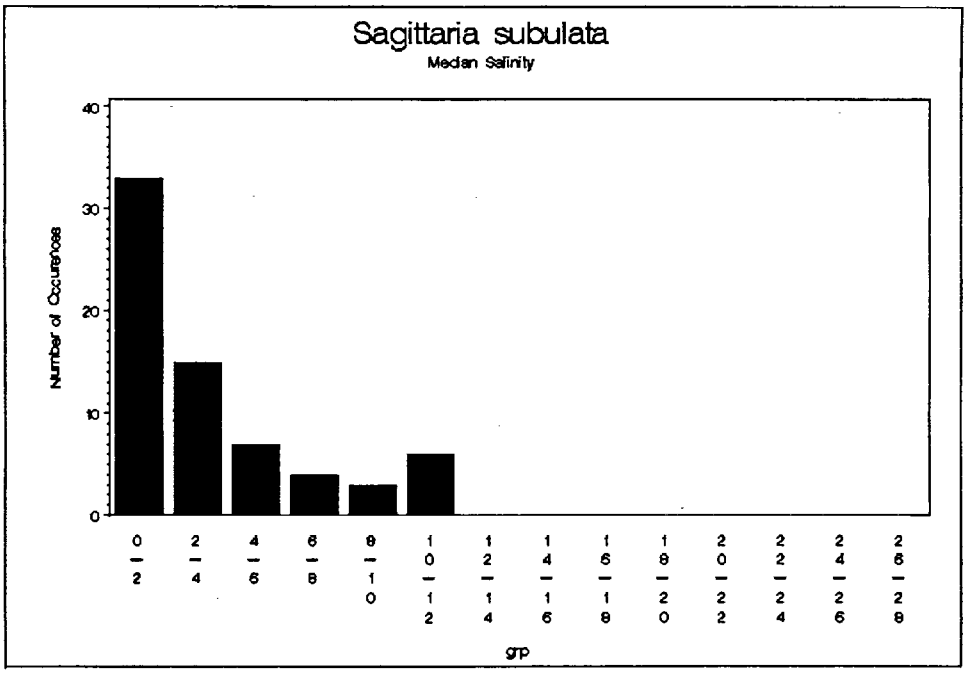


Figure 5.10A. Histogram of median salinity values at sites where *Sagittaria subulata* was recorded.

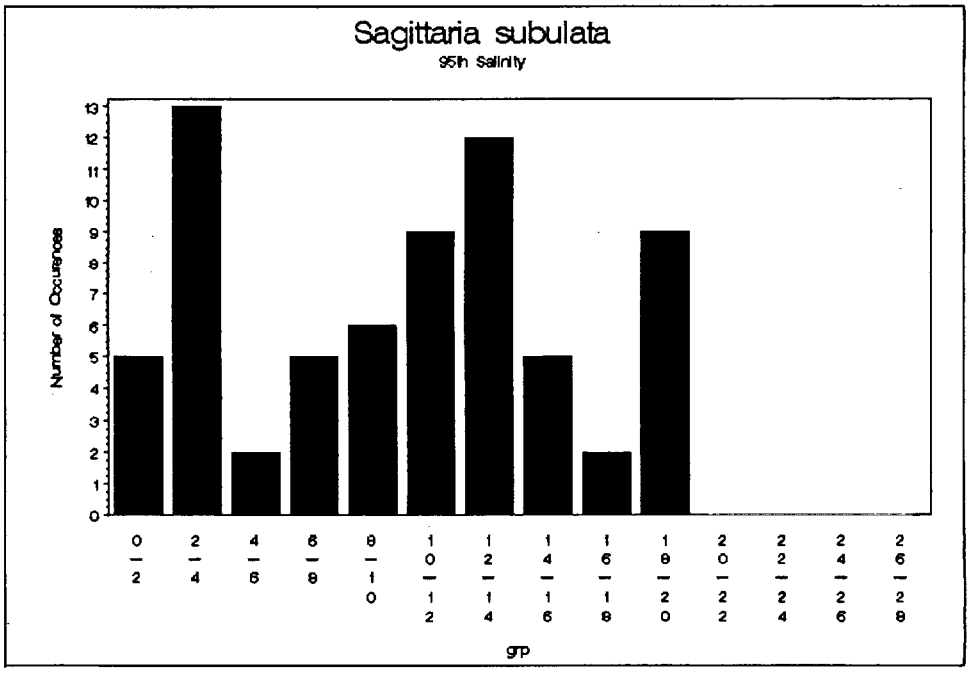


Figure 5.10B. Histogram of 95th percentile salinity values at sites where *Sagittaria subulata* was recorded.

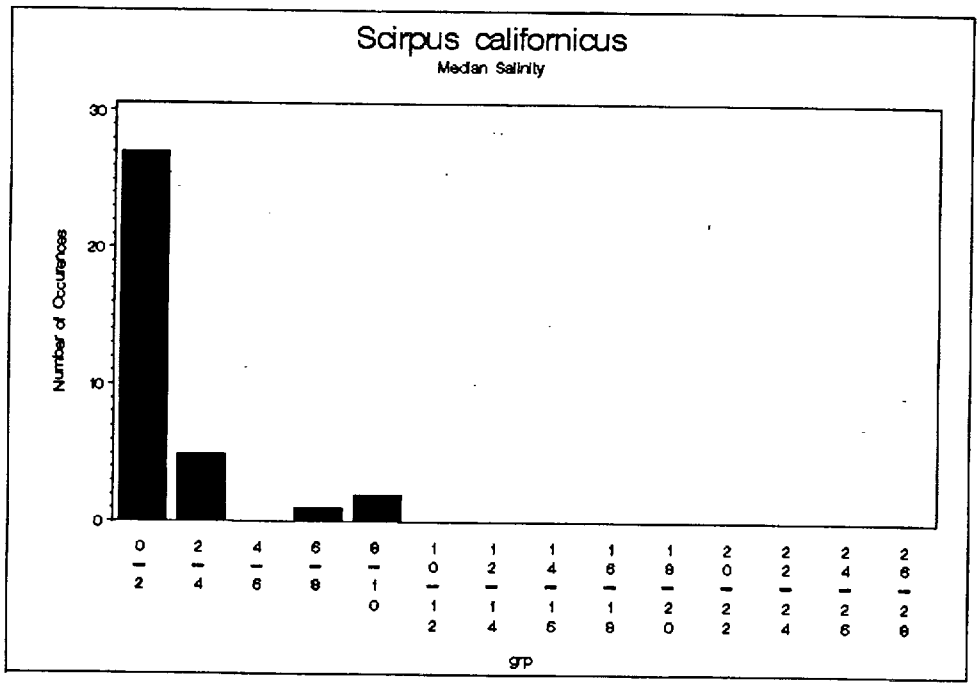


Figure 5.11A. Histogram of median salinity values at sites where Scirpus californicus was recorded.

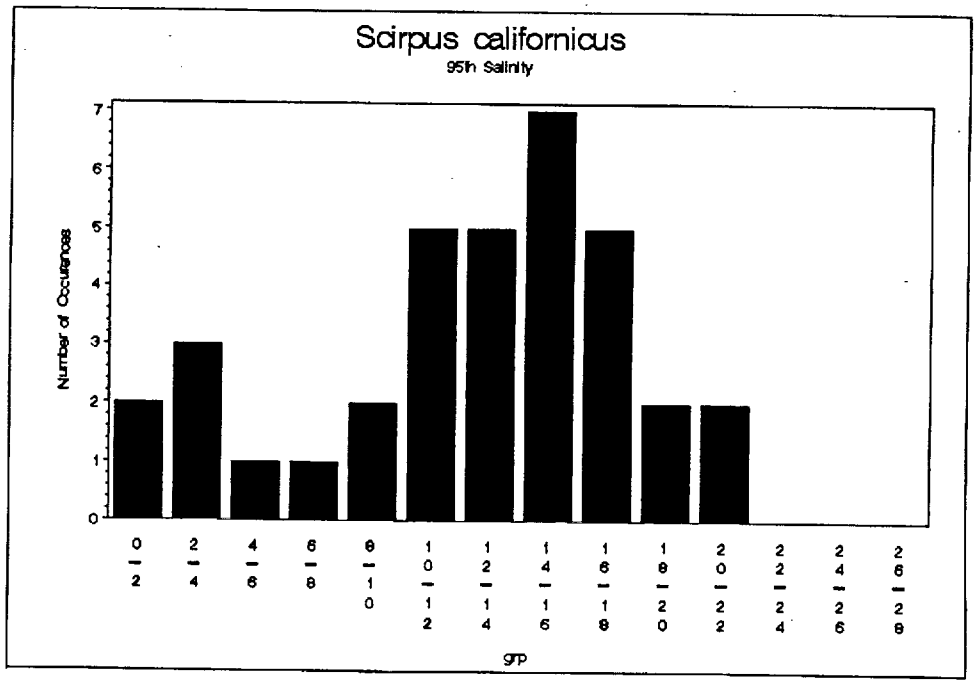


Figure 5.11B. Histogram of 95th percentile salinity values at sites where *Scirpus californicus* was recorded.

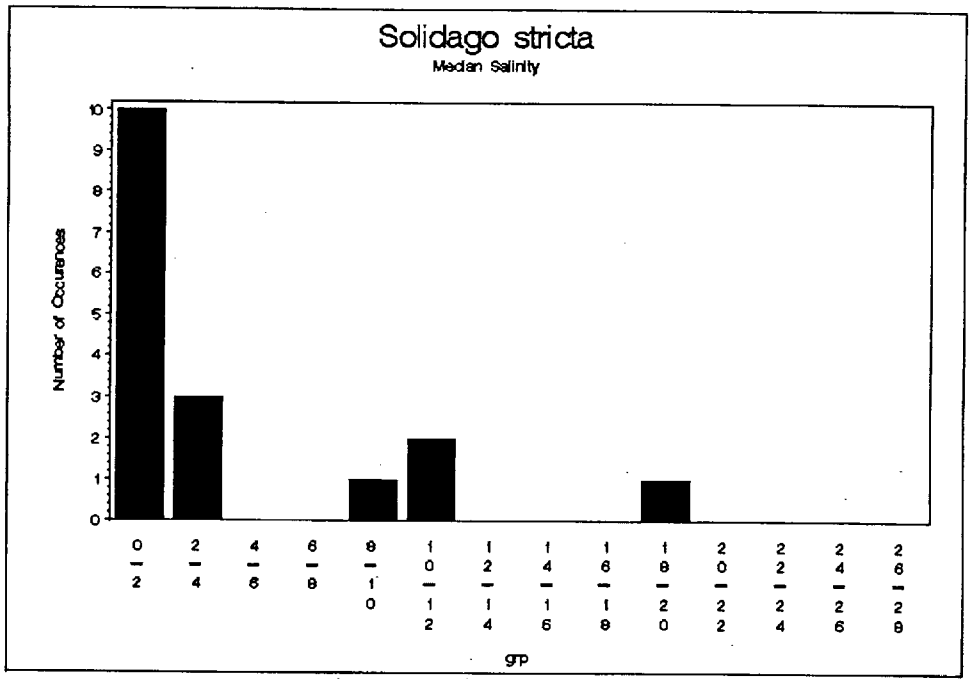


Figure 5.12A. Histogram of median salinity values at sites where *Solidago stricta* was recorded.

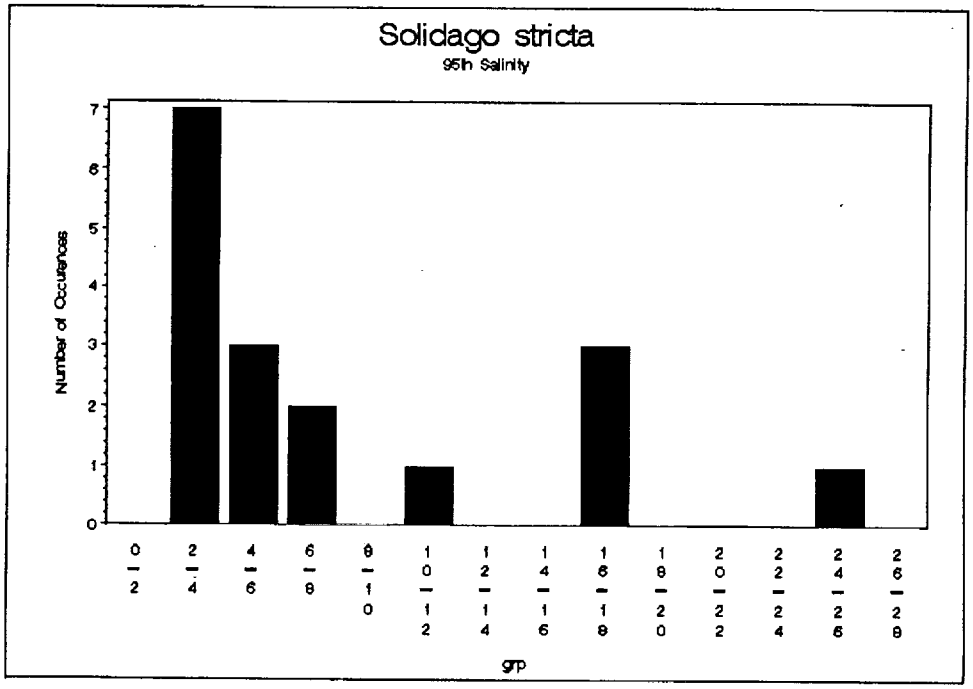


Figure 5.12B. Histogram of 95th percentile salinity values at sites where *Solidago stricta* was recorded.

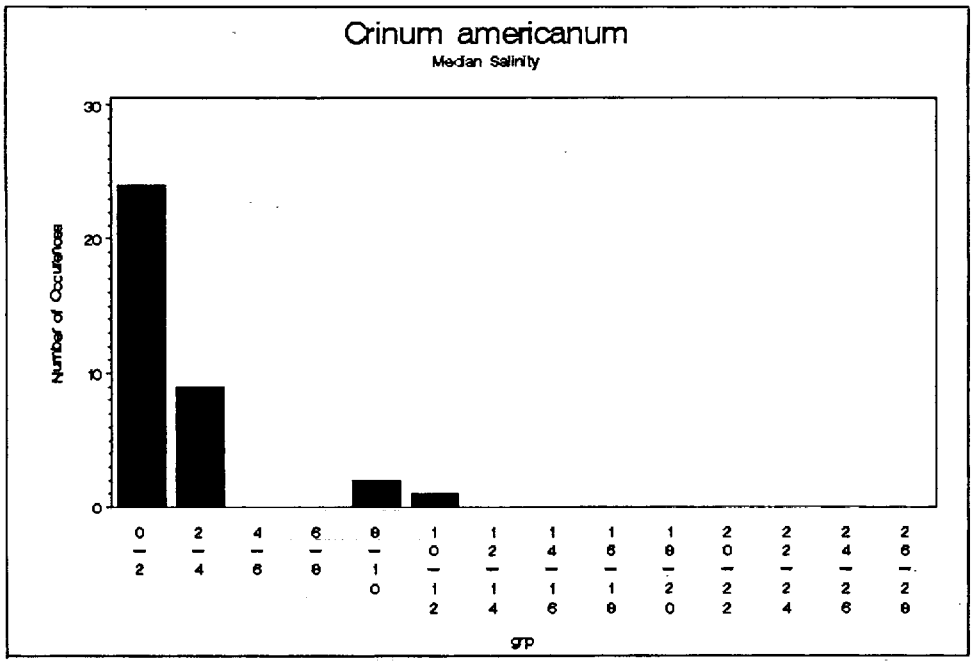


Figure 5.13A. Histogram of median salinity values at sites where *Orinum americanum* was recorded.

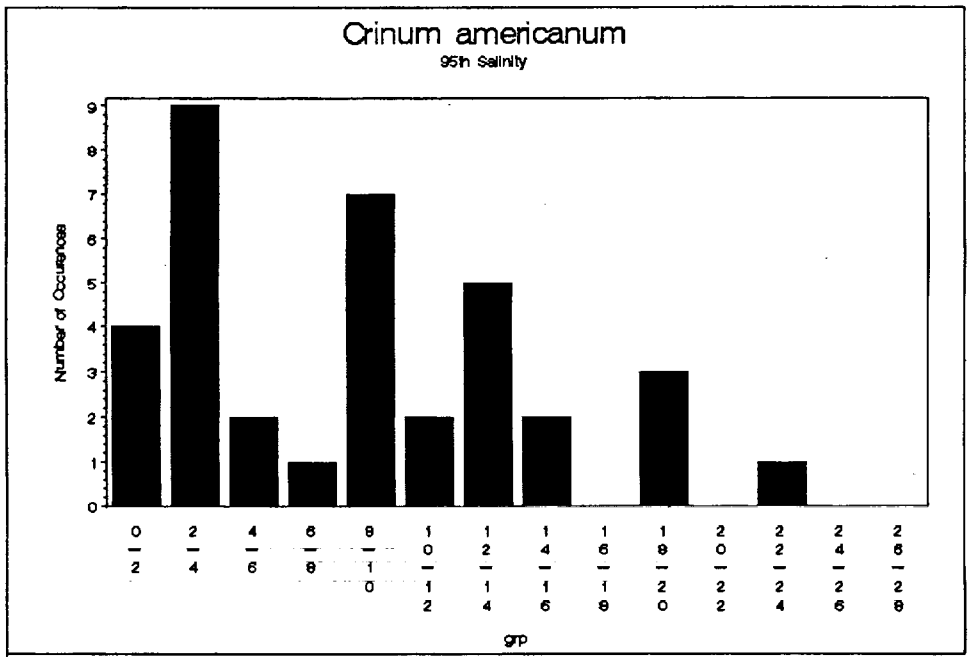


Figure 5.13B. Histogram of 95th percentile salinity values at sites where *Orinum americanum* was recorded.

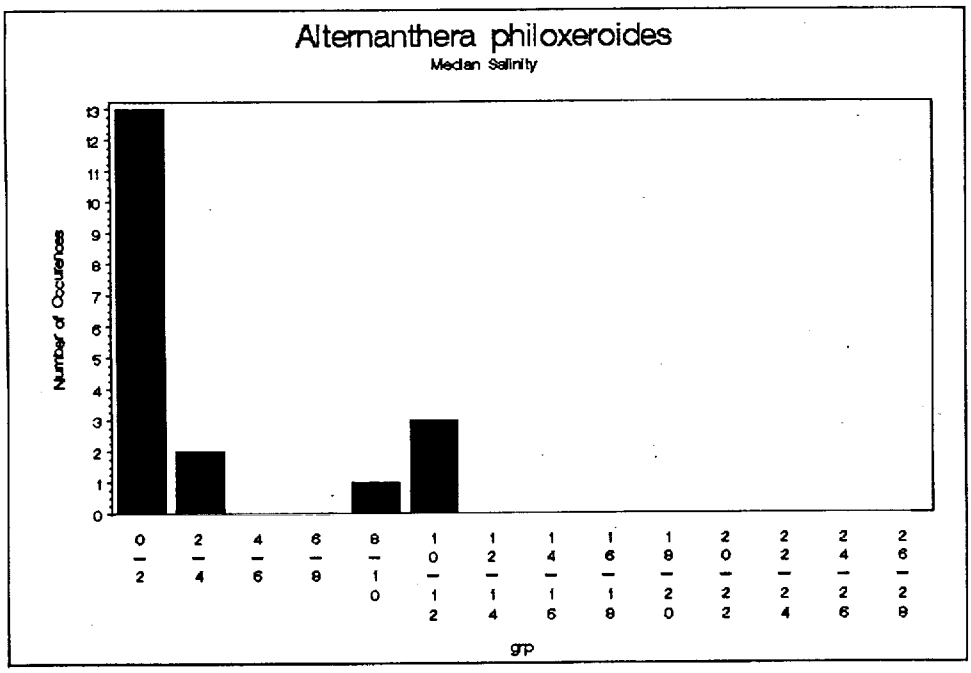


Figure 5.14A. Histogram of median salinity values at sites where *Alternanthera philoxeroides* was recorded.

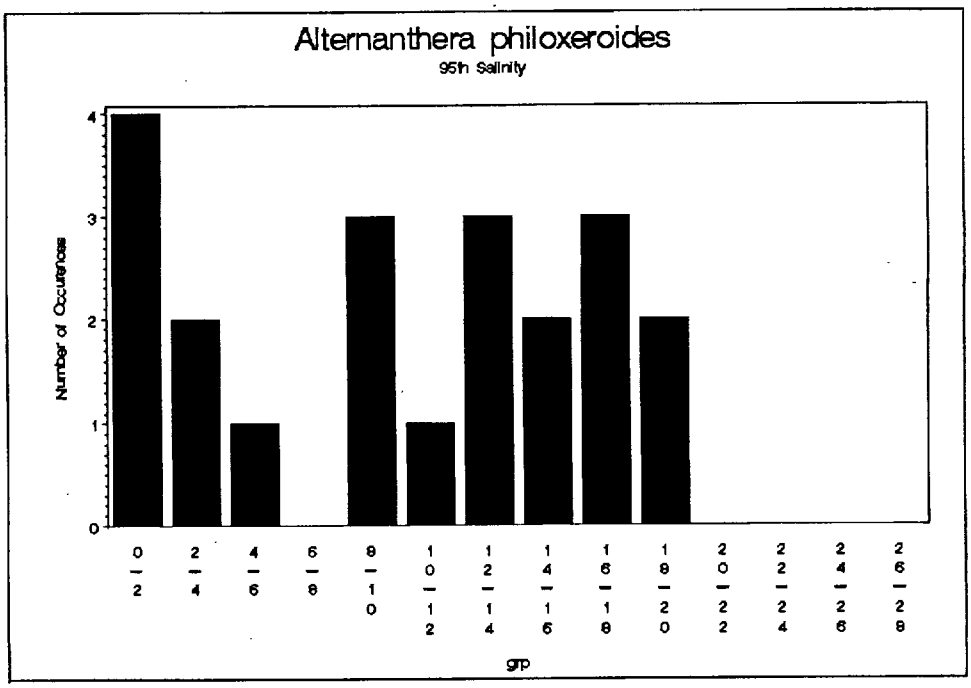


Figure 5.14B. Histogram of 95th percentile salinity values at sties where *Alternanthera philoxeroides* was recorded.

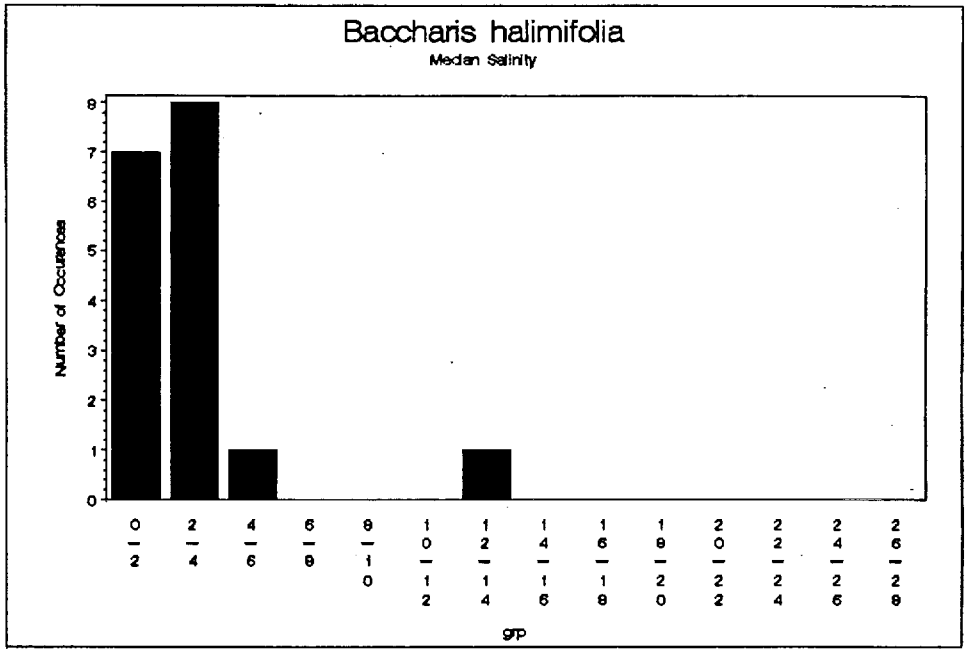


Figure 5.15A. Histogram of median salinity values at sites where *Baccharis halimifolia* was recorded.

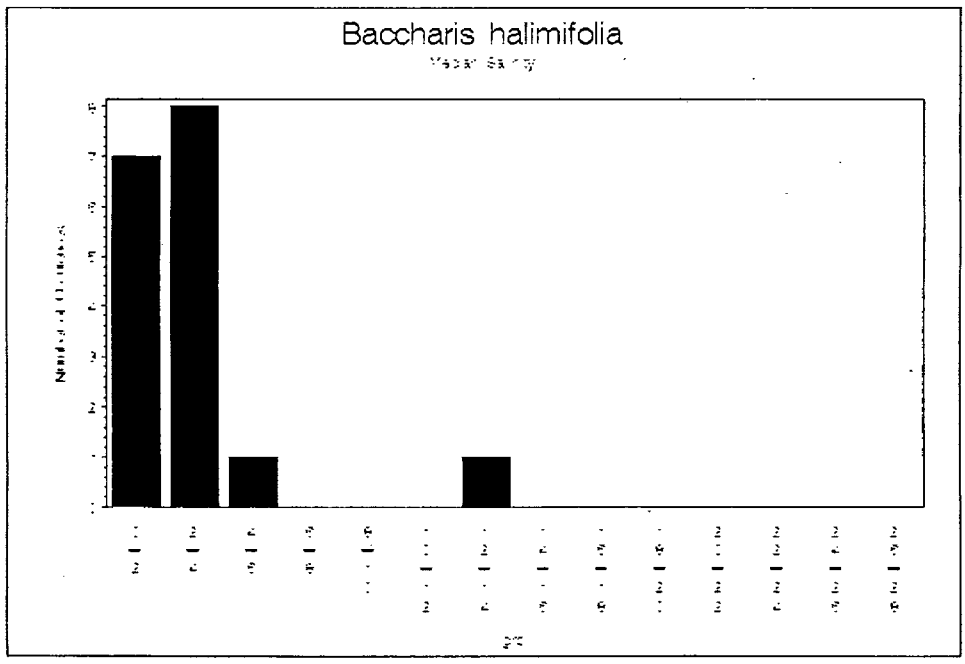


Figure 5.15B. Histogram of 95th percentile salinity values at sites where *Baccharis halimifolia* was recorded.

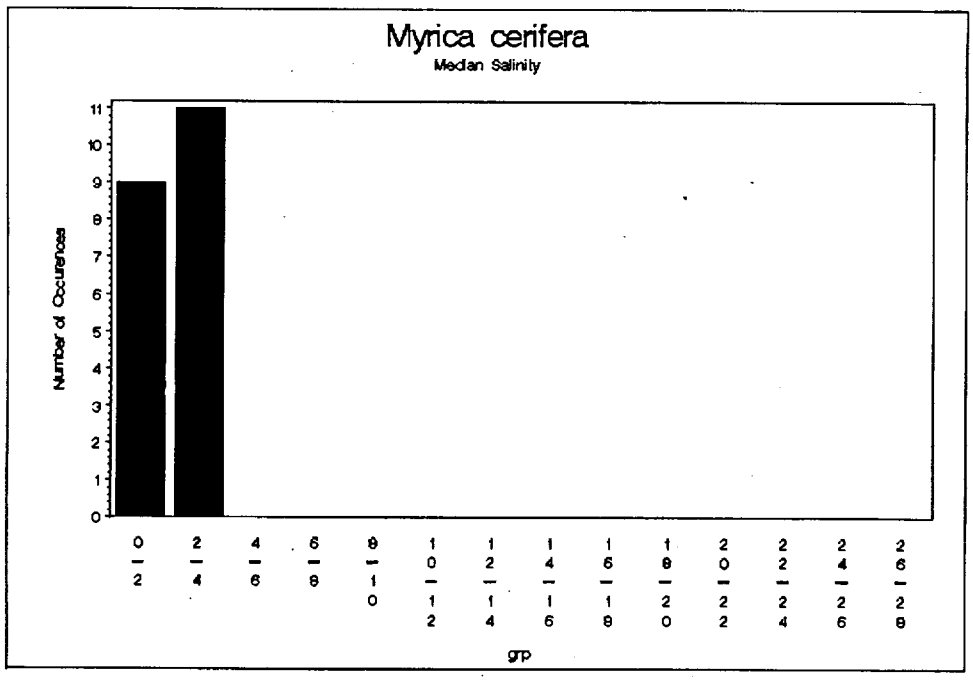


Figure 5.16A. Histogram of median salinity values at sites where *Myrica cerifera* was recorded.

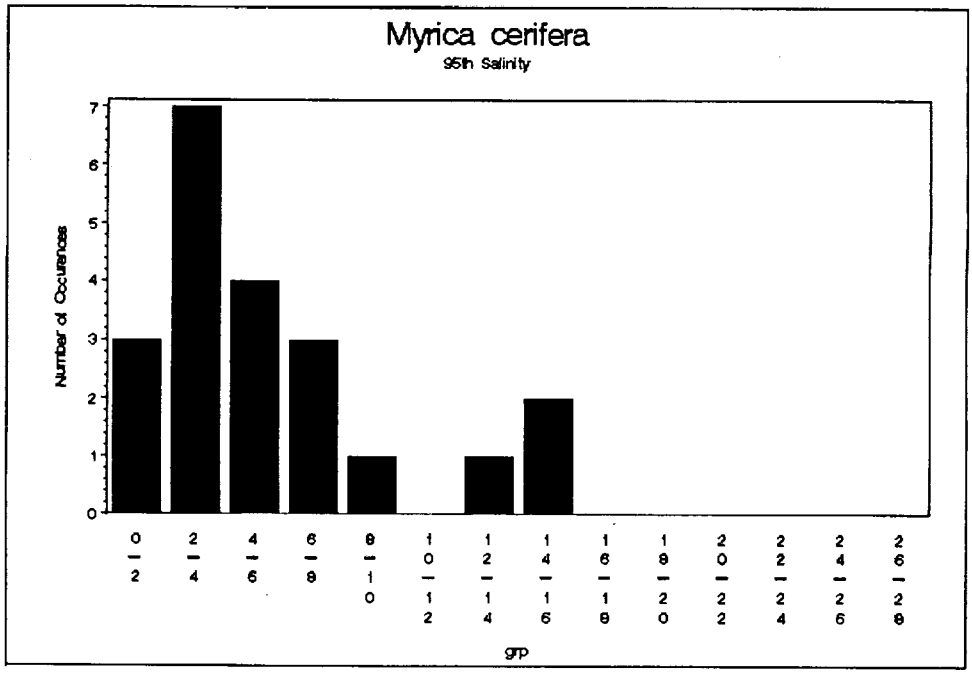


Figure 5.16B. Histogram of 95th percentile salinity values at sites where *Myrica cerifera* was recorded.

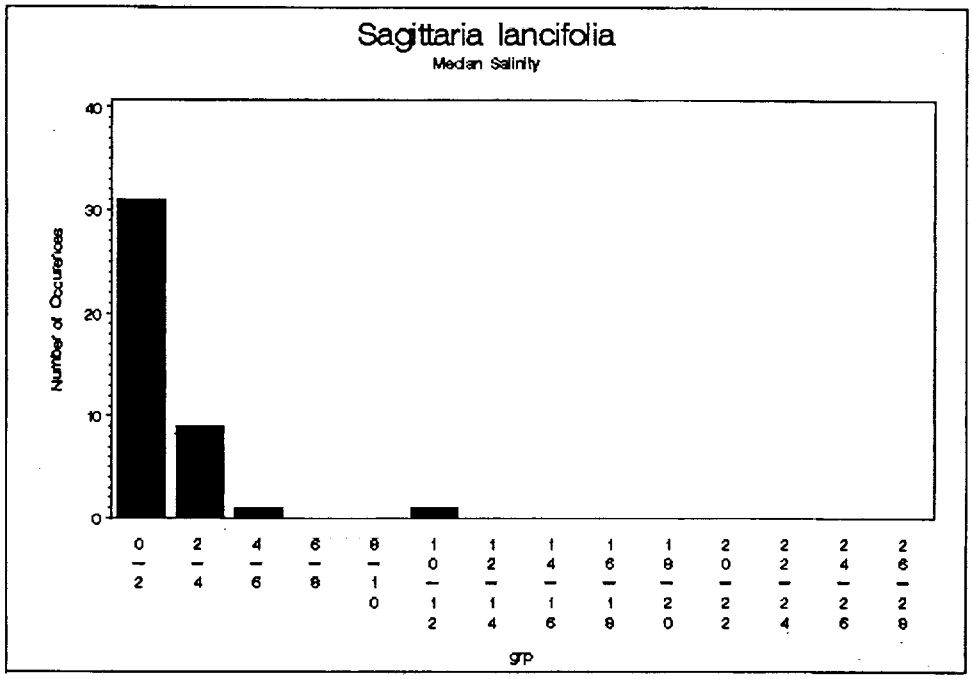


Figure 5.17A Histogram of median salinity values at sites where *Sagittaria lancifolia* was recorded.

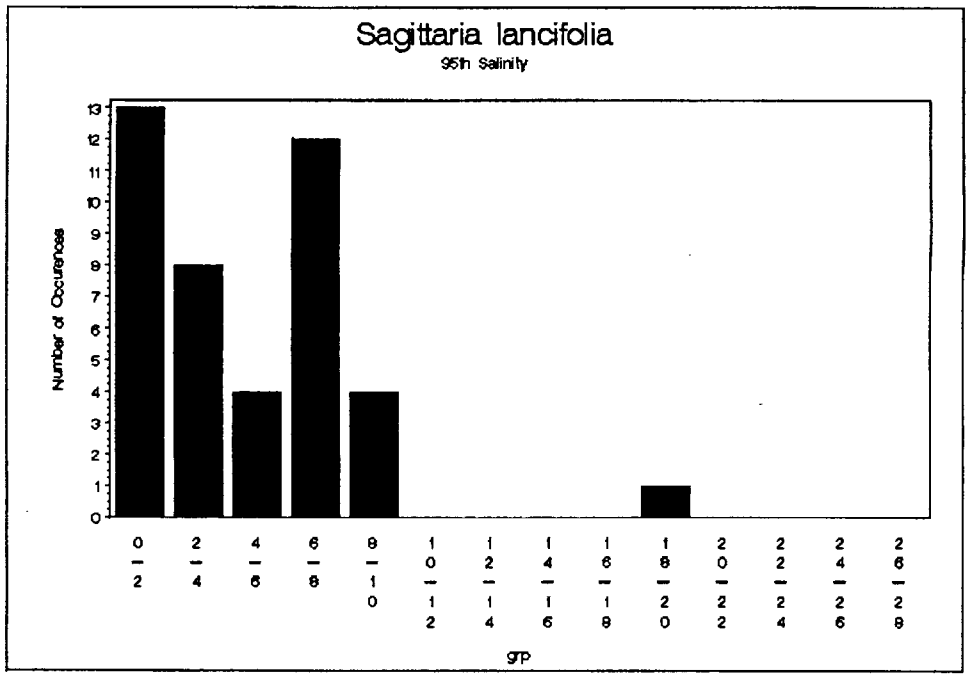


Figure 5.17B Histogram of 95th percentile salinity values at sites where *Sagittaria lancifolia* was recorded.

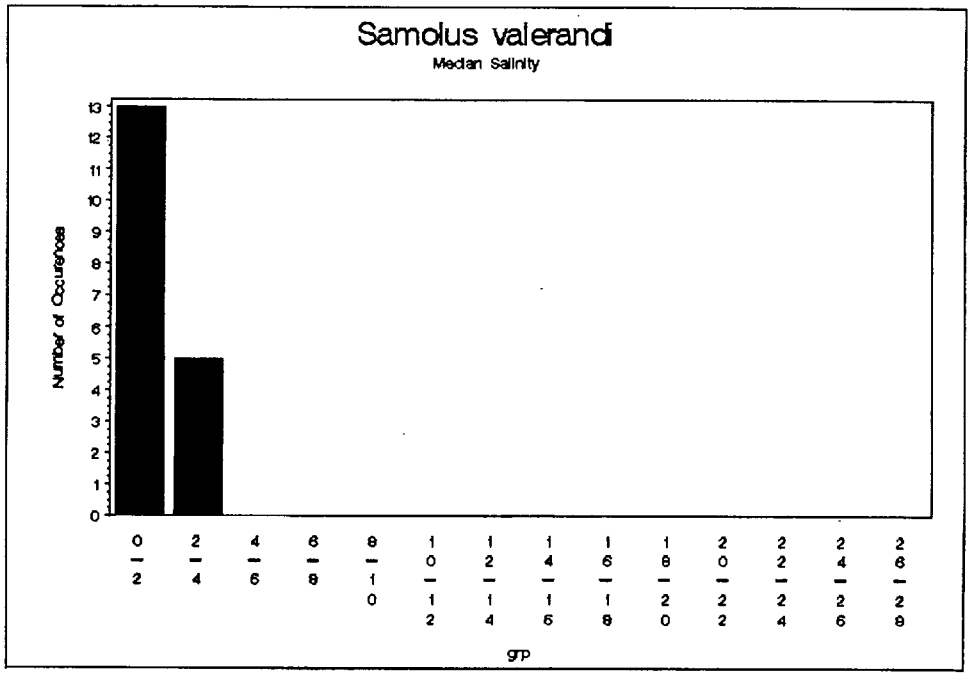


Figure 5.18A. Histogram of median salinity values at sites where *Samolus valerandi* was recorded.

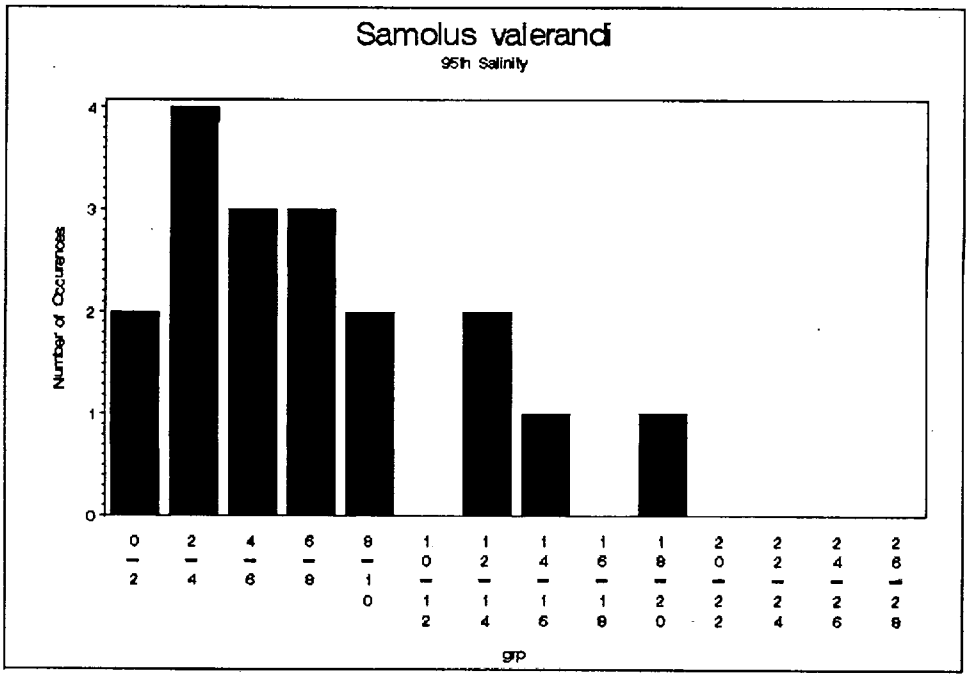


Figure 5.18B. Histogram of 95th percentile salinity values at sites where *Samolus valerandi* was recorded.

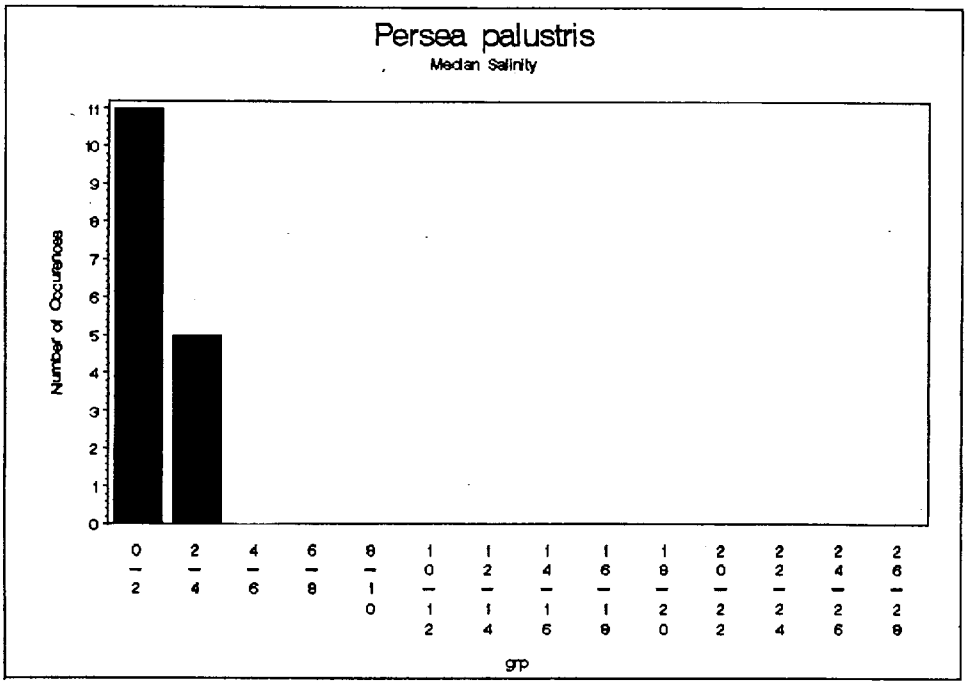


Figure 5.19A. Histogram of median salinity values at sites where *Persea palustris* was recorded.

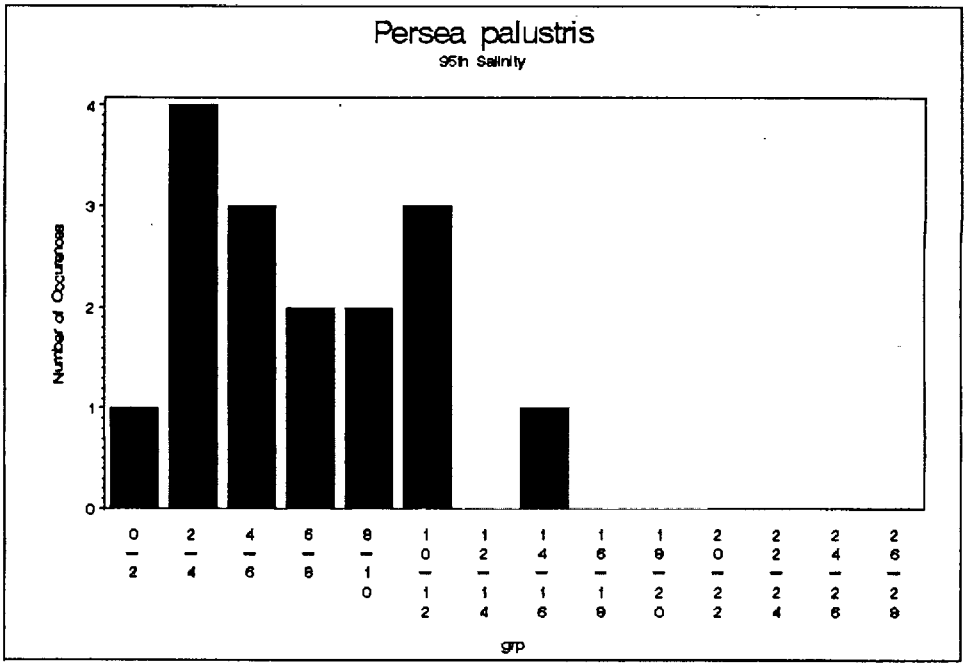


Figure 5.19B Histogram of 95th percentile salinity values at sites where *Persea palustris* was recorded.

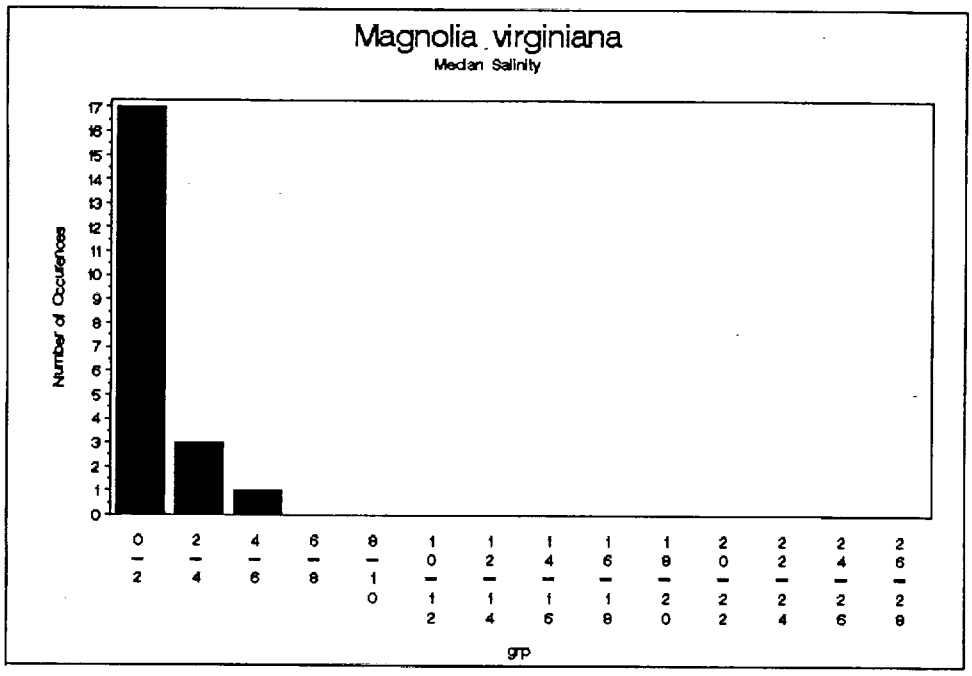


Figure 5.20A Histogram of median salinity values at sites where *Magnolia virginiana* was recorded.

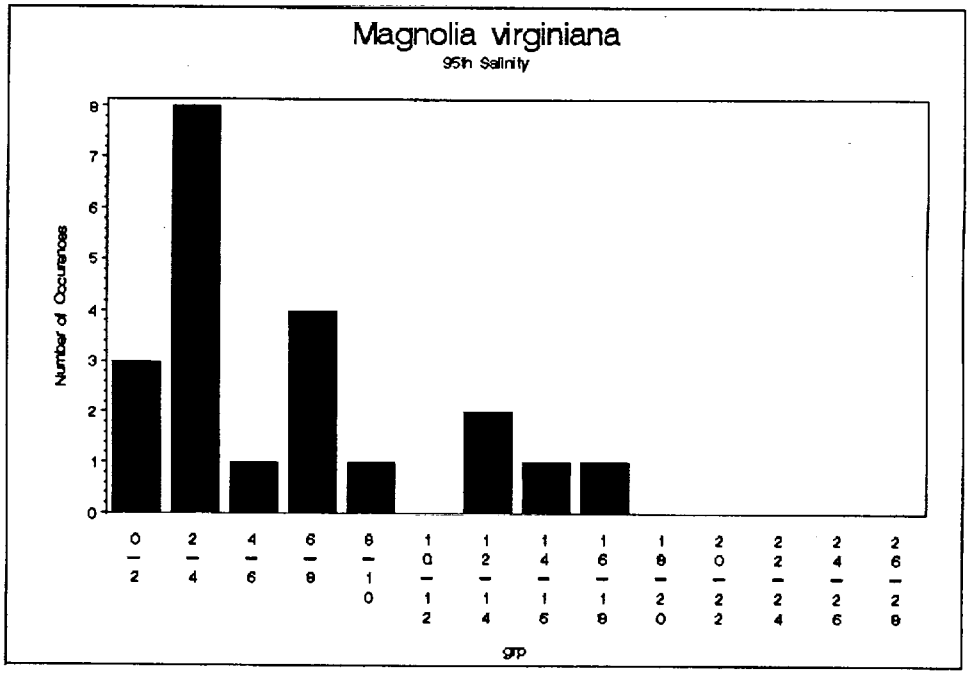


Figure 5.20B Histogram of 95th percentile salinity values at sites where *Magnolia virginiana* was recorded.

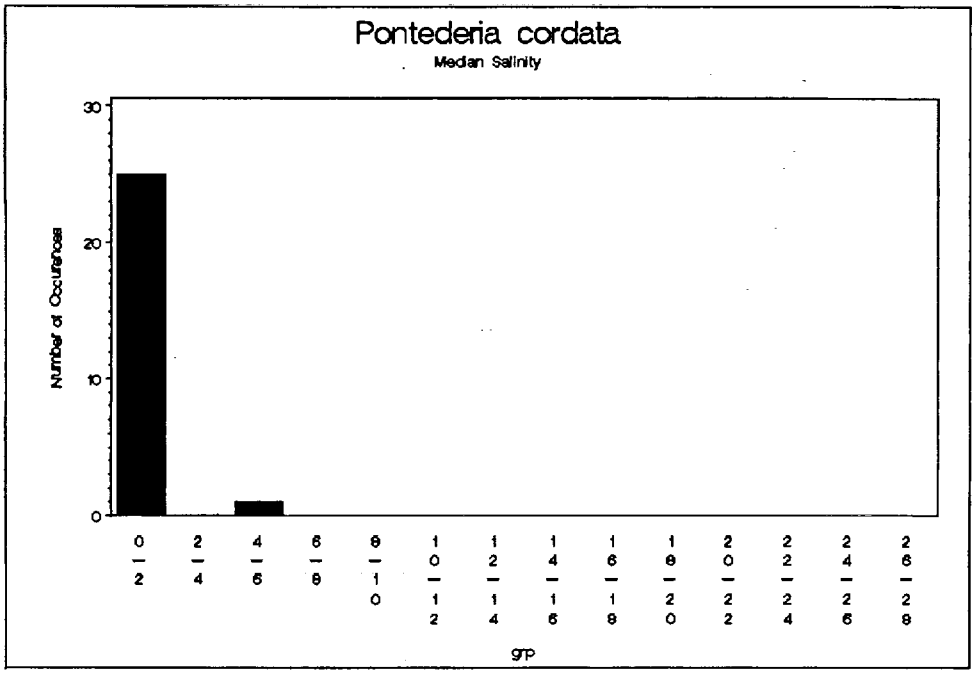


Figure 5.21A. Histogram of median salinity values at sites where *Pontederia cordata* was recorded.

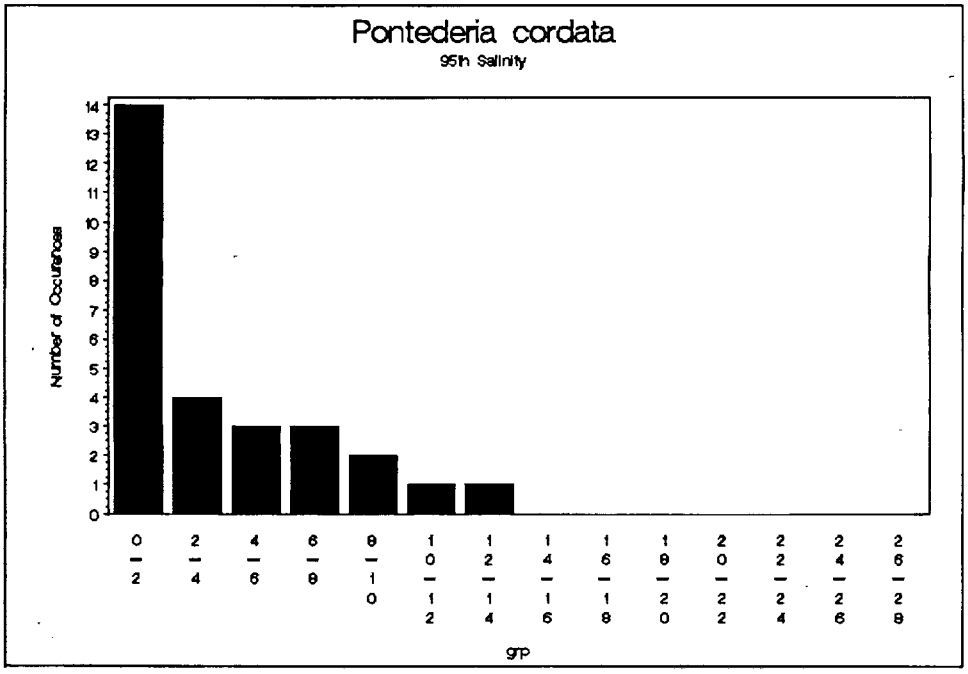


Figure 5.21B. Histogram of 95th percentile salinity values at sites where *Pontederia cordata* was recorded.

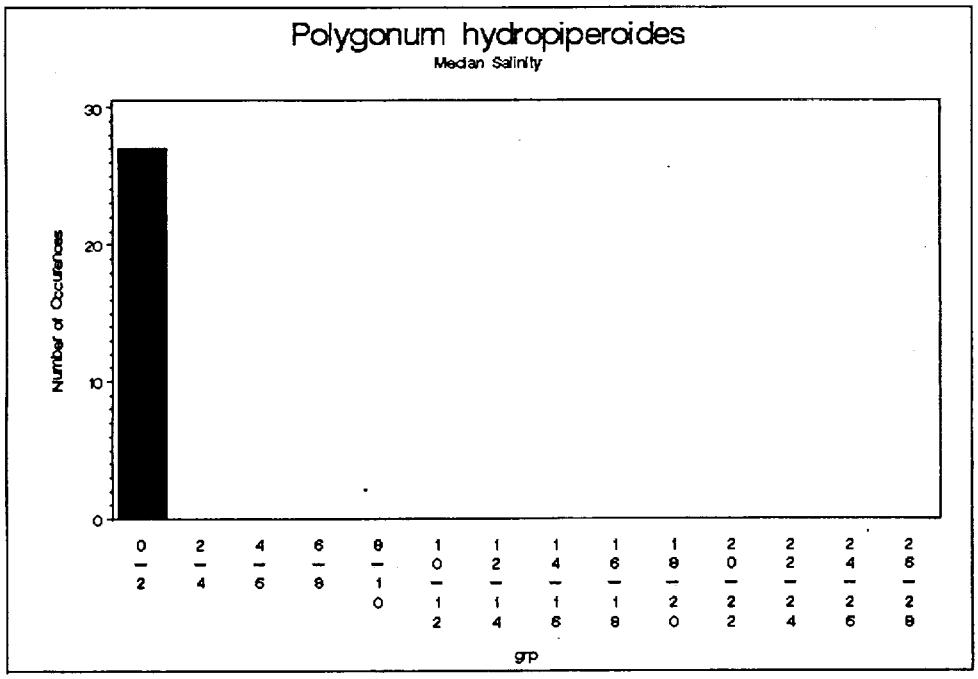


Figure 5.22A. Histogram of median salinity values at sites where *Polygonum hydropiperoides* was recorded.

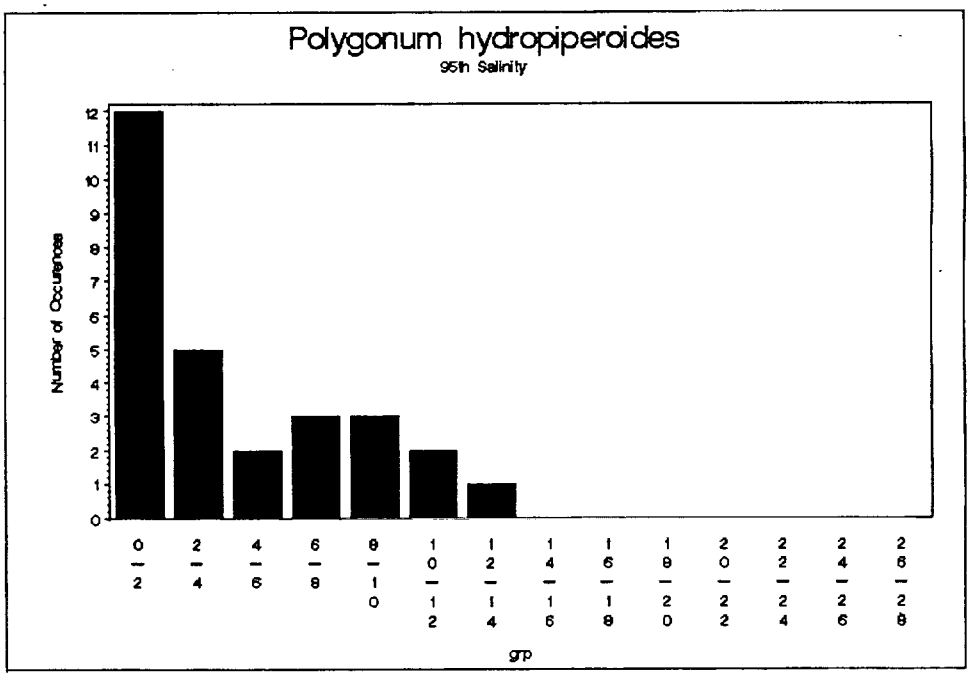


Figure 5.22B. Histogram of 95th percentile salinity values at sites where *Polygonum hydropiperoides* was recorded.

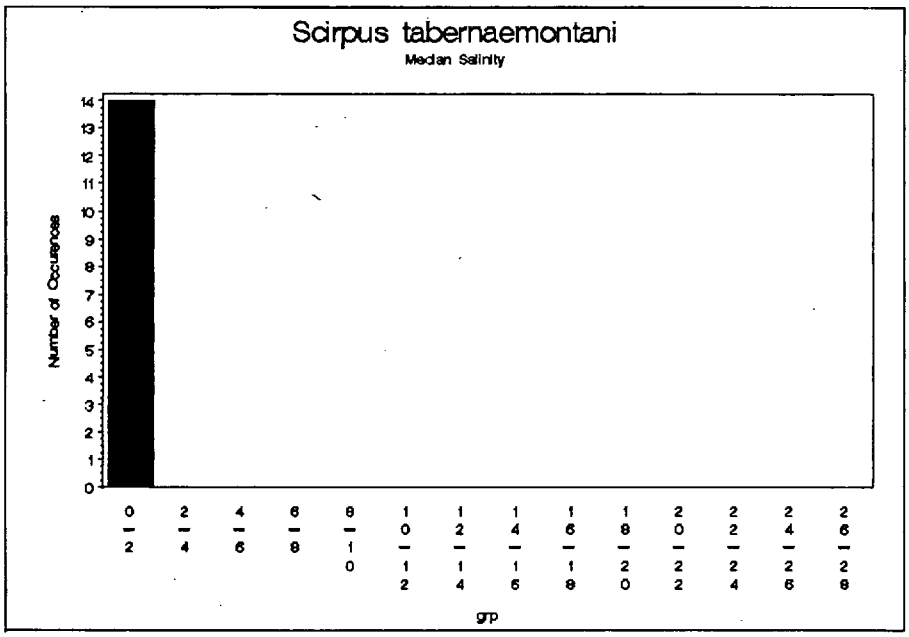


Figure 5.23A. Histogram of median salinity values at sites where Scirpus *tabernaemontani* was recorded.

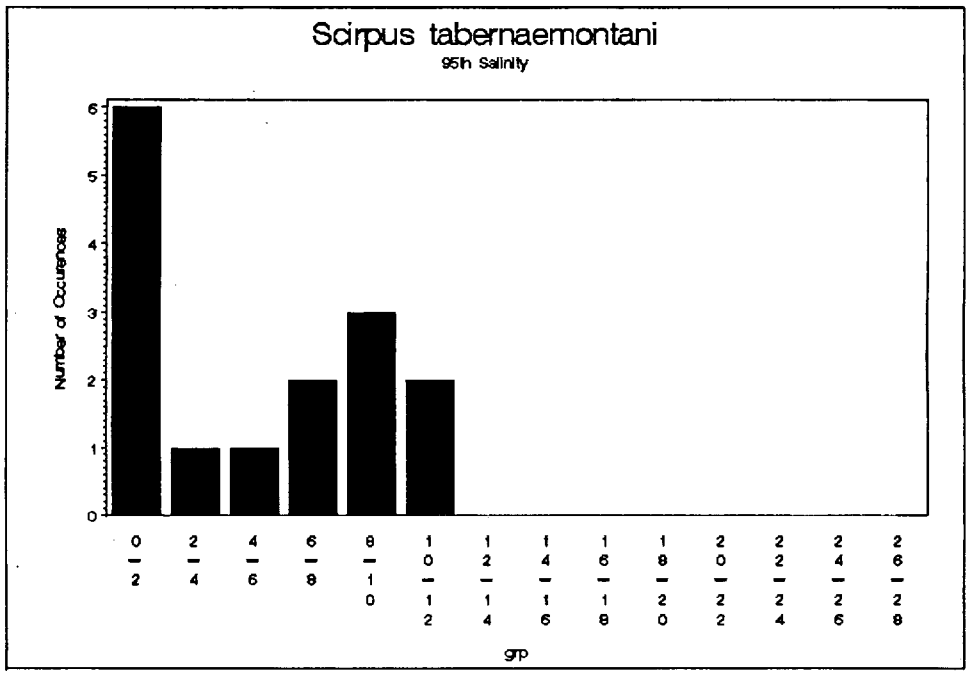


Figure 5.23B. Histogram of 95th percentile salinity values at sites where *Scirpus tabernaemontani* was recorded.

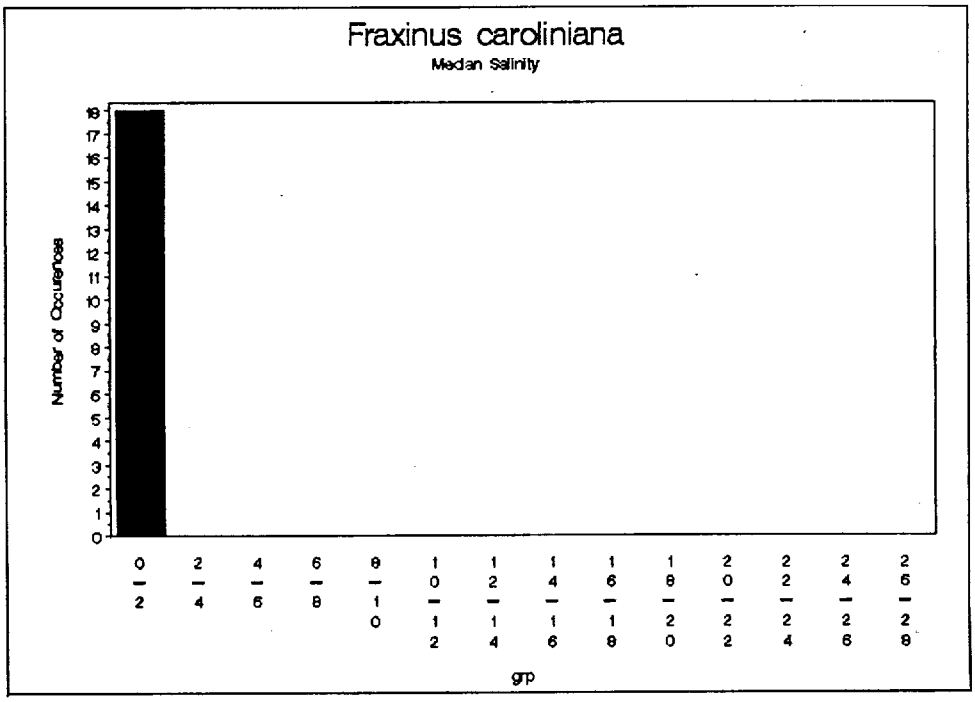


Figure 5.24A Histogram of median salinity values at sites where *Fraxinus caroliniana* was recorded

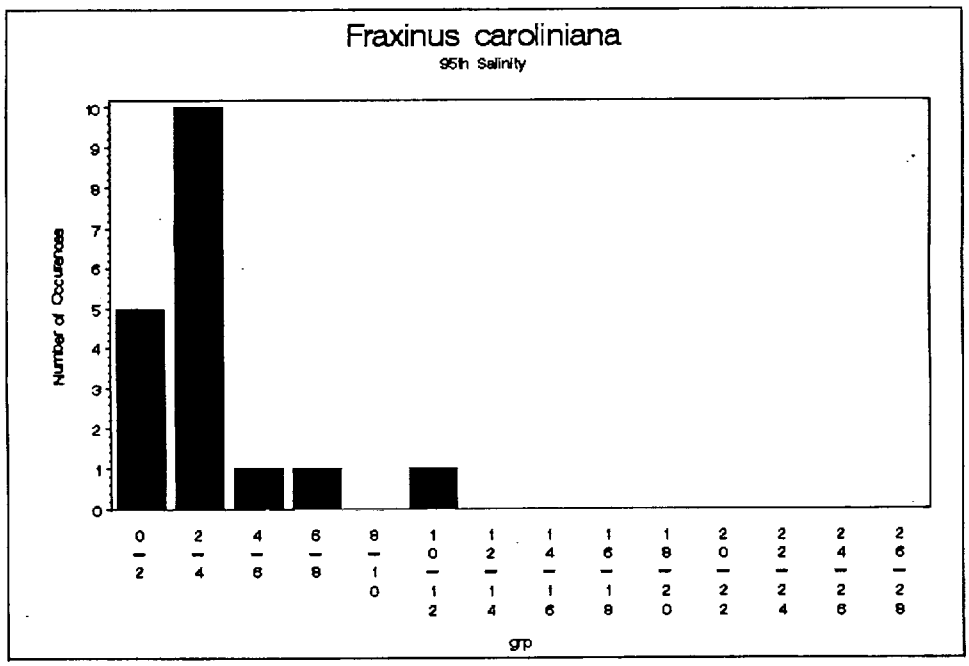


Figure 5.24B. Histogram of 95th percentile salinity values at sites where *Fraxinus caroliniana* was recorded.

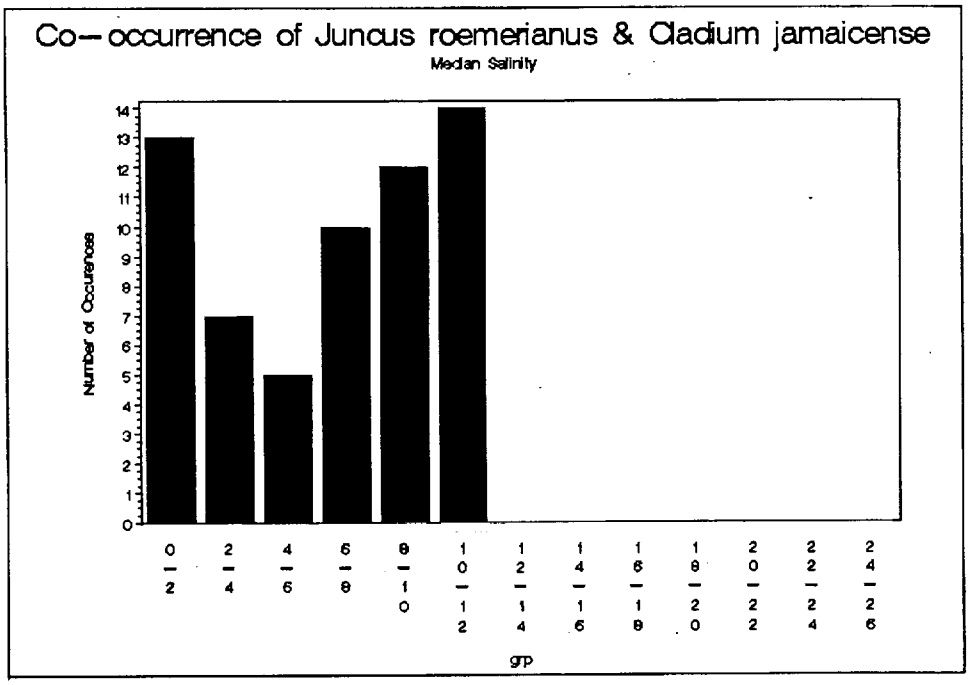


Figure 5.25A. Histogram of median salinity values at sites where *Juncus roemerianus* and *Cladium jamaicense* were both recorded

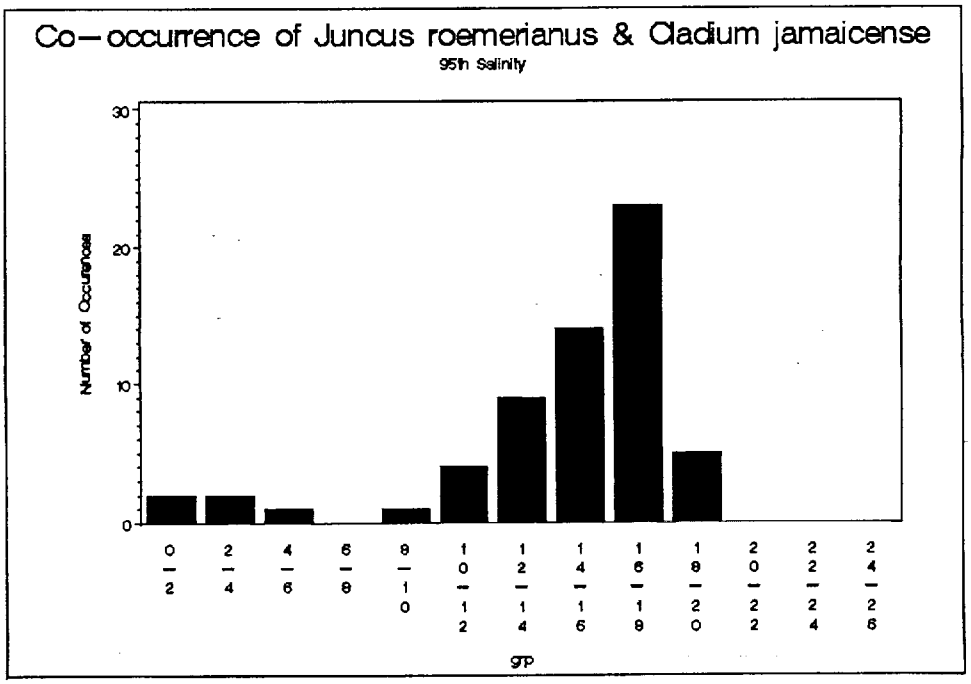


Figure 5.25B. Histogram of 95th percentile salinity values at sites where *Juncus roemerianus* and *Cladium jamaicense* were both recorded

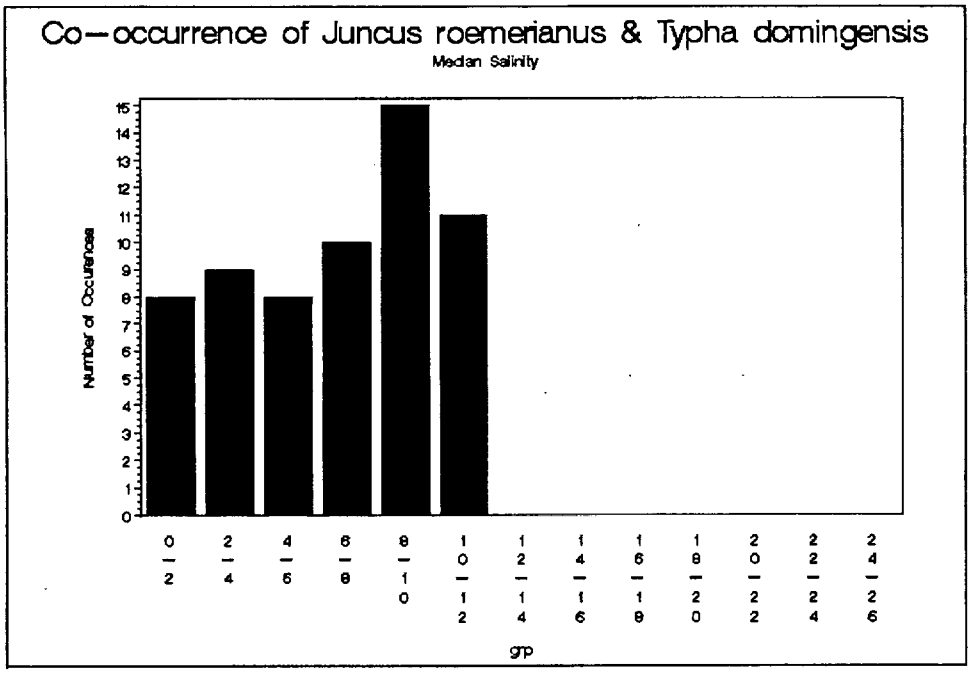


Figure 5.26A. Histogram of median salinity values at sites where *Juncus roemerianus* and *Typha domingensis* were both recorded.

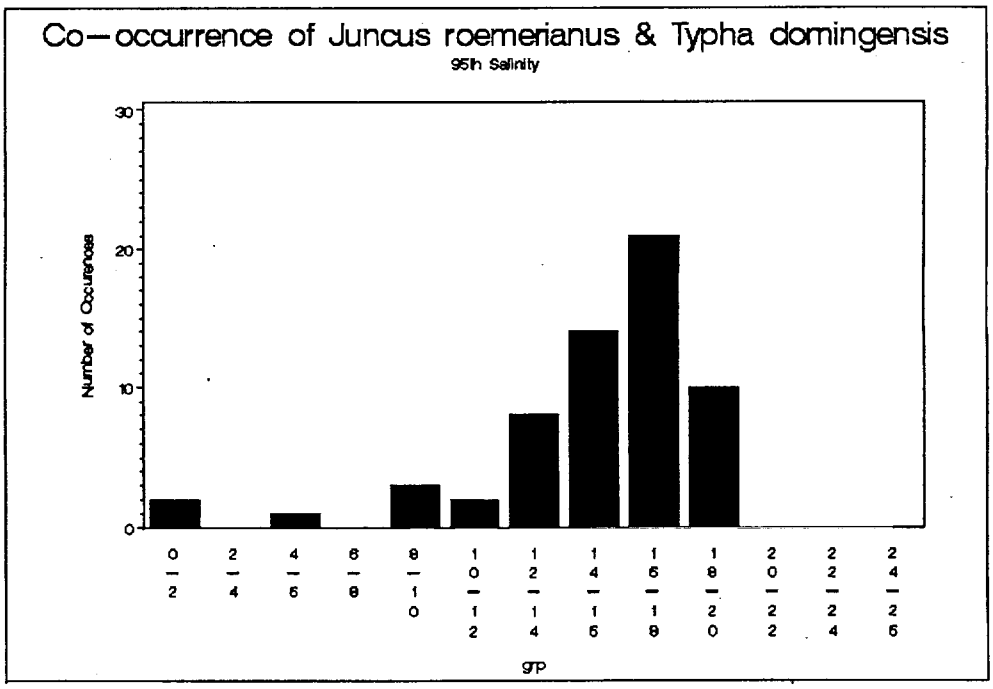


Figure 5.26B. Histogram of 95th percentile salinity values at sites where *Juncus roemerianus* and *Typha domingensis* were both recorded.

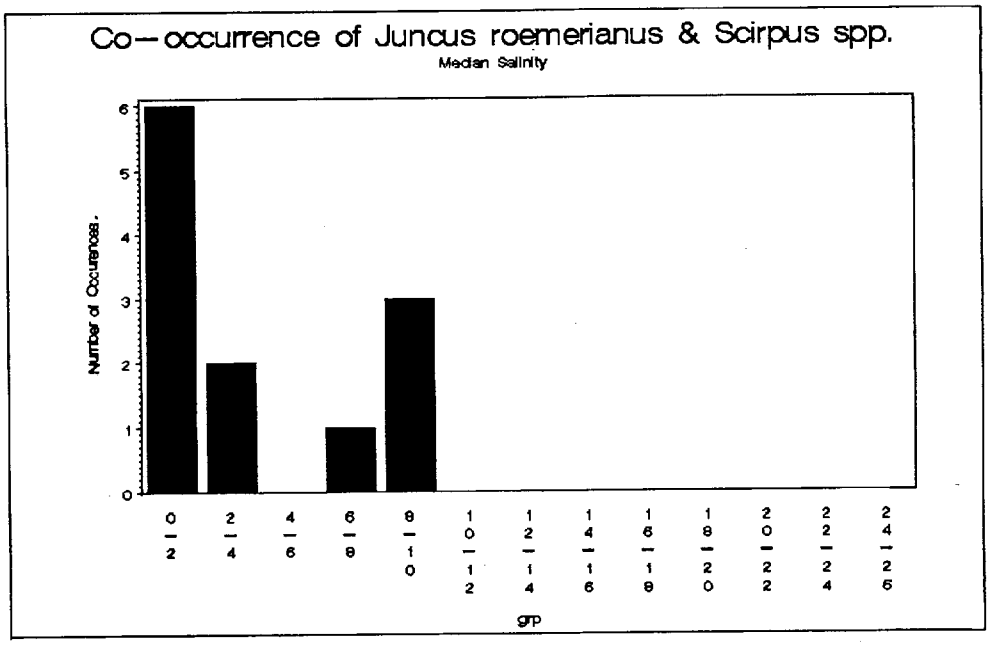


Figure 5.27A. Histogram of median salinity values at sites where *Juncus roemerianus* and *S`cirpus spp.* were both recorded

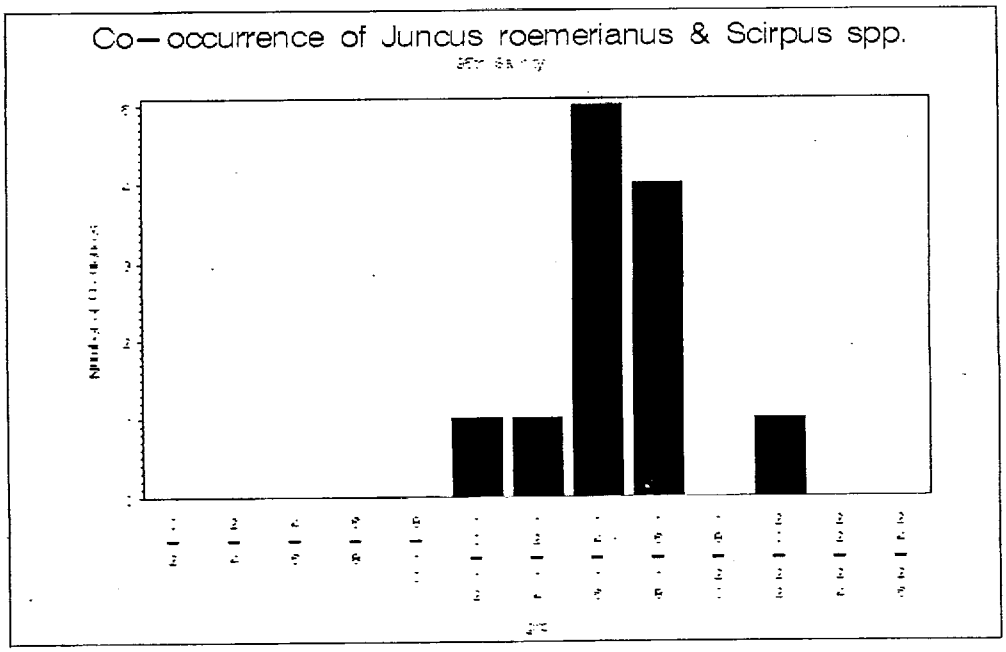


Figure 5.27B. Histogram of 95th percentile salinity values at sites where *Juncus roemerianus* and *Scirpus spp.* were both recorded

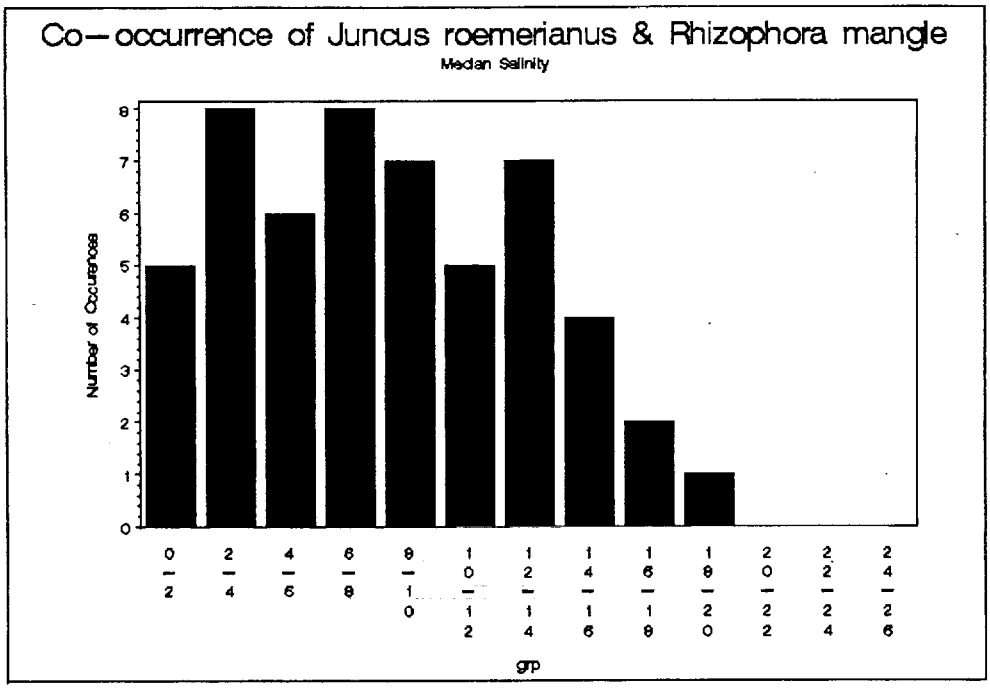


Figure 5.28A. Histogram of median salinity values at sites where *Juncus roemerianus* and *Rhizophora mangle* were both recorded

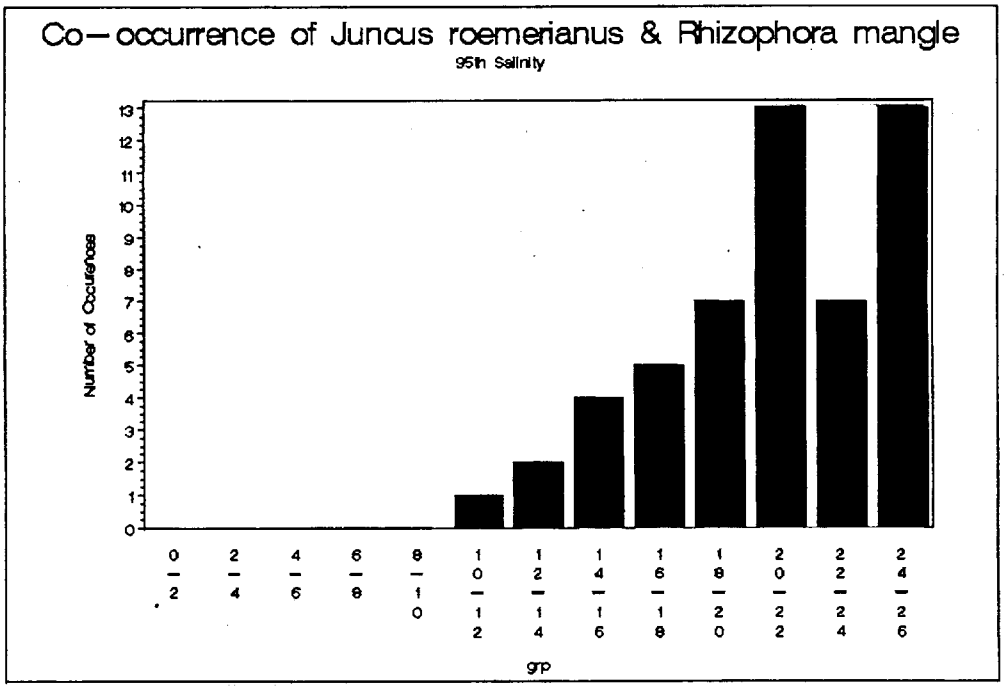


Figure 5.28B. Histogram of 95th percentile salinity values at sites where *Juncus roemerianus* and *Rhizophora mangle* were both recorded

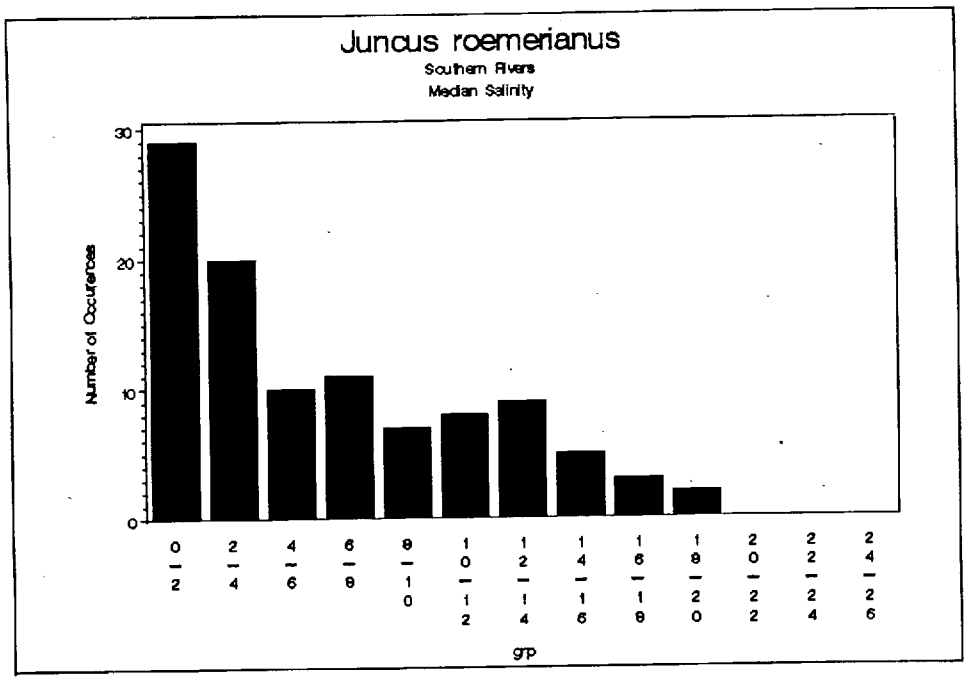


Figure 5.29A. Histogram of median salinity values for sites where *Juncus roemerianus* was recorded on the three southern rivers

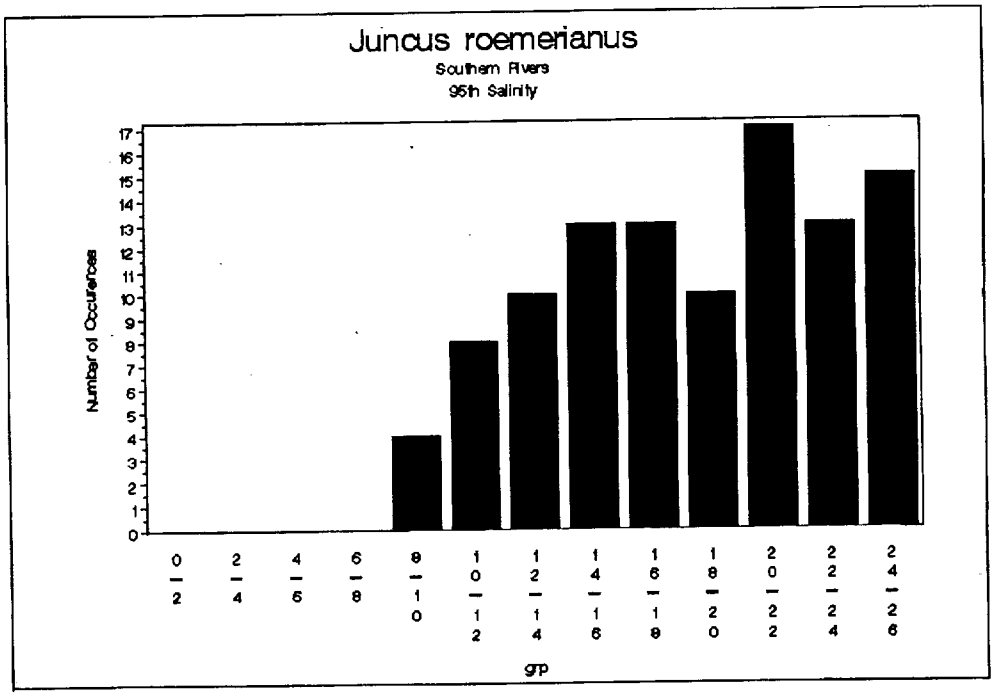


Figure 5.29B. Histogram of 95th percentile salinity values for sites where *Juncus roemerianus* was recorded on the three southern rivers

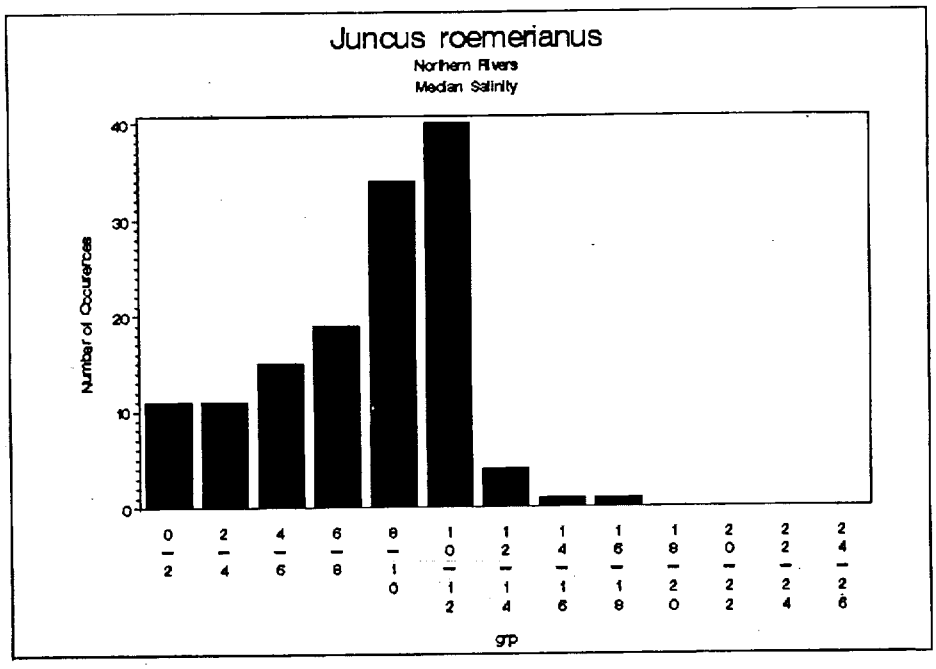


Figure 5.30A. Histogram of median salinity values for sites where *Juncus roemerianus* was recorded on the four northern rivers

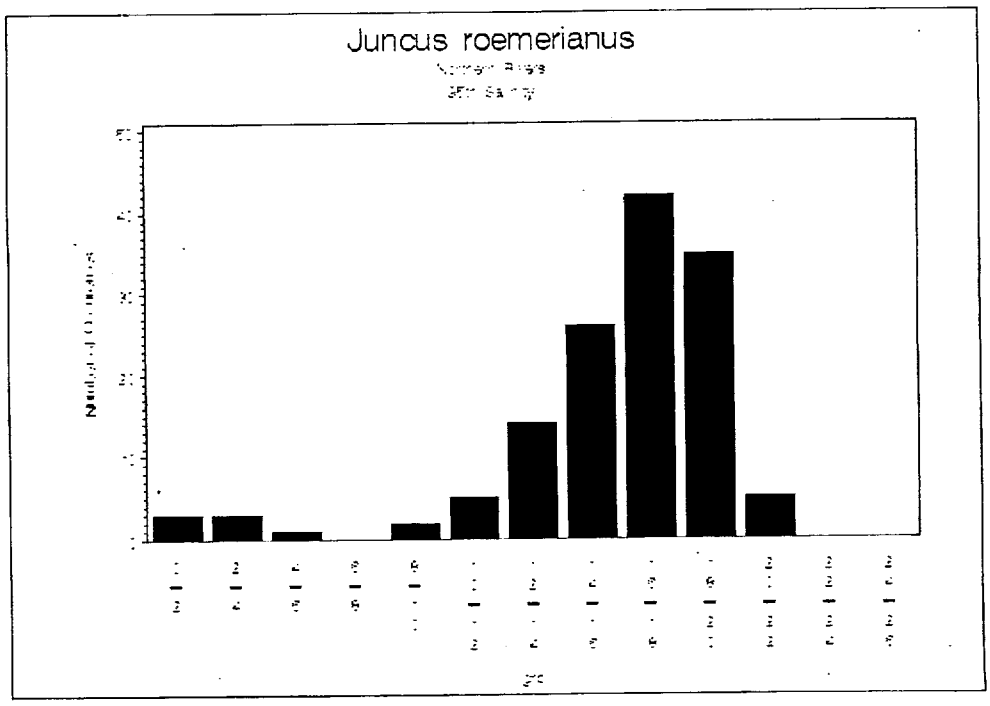


Figure 5.30B. Histogram of 95th percentile salinity values for sites where *Juncus roemerianus* was recorded on the four northern rivers

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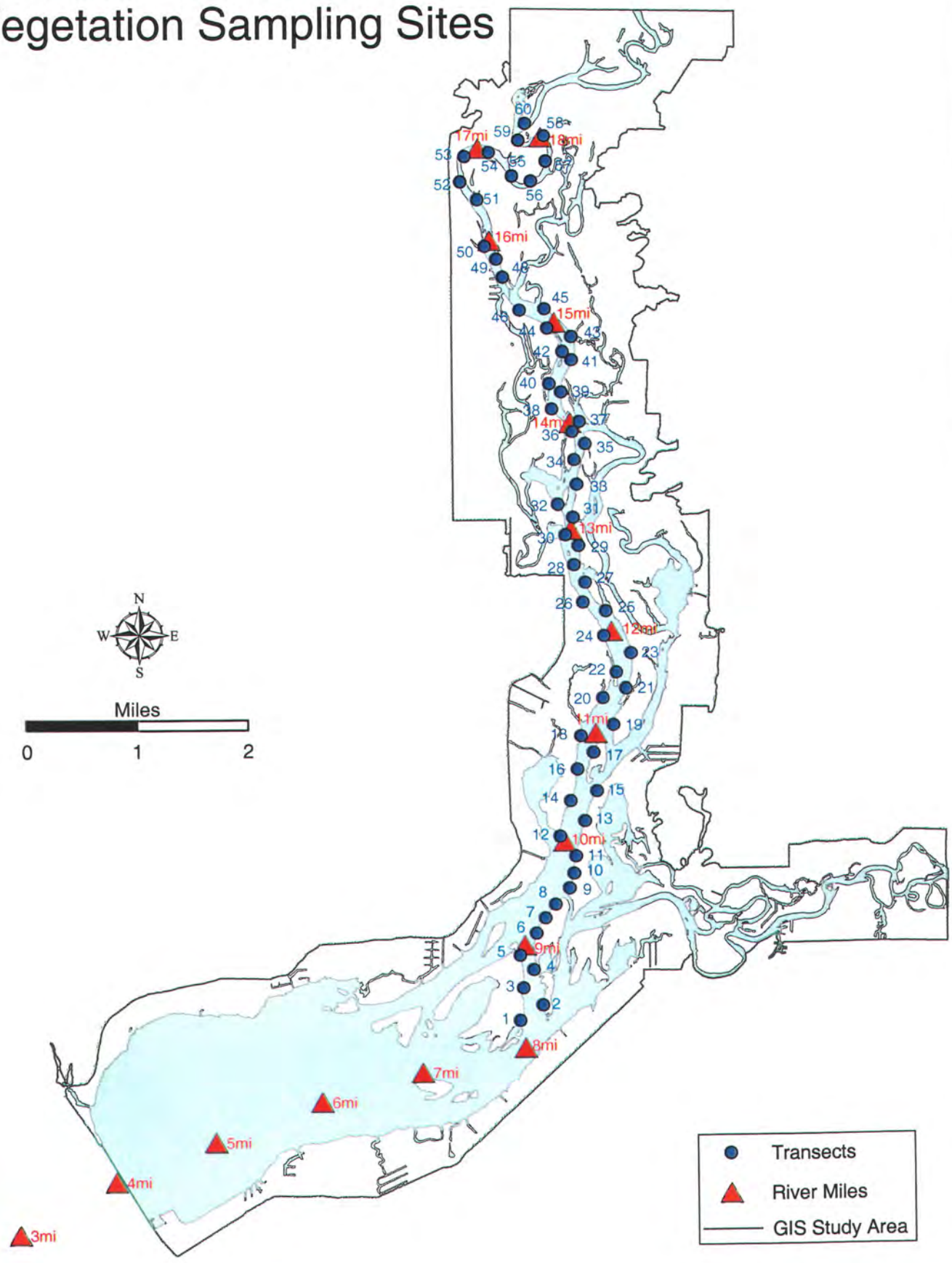
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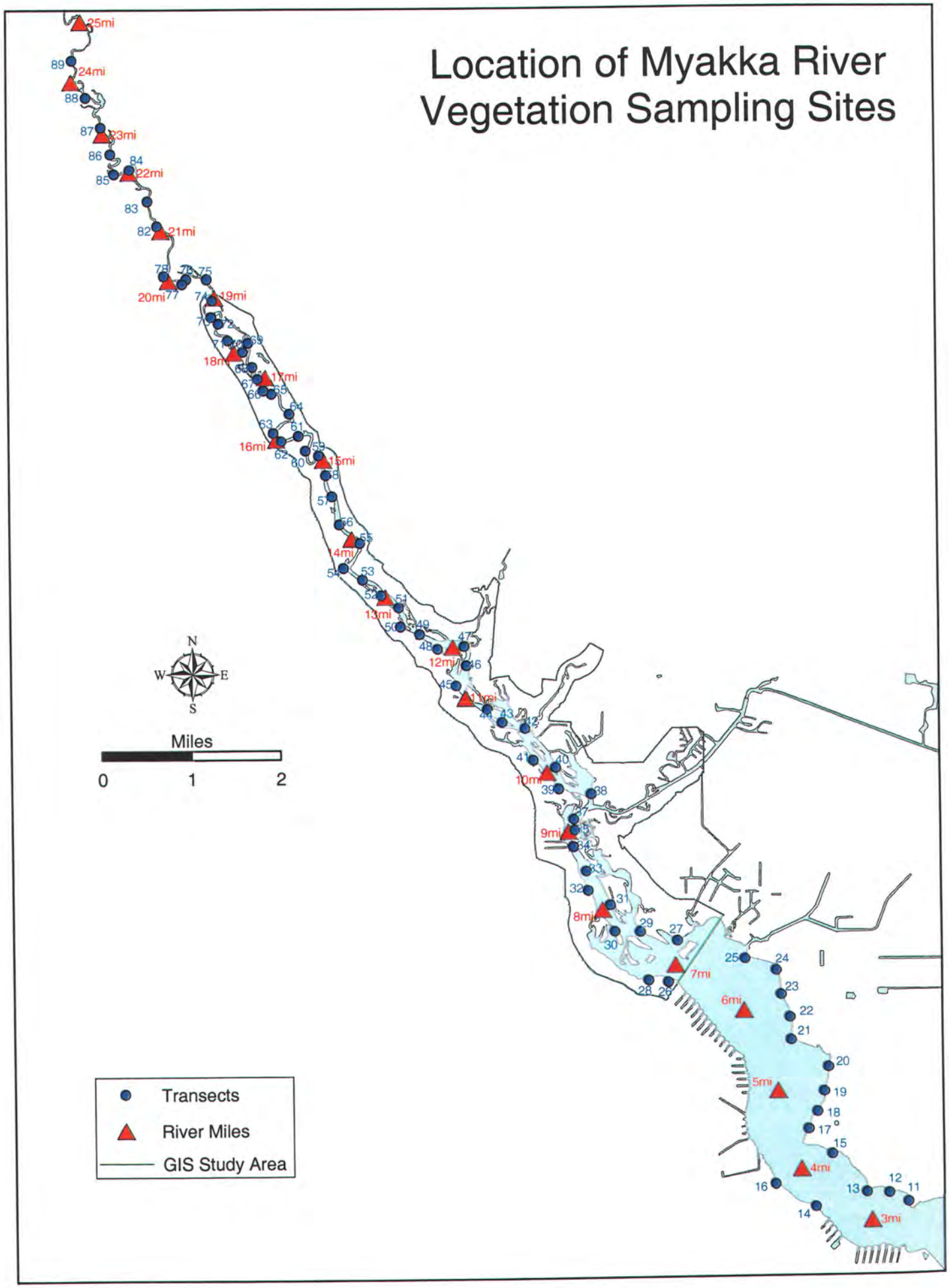
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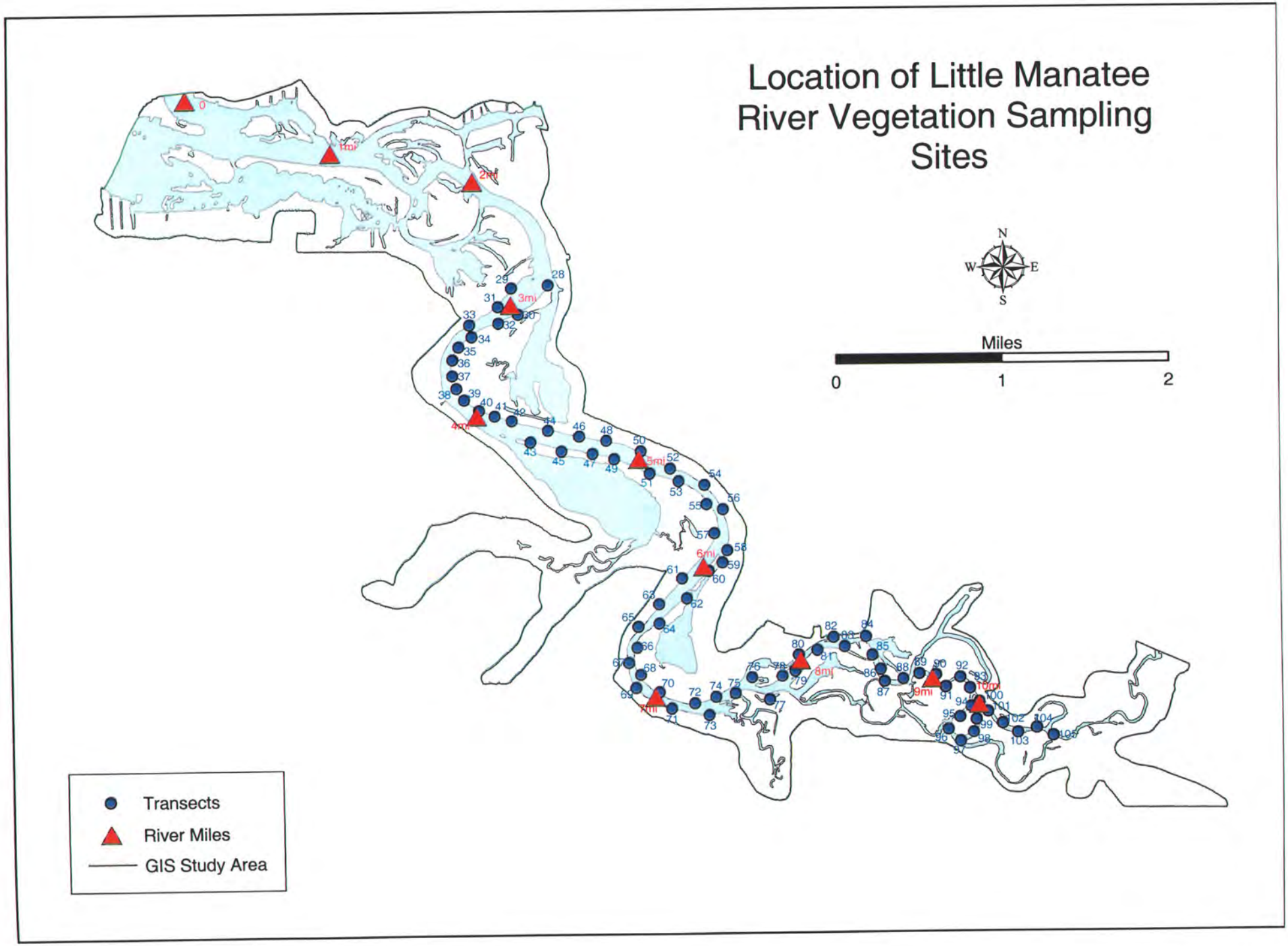
Appendix A

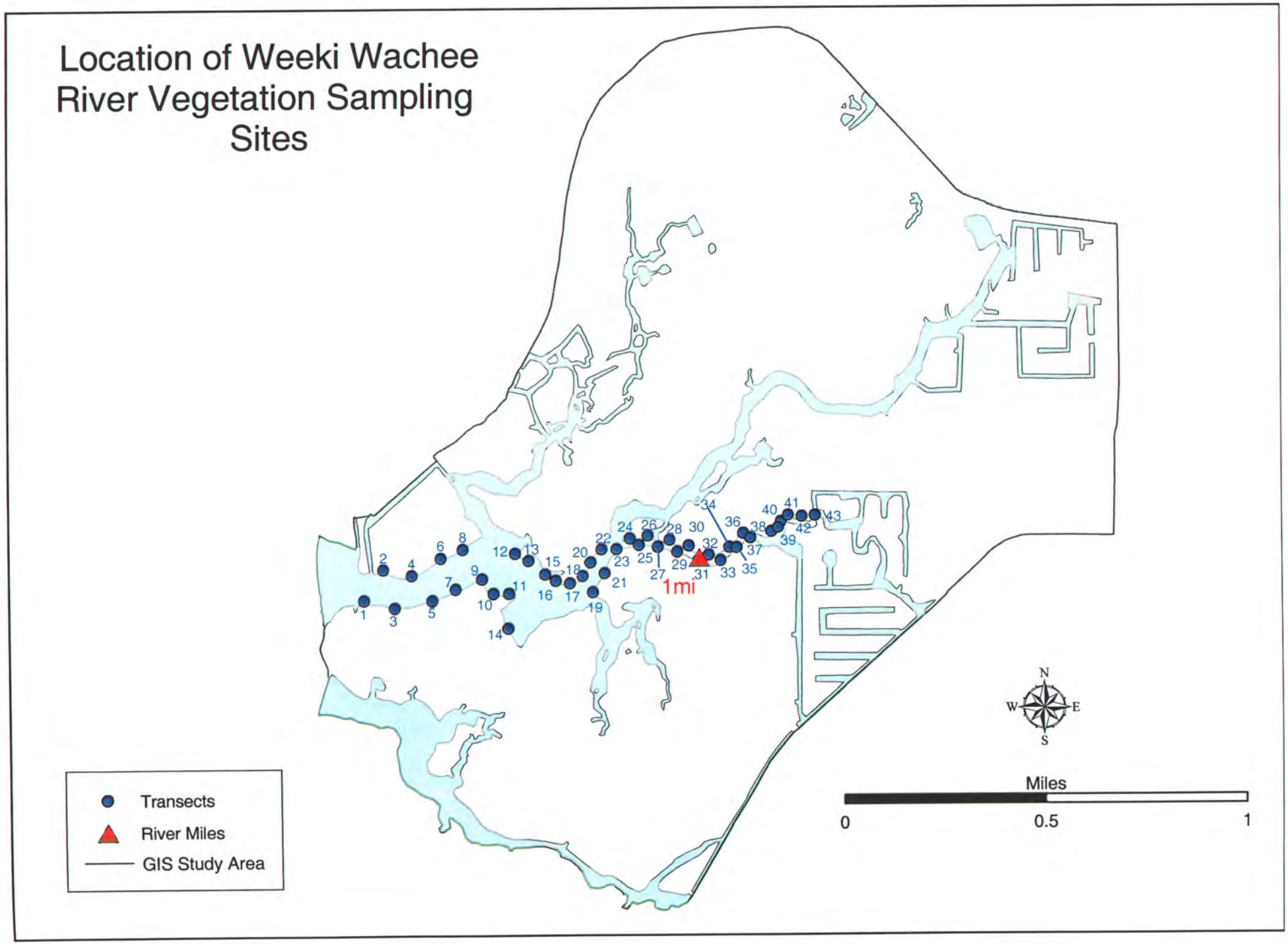
Location of the Vegetation Sampling Sites on the Seven Rivers

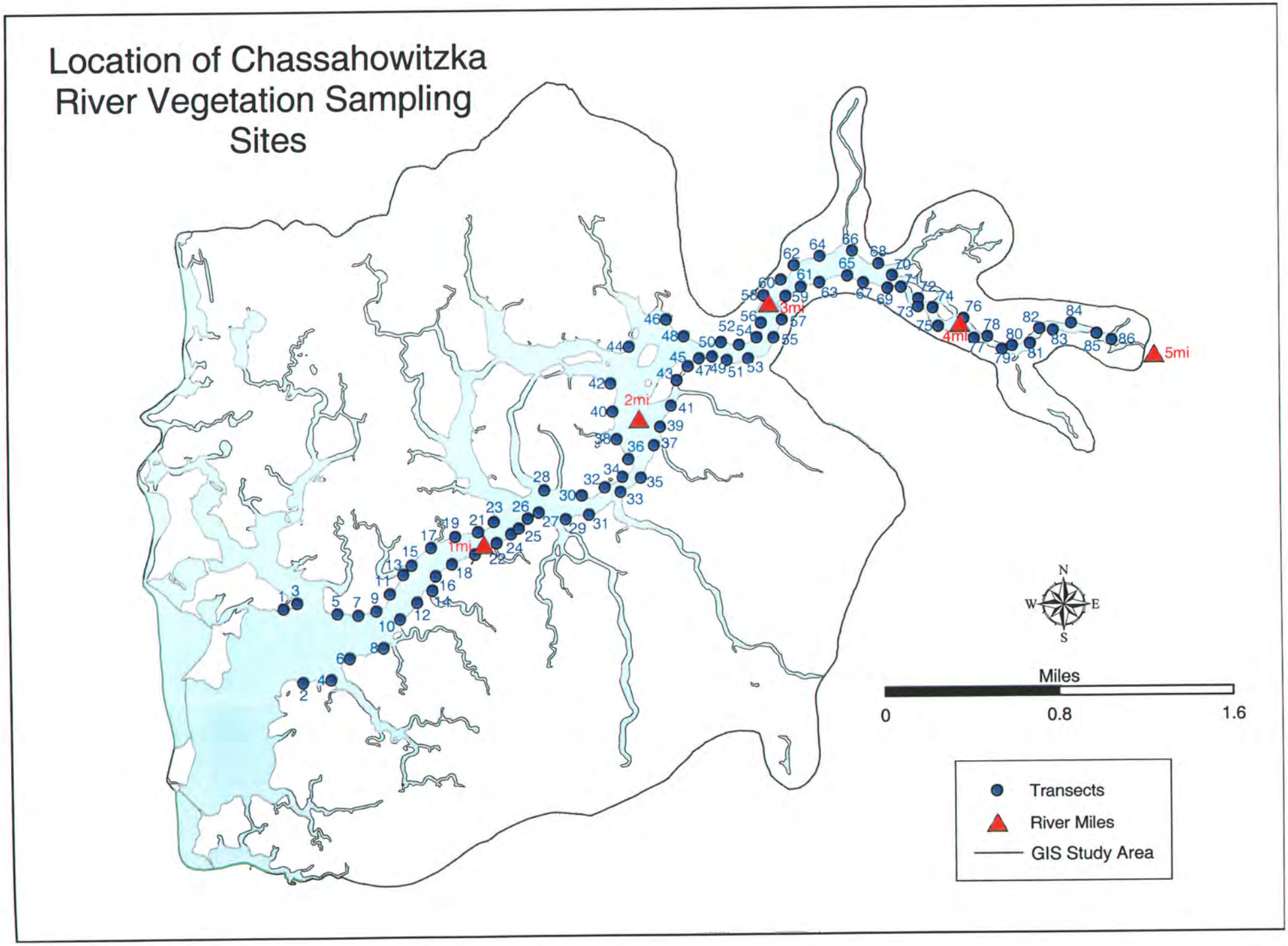
Location of Peace River Vegetation Sampling Sites

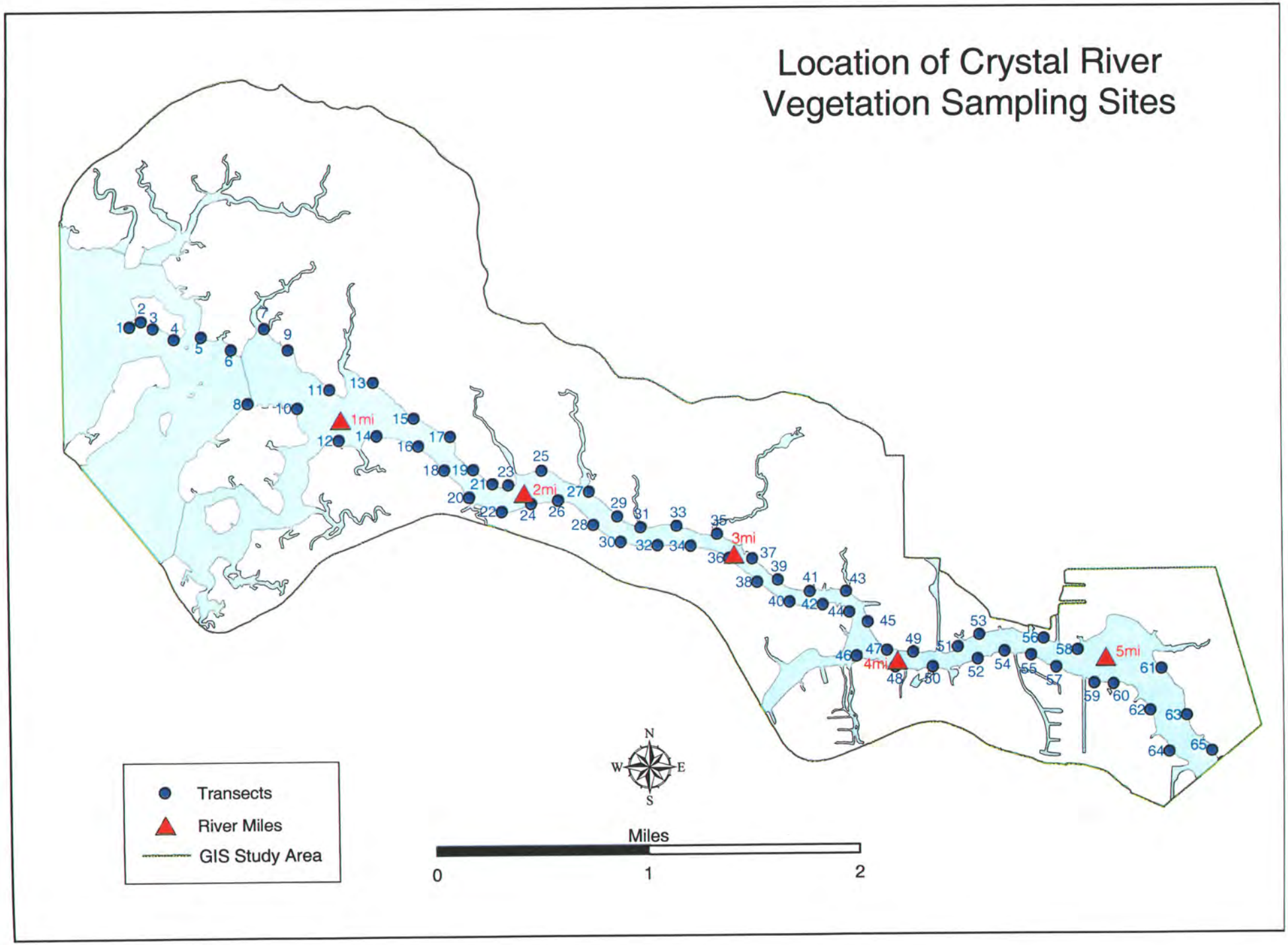


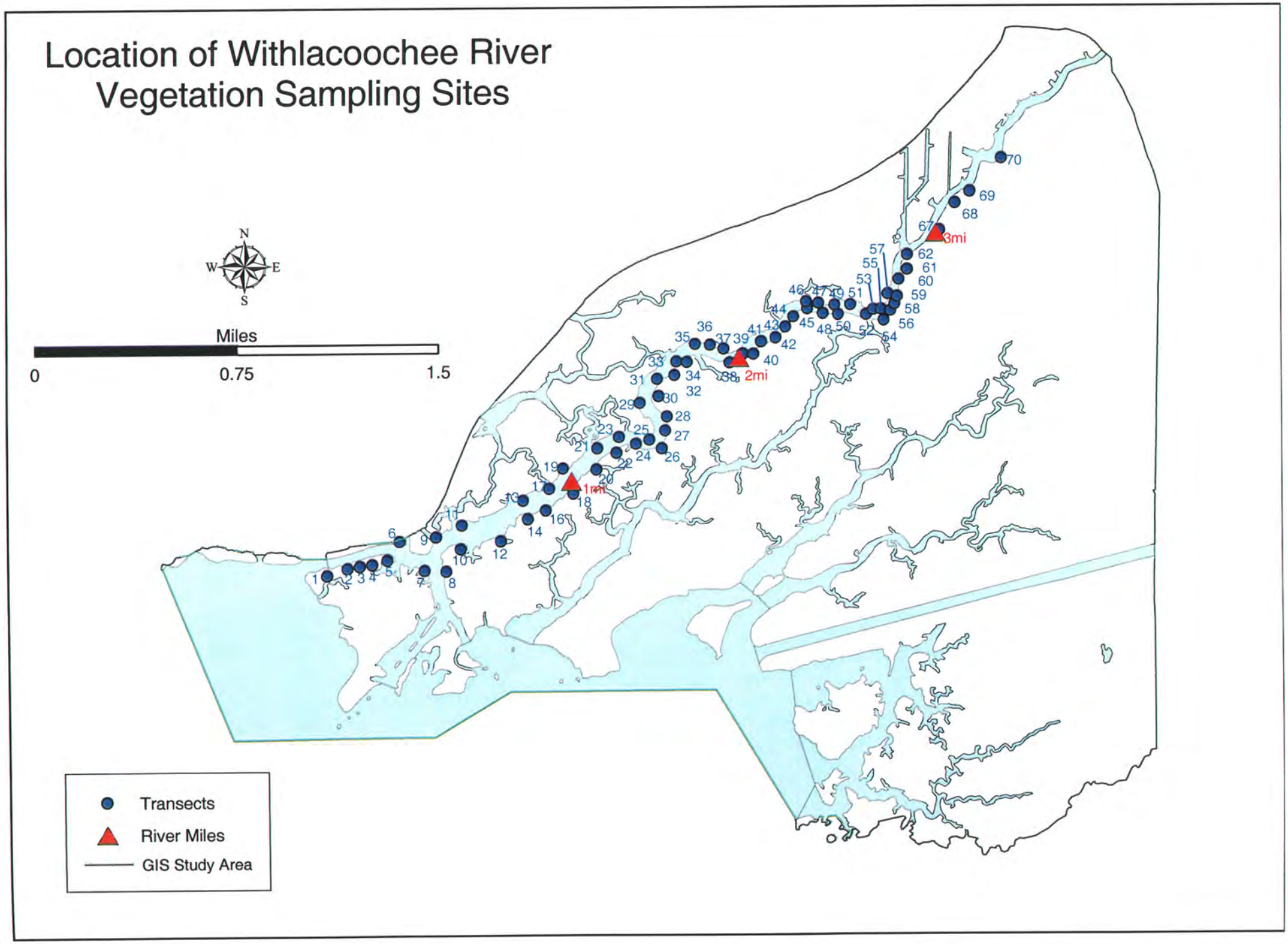

Location of Myakka River
Vegetation Sampling Sites
25mi
24mi
23mi
22mi
21mi
20mi
19mi
18mi
17mi
16mi
15mi
14mi
13mi
12mi
11mi
10mi
9mi
8mi
7mi
6mi
5mi
4mi
3mi
N
W
E
S
Miles
0
1
2
Transects
River Miles
GIS Study Area


Location of Little Manatee River Vegetation Sampling Sites
N
W
E
S
Miles
0
1
2
Transects
River Miles
GIS Study Area


Location of Weeki Wachee River Vegetation Sampling Sites
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43
1mi
Transects
River Miles
GIS Study Area
N
W
E
S
Miles
0
0.5
1


Location of Chassahowitzka River Vegetation Sampling Sites
1mi
2mi
3mi
4mi
5mi
N
W
E
S
Miles
0
0.8
1.6
Transects
River Miles
GIS Study Area


Location of Crystal River
Vegetation Sampling Sites
1mi
2mi
3mi
4mi
5mi
Transects
River Miles
GIS Study Area
N
W
E
S
Miles
0
1
2


Location of Withlacoochee River
Vegetation Sampling Sites
N
W
E
S
Miles
0
0.75
1.5
1mi
2mi
3mi
Transects
River Miles
GIS Study Area

Appendix B

Plant Nomenclature and Identification.

This appendix clarifies nomenclatural usage and indicates problematic species identifications. Nomenclature follows Wunderlin (1998).

Baccharis halimifolia (groundsel tree, saltbush). *Baccharis halimifolia* is a typical brackish marsh species which, incidentally, has become abundant inland throughout Florida on cleared land. Plants of it can scarcely be distinguished in vegetative condition from *Baccharis glomeruliflora,* which is a characteristic undergrowth shrub in forested freshwater wetlands. Some data entries for this study were made for *Baccharis glomeruliflora* as well as for *B. halimifolia.* These entries represented areas with essentially identical salinity regimes. In light of the contrasting habitat preferences for these species and the difficulty in distinguishing them morphologically, all field data entries for *B. glomeruliflora* were referred to *B. halimifolia* in this report.

Ceratopteris thalicroides. A few field data entries for this free-floating aquatic species were ignored in the report, because plants of it can drift into atypically saline river reaches and persist for short periods, particularly at times of high river discharge that temporarily depresses salinity.

Cicuta maculata (spotted water hemlock). This taxon was entered in field data as *Cicuta mexicana,* which some authors variously recognized as being either conspecific with *C. maculata* or as a variety of it.

Cyperus sudanensis. One field data entry was made for this taxon, which is otherwise unknown from Florida. It was ignored in the report.

Eichhornia crassipes (water-hyacinth). A few field data entries for this free-floating aquatic species were ignored in the report, because plants of it can drift into atypically saline river reaches and persist for short periods, particularly at times of high river discharge that temporarily depresses salinity.

Eleocharis fallax (creeping spikerush). Field data entries for this uncommon species were made under the name of *Eleocharis elongata,* a freshwater species that closely resembles *E. fallax* in vegetative condition. *Eleocharis fallax* is a tidal marsh species that is infrequently observed in fertile condition (Clewell et al. 1999). It is probable, but not certain, that infertile plants of *E. fallax* were mistaken for *E. elongata.*

Eleocharis flavescens (yellow spikerush). A few entries were made in the field data s for *Eleocharis* sp. For purposes of this reports, these were assumed to be identifiable as *E. flavescens* a common tidal marsh species that would be expected to occur in the oligohaline habitats where they were recorded. Additional field verification would be appropriate.

Fraxinus caroliniana (pop ash). No effort was made to distinguish *Fraxinus caroliniana* from *Fraxinus profunda* (pumpkin ash) in this report. Wunderlin (1998) considered them

to be conspecific. Clewell (1985) distinguished them and noted that trees identifiable as *Fraxinus profunda* are distinctly more tolerant of salinity than are those of *F. caroliniana* (Clewell et al. 1999). Trees identifiable as *F. profunda* can be distinguished by their single trunks (not multiple trunks from the base), their much thicker twigs, and their longer and more nearly lanceolate leaflets with entire (not serrulate) margins. If *F. profunda* is recognized as a distinct taxon, then all or nearly all data entries from brackish river reaches should be referred to that species. Data entries from freshwater reaches could be for either species.

Lythrum alatum (Winged Loosestrife). All plants of loosestrife were field-identified in 1991 to this common and widespread species. Reconnaissance in 1997 revealed the presence of *Lythrum lineare* (Wand Loosestrife) at various sites along the Weeki Wachee, Chassahowitzka, Crystal, and Withlacoochee rivers and no *Lythrum alatum* along any river. *Lythrum lineare* is strictly a halophyte of brackish marshes (Graham 1975), whereas *L. alatum* is evidently a glycophyte. *Lythrum lineare* occurred commonly in saline habitat along the Suwannee River and was absent from freshwater intertidal habitat (Clewell et al. 1999). *Lythrum alatum* was not recorded at all along the intertidal Suwannee River. Graham (1975) said that *L. alatum* var. *lanceolatum* may grow with *L. lineare* and that these two taxa are occasionally confused with one another. It seems plausible, if not likely, that many if not all loosestrifes in this report should be referred to *Lythrum lineare*.

Paspalidium geminatum (Egyptian paspalidium). The single field data entry of this species was recorded under the name of *Panicum repens*, which it closely resembles in vegetative condition. A large reproductive colony of *Paspalidium geminatum* grew in 1997 where *Panicum repens* was recorded in 1991, and no *P. repens* was observed.

Persea palustris (swamp bay). Some field data entries were recorded for *Persea borbonia* (red bay), which is an inland tree typical of well-drained soils. Some authors have treated swamp bay as a variety of the morphologically similar red bay under the name of *Persea borbonia* var. *pubescens*. Recently, taxonomic consensus has come to recognize swamp bay as a separate species. In accordance with that consensus, all data entries of *P. borbonia* were treated as *P. palustris* in this report.

Ptilimnium capillaceum. The several field data entries for this species were recorded as *Ptilimnium* sp. Since *Ptilimnium capillaceum* is the only species of *Ptilimnium* known from Florida, entries of *Ptilimnium* sp. were referred to *P. capillaceum* in the report.

Samolus ebracteatus. The very few field identifications for this species in 1991 were referred in the report to the very similar *Samolus valerandi,* with which it may have been confused.

Urochloa mutica (paragrass). Entries for this exotic species were recorded as *Brachiaria mutica,* which is the name by which this species has been know in Florida until very recently.

Appendix C

Scientific names, common names, and families of all species from all rivers, their salinity preferences, life forms, and notes on tropical affinity and exotic species status.

Salinity preference types are: mesohalophytes (M), oligohalophytes (O), and glycophytes (G). These designations indicate general tolerances and not precise salinity regimes.

Species Name	Common Name	Family	Salinity Preference	Life Form and Notes
Acer rubrum	Red Maple	Aceraceae	G	Tree
Acrostichum aureum	Golden Leather Fern	Pteridaceae	O	Perennial herb, tropical
Acrostichum danaeifolium	Giant Leather Fern	Pteridaceae	O	Perennial herb
Alternanthera philoxeroides	Alligatorweed	Amaranthaceae	G, O	Perennial herb, exotic
Amaranthus australis	Southern Amaranth	Amaranthaceae	O	Annual or ?perennial herb
Ampelopsis arborea	Peppervine	Vitaceae	G	Woody vine
Ardisia escallonoides	Marlberry	Myrsinaceae	GO	Shrub, tropical
Aster carolinianus	Climbing Aster	Asteraceae	G	Clambering perennial herb
Aster subulatus	Annual Saltmarsh Aster	Asteraceae	G,O	Annual herb
Aster tenuifolius	Perennial Saltmarsh Aster	Asteraceae	M	Perennial herb
Avicennia germinans	Black Mangrove	Avicenniaceae	M	Shrubby tree, tropical
Baccharis angustifolia	Saltwater Falsewillow	Asteraceae	O	Shrub
Baccharis halimifolia	Groundsel Tree	Asteraceae	G, O	Shrub
Bacopa monnieri	Herb-of-Grace	Scrophulariaceae	G,O	Perennial herb
Bidens laevis	Burrmarigold	Asteraceae	G	Annual herb
Blechnum serrulatum	Swamp Fern	Blechnaceae	G	Perennial herb
Blutaparon vermiculare	Silver Head	Amaranthaceae	O	Perennial herb
Boehmeria cylindrica	False Nettle	Urticaceae	G	Perennial herb
Borrichia frutescens	Bushy Seaside Oxeye	Asteraceae	M	Perennial herb
Carex lupulina	Hop Sedge	Cyperaceae	G	Perennial herb
Carya aquatica	Water Hickory	Juglandaceae	G	Tree
Cephalanthus occidentalis	Buttonbush	Rubiaceae	G	Shrub
Chasmanthium nitidum	Shiny Woodoats	Poaceae	G	Perennial herb
Cicuta maculata	Spotted Water Hemlock	Apiaceae	G	Perennial herb
Cladium jamaicense	Sawgrass	Cyperaceae	G, O	Perennial herb
Colocasia esculenta	Wild Taro	Araceae	G	Perennial herb, exotic
Conocarpus erectus	Buttonwood	Combretaceae	O	Tree, tropical
Cornus foemina	Swamp Dogwood	Cornaceae	G	Small tree
Crinum americanum	String-lily	Amaryllidaceae	G, O	Perennial herb
Crotalaria incana	Shakeshake	Fabaceae	G	Perennial herb, exotic
Cyperus distinctus	Swamp Flatsedge	Cyperaceae	G	Perennial herb
Dalbergia ecastophyllum	Coinvine	Fabaceae	O	Clambering shrub, tropical
Decumaria barbara	Cowitch Vine	Saxifagaceae	G	Woody vine
Diodia virginiana	Virginia Buttonweed	Rubiaceae	G	Perennial herb
Distichlis spicata	Saltgrass	Poaceae	M	Perennial herb
Echinochloa muricata	Rough Barnyardgrass	Poaceae	G	Annual herb
Eclipta prostrate	False Daisy	Asteraceae	G	Short-lived perennial herb
Eleocharis fallax	Creeping Spikerush	Cyperaceae	O	Perennial herb
Eleocharis flavescens	Yellow Spikerush	Cyperaceae	G	Perennial herb
Ficus aurea	Strangler Fig	Moraceae	G, O	Tree, tropical
Fraxinus caroliniana	Pop Ash	Oleaceae	G	Tree
Gratiola virginiana	Roundfruited Hedgehyssop	Scrophulariaceae	G	Annual herb

Appendix C continued

Species Name	Common Name	Family	Salinity Preference	Life Form and Notes
Hydrocotyle umbellata	Marshpennywort	Apiaceae	G	Perennial herb
Hypericum mutilum	Dwarf St.John's-wort	Clusiaceae	G	Perennial herb
Ilex cassine	Dahoon	Aquifoliaceae	G	Tree
Iris hexagona	Prairie Iris	Iridaceae	G	Perennial herb
Isoetes flaccida	Florida Quillwort	Isoetaceae	G, O	Perennial herb, aquatic
Itea virginica	Virginia Willow	Saxifragaceae	G	Shrub
Iva frutescens	Bigleaf Sumpweed	Asteraceae	M	Shrub
Juncus effusus	Soft Rush	Juncaceae	G	Perennial herb
Juncus megacephalus	Bighead Rush	Juncaceae	G	Perennial herb
Juncus roemerianus	Needle Rush	Juncaceae	O, M	Perennial herb
Juniperus virginiana	Red Cedar	Cupressaceae	G, O	Tree
Laguncularia racemosa	White Mangrove	Combretaceae	O, M	Shrubby tree, tropical
Limonium carolinianum	Carolina Sealavender	Plumbaginaceae	M	Perennial herb
Lobelia cardinalis	Cardinalflower	Campanulaceae	G	Perennial herb
Lobelia feayana	Bay Lobelia	Campanulaceae	G	Perennial (?) herb
Ludwigia repens	Creeping Primrosewillow	Onagraceae	G, O	Perennial herb
Lycium carolinianum	Christmasberry	Solanaceae	O, M	Shrub
Lythrum alatum	Winged Loosestrife	Lythraceae	G	Perennial herb
Magnolia virginiana	Sweetbay	Magnoliaceae	G, O	Tree
Mikania scandens	Climbing Hempvine	Asteraceae	G	Perennial herb
Myrica cerifera	Wax Myrtle	Myricaceae	G, O	Shrub
Nuphar lutea	Spatterdock	Nymphaeaceae	G	Perennial herb, aquatic
Ophioglossum petiolatum	Stalked Adder's-tongue	Ophioglossaceae	G	Perennial herb
Osmunda regalis	Royal Fern	Osumndaceae	G, O	Perennial herb
Panicum anceps	Beaked Panicum	Poaceae	G	Perennial herb
Panicum rigidulum	Redtop Panicum	Poaceae	G	Perennial herb
Parthenocissus quinquefolia	Virginia Creeper	Vitaceae	G	Woody vine
Paspalidium geminatum	Egyptian Paspalidium	Poaceae	G	Perennial herb
Paspalum vaginatum	Seashore Paspalum	Poaceae	O, M	Perennial herb
Persea palustris	Swamp Bay	Lauraceae	G, O	Tree
Phragmites australis	Common Reed	Poaceae	O, M	Perennial herb
Phyla nodiflora	Capeweed	Verbenaceae	G	Perennial herb
Pluchea odorata	Sweetscent	Asteraceae	G, O	Annual herb
Polygonum hydropiperoides	Mild Waterpepper	Polygonaceae	G	Perennial herb
Pontederia cordata	Pickerelweed	Pontederiaceae	G	Perennial herb
Quercus geminata	Sand Live Oak	Fagaceae	G, O	Tree
Quercus virginiana	Virginia Live Oak	Fagaceae	G, O	Tree
Rhabdadenia biflora	Rubbervine	Apocynaceae	O, M	Woody vine, tropical
Rhizophora mangle	Red Mangrove	Rhizophoraceae	O, M	Shrubby tree, tropical
Rhynchospora colorata	Starrush Whitetop	Cyperaceae	G	Perennial herb
Rumex verticillatus	Swamp Dock	Polygonaceae	G,O	Perennial herb
Ruppia maritima	Wigeongrass	Ruppiaceae	O, M	Perennial (?) herb, aquatic
Sabal palmetto	Cabbage Palm	Arecaceae	G, O	Tree
Sabatia calycina	Coastal Rosegentian	Gentianaceae	G, O	Annual herb
Sagittaria lancifolia	Bulltongue Arrowhead	Alismataceae	G, O	Perennial herb
Sagittaria subulata	Awlleaf Arrowhead	Alismataceae	O	Perennial herb
Salix caroliniana	Coastalplain Willow	Salicaceae	G	Tree
Sambucus canadensis	Elderberry	Caprifoliaceae	G	Shrub
Samolus valerandi	Seaside Brookweed	Primulaceae	G, O	Perennial herb
Saururus cernuus	Lizard's Tail	Saururaceae	G, O	Perennial herb
Schinus terebinthifolius	Brazilian Pepper	Anacardiaceae	G, O, M	Shrub
Scirpus americanus	American Bulrush	Cyperaceae	O, M	Perennial herb
Scirpus californicus	Giant Bulrush	Cyperaceae	O	Perennial herb
Scirpus robustus	Saltmarsh Bulrush	Cyperaceae	M	Perennial herb
Scirpus tabernaemontani	Softstem Bulrush	Cyperaceae	G,O	Perennial herb
Senecio glabellus	Butterwort	Asteraceae	G, O	Annual herb

Appendix C continued

Species Name	Common Name	Family	Salinity Preference	Life Form and Notes
Sesuvium portulacastrum	Shoreline Seapurslane	Aizoaceae	M	Perennial herb
Smilax bona-nox	Saw Greenbrier	Smilacaceae	G	Woody vine
Smilax laurifolia	Bamboo Vine	Smilacaceae	G	Woody Vine
Smilax walteri	Coral Greenbrier	Smilacaceae	G	Woody vine
Solidago sempervirens	Seaside Goldenrod	Asteraceae	O, M	Perennial herb
Solidago stricta	Wand Goldenrod	Asteraceae	O	Perennial herb
Spartina alterniflora	Smooth Cordgrass	Poaceae	M	Perennial herb
Spartina bakeri	Sand cordgrass	Poaceae	G, O	Perennial herb
Spartina patens	Saltmeadow Cordgrass	Poaceae	O	Perennial herb
Stenotaphrum secundatum	St.Augustinegrass	Poaceae	O	Perennial herb
Taxodium distichum	Bald-Cypress	Cupressaceae	G, O	Tree
Teucrium canadense	Wood Sage	Lamiaceae	G, O	Perennial herb
Tilia caroliniana	Carolina Basswood	Tiliaceae	G	Tree
Triglochin striata	Arrowgrass	Juncaginaceae	O	Perennial herb
Typha domingensis	Southern Cattail	Typhaceae	G, O	Perennial herb
Ulmus americanus	American Elm	Ulmaceae	G	Tree
Urochloa mutica	Paragrass	Poaceae	G	Perennial herb, exotic
Vallisneria americana	Tapegrass	Hydrocharitaceae	G, O	Perennial herb, aquatic
Viburnum obovatum	Walter's Viburnum	Caprifoliaceae	G	Shrub
Vitis rotundifolia	Muscadine	Vitaceae	G	Woody vine
Zizania aquatica	Indian Rice	Poaceae	G	Perennial herb

Appendix D

Autecology of Selected Species

This appendix summarizes autecological information on salinity tolerance, habitat requirements for seedling establishment, and responses to interspecific competition to the extent that such information is available.

Acrostichum danaeifolium (giant leather fern). This large rhizomatous fern with leathery fronds is common or at least conspicuous on natural levees. It prefers slopes that face the interior of the marsh rather than the river. Along the Suwannee River, the highest salinity was 4 ppt in soil where leather fern grew (Clewell et al., 1999).

Alternanthera philoxeroides (alligatorweed). This is a sprawling perennial herb with rather succulent stems that root from their lower nodes. Alligatorweed frequents freshwater and saline marshes, generally on or near riverbanks and sometimes forms semi-floating mats in combination with other species in relative still water. Penfound and Hathaway (1938) reported it growing in Louisiana in water with a salinity of 0-15 ppt. It grew where soil salinity reached as much as 2 ppt along the Suwannee River (Clewell et al. 1999). Alligatorweed should be used with caution as an indicator of the salinity regime, because it may persist for an indefinite time if it floats downstream into water that is much more saline than where it initially developed. This recommendation is made more poignant by the work of Balagtas-Burow et al. (1993). They reported that alligatorweed cells grown in suspension exhibited rapid recovery of their water balance and resumed growth after an abrupt and substantial increase in salinity.

Cladium jamaicense (sawgrass). Next to needlerush, sawgrass is the principal tidal marsh plant species along the Gulf coast of Florida. It forms very dense, essentially monotypic and uninterrupted stands that may cover many hectares in the lower oligotrophic marsh zone. Sawgrass is not nearly as tolerant of salinity as is needlerush. It reaches its maximum cover in a low-saline zone that lies between the more Gulfward needlerush zone and the more landward coastal swamp. Sawgrass may extend as a dense ground cover well into swamps with open canopies.

Oligohaline marshes are not always dominated by sawgrass. The principal reason may relate to fire. Sawgrass readily survives and resprouts after fire (Steward and Ornes 1975)—more so than most other marsh species. Frequent fires may explain why some sawgrass marshes are nearly monotypic. Where fire is less common or absent in oligotrophic marsh, sawgrass grows as a codominant or as an incidental species along with many other species.

Sometimes the oligohaline zone is narrow or absent, and needlerush dominates nearly or quite to the edge of forest. This pattern is common along

the more southerly of the seven rivers in the present study. The lack of well developed sawgrass zones in association with the Peace, Myakka, and Little Manatee rivers could be explained by steeper gradients, greater tidal amplitude, or less frequent fires as compared to the more northerly rivers which have expansive sawgrass zones. Latitude is not a factor, as is evidenced by the dominance of sawgrass in the Florida Everglades, where fires happen frequently.

Sawgrass is a coarse stoloniferous perennial herb. It is a better colonizer than is needlerush, as is evidenced by its dominance relative to needlerush on low levees that are subjected to frequent scouring and wrack deposition. Chabreck (1972) reported a range of salinity for sawgrass of 4 $\pm$3 ppt in Louisiana. Sawgrass grew along the Suwannee River where the salinity of interstitial soil water was 8 ppt (Clewell et al. 1999).

Sawgrass tolerates deep inundation but not indefinitely. David (1996) reported that sawgrass was prevalent in the Florida Everglades where the soil was inundated from zero to 85% of the time and where the mean water depth of flooded areas was 25 $\pm$18 cm. Newman et al. (1996) said that sawgrass can tolerate depths > 1.2 m for sustained periods. David (1996) observed that sawgrass is favored at sites receiving brief shallow inundation and eventually loses its competitive advantage to other species with increased hydroperiod. This observation was verified experimentally by Newman et al. (1996). Steward and Ornes (1975) attributed much ecological success of sawgrass to its ability to thrive on soils containing exceedingly low amounts of P and Cu (a trace element) and also to low levels of N and K. Soil enrichment allows other species to compete successfully with sawgrass (Davis 1991, Newman et al. 1996, Craft and Richardson 1997).

Crinum americanum (string lily). String lilies are sometimes common in oligohaline marsh. Salinity of the soil water where they grew was recorded at ~ 2-5 ppt in Louisiana (Penfound and Hathaway 1938) and ~ 3 ppt along the Suwannee River (Clewell et al. 1999). String lilies tended to be missing from recently disturbed sites along the Suwannee River and were associated with dense and ecologically rather mature stands of needlerush and sawgrass. These observations suggest that swamp lily would be a dependable candidate-species for predicting the salinity regime in the reach of river next to where it grows.

Distichlis spicata (saltgrass). Saltgrass largely grows in mesohaline marsh. Salinity of the soil water was recorded at ~ 5-50 ppt in Louisiana (Penfound and Hathaway 1938). Warren and Brockelman (1989) reported it growing at 25-30 ppt in Connecticut. In Suwannee River marshes it grew where the salinity of soil water was ~ 8 ppt (Clewell et al. 1999). Saltgrass tolerates high salinity even better than does *Spartina alterniflora*. It exudes salt from glands on its leaves at a rate that is proportionate to the salinity of the soil (Parrondo et al. 1978).

Bertness and Ellison (1987) said that saltgrass was a disturbance-dependent species and that its success depended upon its ability to tolerate and recover from disturbance.

Juncus roemerianus (needlerush). Needlerush is clearly the single most characteristic and ecologically important tidal marsh species on the Gulf coast of Florida. It forms very dense, essentially monotypic and uninterrupted stands that cover many hectares and even square kilometers of area. The keys to the success of this species are (1) its tolerance of a wide range of salinity, (2) its dense surficial mat of tough and wiry, interlocking rhizomes that cover the soil and mechanically prevent colonization by other species, and (3) the deep shade its shoots cast which deprives potential competitors of the light they require for establishment. The effectiveness of the mat of rhizomes is enhanced by dead rhizomes that apparently persist for years or even decades in saline soils. The ability of needlerush to shade-out competition is enhanced by the persistence of dead shoots that commonly stand in place for 4 years or more before deteriorating (Eleuterius and Caldwell 1981). In Wakulla County, Kruczynski et al. (1978) reported densities of 1,692 live and 3,029 standing dead shoots of needlerush per square meter.

Needlerush can be killed beneath deep deposits of storm wrack (Brinson and Christian 1999, Clewell et al. 1999). Once the wrack rots or is removed by tidal flushing, needlerush may reestablish itself from rhizomes if any survived. Otherwise, it must recover by seed. Needlerush does not readily establish new populations on disturbed terrain relative to most other tidal marsh species. Several years may pass before new seedlings appear. Although they may soon attain co-dominance with other species that initially colonized, it probably takes one or two decades before a new mat of rhizomes fully develops and before shoot density produces maximum shade. During that interim, several other species commonly co-exist with needlerush. The number of species and their abundance diminish over the years as needlerush reasserts dominance. Some habitats, though, such as low levees along intertidal rivers, are subject to recurring disturbance from wrack and scouring. In such locations, needlerush populations cannot fully mature, and it grows intermixed with other species in a perpetual state of recovery from disturbance.

Needlerush grows as a co-dominant with other tidal marsh species in oligotrophic marsh zones, and it grows in small, isolated patches along freshwater reaches of tidal rivers. It is incapable of monotypic dominance in oligotrophic and glycophytic tidal marsh zones. Eleuterius (1984) reported that living needlerush rhizomes in such areas are subject to predation by soil animals. These animals are evidently intolerant of saline soil and cannot venture into the mesohaline marshes where needlerush is most prevalent (Hackney and de la Cruz 1980). Other detrital organisms may be capable of efficiently attacking dead needlerush rhizomes in non-saline environments, thereby depriving needlerush of its rhizomatous mat. With its defenses reduced, needlerush

succumbs to the competition of glycophytes that are better suited to freshwater environments.

The mean salinity of standing water in needlerush marshes was calculated as 14 ± 8 ppt by Chabreck (1972) in Louisiana, from zero to ~ 20 ppt by Cooper and Waits (1973) in North Carolina, and from 1-44 ppt by Penfound and Hathaway (1938) in Louisiana. Eleuterius (1984) recorded needlerush growing where the salinity of the soil water was 70 ppt but noted that it cannot tolerate soil salinity > 30 ppt indefinitely. The highest salinity recorded in soil water where needlerush grew along the banks of the Suwannee River was ~ 8 ppt; however, salinity in the water column varied widely (Clewell et al., 1999). Eleuterius (1984) believed that salinity was the principal edaphic factor affecting the distribution and growth of needlerush. He reported that needlerush grew on a variety of soils, including sand, silty clay, and peat and that the soil could be compacted or not. Soil nutrient content could vary widely for P. K, and N content. He concluded that soil type and soil fertility were not critical in limiting the distribution and prevalence of needlerush.

Pontederia cordata (pickerelweed). Pickerelweed is a glycophyte that extends slightly into oligohaline marsh. In contrast to its abundance in deeper freshwater marshes, it may be common but not dominant in intertidal marshes. In Suwannee River tidal marshes, it grew where the salinity in soil water reached as much as ~ 2.5 ppt (Clewell et al. 1999). Penfound and Hathaway (1938) recorded salinity of ~ 0-9 ppt in soil water where pickerelweed grew in Louisiana.

Sagittaria lancifolia (bulltongue arrowhead). This large and conspicuous perennial herb is sometimes abundant, although less so on riverbanks than on levees and in interior marshes. It grew where soil salinity was recorded at ~ 0-9 ppt in Louisiana (Penfound and Hathaway 1938). Along the Suwannee River it aggressively colonized mud flats that were exposed after wrack had smothered former vegetation. Holm and Sasser (2001) reported that growth of *Sagittaria lancifolia* was impaired after 13 days of exposure to 6 ppt salinity under controlled conditions. Greiner La Peyre et al. (2001) independently verified this result. Arrowhead persists indefinitely after it has become established and was common growing in maturing stands of needlerush and sawgrass (Clewell et al. 1999). For that reason, mature plants of *Sagittaria lancifolia* are reliable candidate-species for indicating the salinity regime in adjacent river reaches along the Suwannee River where their parental species were growing sympatrically (Clewell et al. 1999). Both species are colonizers of disturbed shorelines, and both may persist indefinitely.

Samolus valerandi (seaside brookweed). This small perennial herb is characteristic of river swamps and extends into tidal marshes along stream banks (in striking accord with its common name!). It is most common in narrow marshes on shorelines bordering river swamps in freshwater and oligohaline

zones. *Samolus valerandi* (= *S. parviflora*) extended along the Suwannee River banks into the mesohaline zone during an El Niño event but disappeared entirely during the ensuing drought (Clewell et al. 1999, Clewell 2000). For that reason, it should be used with caution as an indicator of salinity in adjacent river reaches.

Scirpus californicus (giant bulrush). *Scirpus californicus* and the very similarly-appearing *Scirpus tabernaemontani* (= *S. validus,* softstem bulrush) are tall, rhizomatous herbs that forms dense, conspicuous colonies along riverbanks, *S. californicus* largely in the mesohaline and lower oligohaline zones and *S. tabernaemontani* in the upper oligohaline and freshwater zones. Salinity of the soil water for *S. californicus* was recorded upwards to ~ 13 ppt in Louisiana (Penfound and Hathaway 1938) and at ~ 5 ppt along the Suwannee River (Clewell et al. 1999). These species are easily mistaken for one another unless plants are identified using diagnostic bristle characters of the perianth. References to *S. californicus* growing in low-salinity water should be considered suspect. Likewise, references to *S. tabernaemontani* growing in mesohaline conditions should be considered suspect. Hybrids with 4 bristles were observed

Spartina alterniflora (smooth cordgrass or, in this report, cordgrass). Cordgrass grows at elevations where it receives saline tidal inundation daily or nearly so. A short form of cordgrass also grows at higher elevations but, in our experience, not in the immediate vicinity of tidal rivers. Cordgrass is the predominant tidal marsh species of the Atlantic seaboard of the United States, including Florida, where tidal amplitude is much greater than it is in the Gulf of Mexico. Tidal inundation from the Atlantic extends inland nearly to the edge of the uplands almost daily, whereas more highly elevated areas of Gulf-coastal salt marsh may not be inundated by lunar tides more than several times a year. Because of the low amplitude of Gulf tides, cordgrass is relegated to riverbanks and the margins of tidal creeks in zones that were too narrow to depict in Figures 4.1-4.7.

Cordgrass, along with needlerush and, to a slightly lesser extent, sawgrass, are the principal tidal marsh species of relatively stable habitats. All other species are colonizers of disturbed terrain, where they may persist for many years, particularly if scouring, wrack deposition, or other stressors periodically recur. Our supposition is that storms and the disturbances they cause could be eliminated for a few decades, these three species would assert dominance over all other species, which, in turn, would become rare. *Acrostichum* spp. may also persist.

Cordgrass owes some of its status as a persistent species to its well developed rhizome and root system, which grows deeper than do most other tidal marsh species (Clewell et al. 1999). This attribute gives cordgrass needed anchorage to grow where waves and strong currents would dislodge plants of most other tidal marsh species. Teal and Howes (1996) reported a very low degree of inter-annual change in cordgrass populations in a 22-year study. A

regular tidal influx of sediments presumably maintains nutrients at suitable levels to sustain cordgrass (DeLaune et al. 1979).

Cordgrass prefers a salinity regime that approaches full sea strength but does not much exceed that level. It grows in the Gulf of Mexico on protected beaches and up river within the mesohaline zone. It rarely extends into oligohaline waters or, if it does, not in abundance.

Salinity of the soil water in cordgrass habitat was measured from ~5-50 ppt in Louisiana (Penfound and Hathaway 1938). Seed germination occurs in water with 25 ppt of salinity (Wijte and Gallagher 1996). Hypersaline water, though, causes the inhibition of photosynthesis in cordgrass (Cavalieri 1983).

Typha domingensis (southern cattail). This tall, rhizomatous herb is common and widespread in tidal marshes, especially along riverbanks in freshwater and oligohaline zones. It sometimes penetrates the mesohaline zone but generally not in abundance. It colonizes disturbed sites densely and rapidly and can be quite susceptible to competition from other emergent perennial species. For that reason, it may reflect current conditions rather than long-term salinity regimes. Comparisons of species composition at specific sites from quadrat data and the reconnaissance in 1997 showed that many populations had persisted and that some new populations had appeared in 1997.

Seed germination was high ($\geq$ 78%) in fresh water, 50% where the salinity was 2.5-12 ppt, and negligible at 15-20 ppt (Beare and Zedler 1987). *Typha domingensis* tolerated moderate salinity as long it was seasonally flushed by freshwater runoff, such as spring floods that reduce soil salinity below 5 ppt for 3 months (Beare and Zedler 1987). It can grow in water > 1.1 m deep for sustained periods (Grace 1989).

Appendix E

Center of abundance, minimum, and maximum river miles for each species and the number of sites at which the species was recorded.

Peace River

	Center of Abundance	Minimum	Maximum	Number of Sites
Rhizophora mangle	9.79	8.45	14.75	15
Juncus roemerianus	10.52	8.30	13.10	17
Laguncularia racemosa	10.72	9.90	10.80	2
Sesuvium portulacastrum	10.80	10.80	10.80	1
Triglochin striate	10.80	10.80	10.80	1
Spartina bakeri	11.60	11.60	11.60	1
Acrostichum danaeifolium	12.07	8.95	16.60	7
Cladium jamaicense	12.94	10.35	14.85	8
Scirpus californicus	14.03	10.05	17.85	12
Alternanthera philoxeroides	14.23	14.05	15.65	2
Blechnum serrulatum	14.45	14.45	14.45	1
Sambucus canadensis	14.65	14.60	14.85	2
Stenotaphrum secundatum	14.75	14.75	14.75	1
Taxodium distichum	14.75	14.75	14.75	1
Juncus effusus	14.75	14.75	14.75	1
Sagittaria subulata	15.00	15.00	15.00	1
Pluchea odorata	15.02	14.75	15.15	2
Zizania aquatica	15.15	15.15	15.15	1
Samolus valerandi	15.16	14.45	15.65	5
Aster caroliniana	15.39	14.45	15.65	3
Rumex verticillatus	15.51	15.50	15.65	2
Colocasia esculenta	15.52	14.45	16.10	6
Typha domingensis	15.56	10.65	17.85	5
Mikania scandens	15.65	15.65	15.65	1
Ludwigia repens	16.08	15.15	18.30	2
Amaranthus australis	16.28	14.05	18.50	2
Bacopa monnieri	16.35	10.80	18.30	3
Phragmites australis	16.40	16.40	16.40	1
Cicuta mexicana	16.48	15.00	18.30	3
Pontederia cordata	16.94	15.00	18.50	6
Sagittaria lancifolia	17.16	14.45	18.50	10
Polygonum hydropiperoides	17.38	14.05	18.50	7
Senecio glabellus	17.39	16.10	18.50	4
Nuphar luteum	17.60	17.60	17.60	1

Appendix E continued

Center of abundance, minimum, and maximum river miles for each species and the number of sites at which the species was recorded.

Myakka River.

	Center of Abundance	Minimum	Maximum	Number of Sites
Borrichia frutescens	2.90	2.90	2.90	1
Spartina alterniflora	3.62	2.70	4.94	5
Distichlis spicata	5.38	5.38	5.38	1
Spartina patens	5.38	5.38	5.38	1
Conocarpus erectus	5.93	4.69	6.92	2
Laguncularia racemosa	6.24	4.69	10.23	6
Iva frutescens	6.56	6.50	6.92	2
Rhizophora mangle	6.59	2.90	11.46	16
Avicenna germinans	6.92	6.92	6.92	1
Acrostichum aureum	7.18	6.92	7.25	2
Juncus roemerianus	9.25	2.90	16.63	34
Acrostichum danaeifolium	11.40	9.75	12.61	3
Cladium jamaicense	12.19	12.19	12.19	1
Spartina bakeri	13.53	13.53	13.53	1
Samolus valerandi	13.85	11.46	14.82	4
Scirpus californicus	13.93	8.25	18.60	15
Aster caroliniana	16.07	16.07	16.07	1
Pluchea odorata	16.17	13.53	17.87	3
Bacopa monnieri	16.37	16.37	16.37	1
Isoetes flaccida	16.63	16.63	16.63	1
Crinum americanum	16.84	13.53	21.00	5
Sagittaria subulata	17.00	16.37	18.48	6
Typha domingensis	17.69	11.46	22.25	10
Senecio glabellus	17.77	17.69	17.87	2
Hydrocotyle umbellate	18.02	16.37	21.31	2
Eleocharis species	18.13	16.37	22.00	11
Sagittaria lancifolia	18.19	17.11	21.31	5
Gratiola virginiana	18.77	17.87	21.31	5
Panicum rigidulum	19.16	19.16	19.16	1
Ludwigia repens	19.39	16.37	21.31	3
Pontederia cordata	19.75	17.69	24.30	7
Mikania scandens	20.46	13.53	23.15	8
Urochloa mutica	20.86	17.87	22.25	6
Iris hexagona	21.31	21.31	21.31	1
Scirpus tabernaemontani	21.73	17.42	24.30	11
Diodia virginiana	22.20	22.00	22.69	2
Polygonum hydropiperoides	22.21	16.37	24.30	9
Juncus megacephalus	22.25	22.25	22.25	1
Rumex verticillatus	23.06	17.69	24.30	6

Appendix E continued

Center of abundance, minimum, and maximum river miles for each species and the number of sites at which the species was recorded.

Little Manatee River

	Center of Abundance	Minimum	Maximum	Number of Sites
Avicenna germinans	3.93	2.90	4.42	3
Laguncularia racemosa	4.00	3.50	4.32	3
Rhizophora mangle	4.44	2.70	7.10	19
Phragmites australis	5.20	5.20	5.20	1
Juncus roemerianus	6.13	3.00	9.40	41
Aster caroliniana	7.30	7.30	7.30	1
Crinum americanum	7.51	4.80	9.30	6
Alternanthera philoxeroides	7.93	7.30	10.20	6
Acrostichum danaeifolium	8.33	6.10	9.30	4
Typha domingensis	8.68	6.70	9.80	9
Lythrum alatum	8.70	8.70	8.70	1
Pluchea odorata	8.70	8.70	8.70	1
Rumex verticillatus	8.70	8.70	8.70	1
???Panicum repens	8.82	7.38	10.10	4
Scirpus tabernaemontani	8.98	8.80	9.00	2
Cladium jamaicense	9.23	8.20	9.90	4
Pontederia cordata	9.68	9.00	10.30	3
Osmunda regalis	9.70	9.70	9.70	1
Blechnum serrulatum	9.90	9.90	9.90	1
Myrica cerifera	9.90	9.90	9.90	1
Urochloa mutica	10.07	9.10	10.40	4

Appendix E continued

Center of abundance, minimum, and maximum river miles for each species and the number of sites at which the species was recorded.

Weeki Wachee River

	Center of Abundance	Minimum	Maximum	Number of Sites
Distichlis spicata	0.46	0.44	0.47	2
Juncus roemerianus	0.50	0.10	1.18	29
Crinum americanum	0.51	0.51	0.51	1
Spartina alterniflora	0.59	0.10	0.91	18
Typha domingensis	0.77	0.36	1.12	11
Ruppia maritime	0.84	0.21	1.12	13
Sagittaria subulata	0.88	0.76	1.12	4
Scirpus californicus	1.12	1.12	1.12	1
Cladium jamaicense	1.14	0.49	1.36	16
Aster subulatus	1.18	1.18	1.18	1
Sabal palmetto	1.18	1.18	1.18	1
Sagittaria lancifolia	1.30	1.30	1.30	1
Acrostichum danaeifolium	1.36	1.21	1.36	2

Appendix E continued

Center of abundance, minimum, and maximum river miles for each species and the number of sites at which the species was recorded.

Chassahowitzka River

	Center of Abundance	Minimum	Maximum	Number of Sites
Aster tenuifolius	0.00	0.00	0.00	1
Lythrum alatum	0.05	0.05	0.05	1
Sagittaria subulata	0.22	0.00	3.55	6
Spartina alterniflora	0.22	0.05	1.70	4
Distichlis spicata	0.40	0.00	0.75	4
Juncus roemerianus	0.85	0.00	2.40	37
Alternanthera philoxeroides	1.29	1.25	1.65	2
Scirpus americanus	1.74	1.60	2.05	4
Cladium jamaicense	2.27	0.15	4.15	56
Typha domingensis	2.49	0.30	3.87	21
Sagittaria lancifolia	2.93	2.60	3.82	10
Cicuta mexicana	2.95	2.95	2.95	1
Ampelopsis arborea	3.20	3.20	3.20	1
Scirpus robustus	3.21	2.60	3.82	2
Crinum americanum	3.28	0.05	4.75	9
Saururus cernuus	3.28	3.05	3.40	2
Iris hexagona	3.40	3.40	3.40	1
Aster caroliniana	3.45	3.45	3.45	1
Acrostichum danaeifolium	3.60	1.10	4.00	3
Sabal palmetto	4.28	4.28	4.28	1
Magnolia virginiana	4.35	4.35	4.35	1
Paspalidium geminatum	4.62	4.60	4.75	2
Phragmites australis	4.68	4.68	4.68	1

Appendix E continued

Center of abundance, minimum, and maximum river miles for each species and the number of sites at which the species was recorded.

Crystal River.

	Center of Abundance	Minimum	Maximum	Number of Sites
Distichlis spicata	0.50	0.50	0.50	1
Spartina alterniflora	1.88	0.02	4.35	47
Juncus roemerianus	2.57	0.06	6.40	38
Ruppia maritime	3.28	2.80	3.82	6
Sagittaria subulata	4.65	2.17	6.50	21
Typha domingensis	5.22	1.10	6.50	21
Cladium jamaicense	5.27	2.60	6.50	13
Sagittaria lancifolia	6.28	5.29	6.40	4
Aster caroliniana	6.30	6.30	6.30	1
Fraxinus caroliniana	6.50	6.50	6.50	1
Pontederia cordata	6.50	6.50	6.50	1

Appendix E concluded

Center of abundance, minimum, and maximum river miles for each species and the number of sites at which the species was recorded.

Withlacoochee River.

	Center of Abundance	Minimum	Maximum	Number of Sites
Aster subulatus	0.29	0.29	0.29	1
Distichlis spicata	0.29	0.29	0.29	1
Baccharis angustifolia	0.55	0.55	0.55	1
Phragmites australis	0.82	0.50	0.98	3
Spartina alterniflora	0.91	0.00	1.82	24
Typha domingensis	1.06	0.46	1.64	19
Juncus roemerianus	1.18	0.12	2.36	28
Cladium jamaicense	2.01	0.85	2.78	24
Aster caroliniana	2.39	2.39	2.39	1
Panicum anceps	2.41	2.39	2.62	2
Fraxinus caroliniana	2.49	2.17	3.15	11
Solidago stricta	2.50	2.39	2.58	2
Smilax walteri	2.50	2.50	2.50	1
Sagittaria lancifolia	2.55	2.33	2.78	3
Chasmanthium nitidum	2.61	2.55	2.62	3
Smilax bona-nox	2.62	2.62	2.62	1
Stenotaphrum secundatum	2.62	2.62	2.62	1
Itea virginiana	2.63	2.62	2.83	2
Magnolia virginiana	2.65	2.27	2.88	5
Eleocharis elongata	2.77	2.50	3.20	8
Cornus foemina	2.82	2.78	2.83	2
Lobelia cardinalis	2.86	2.62	3.20	6
Sagittaria subulata	2.89	2.36	3.35	6
Crinum americanum	2.89	2.62	3.20	3
Isoetes flaccida	2.92	2.45	3.15	2
Saururus cernuus	2.94	2.39	3.20	6
Alternanthera philoxeroides	2.95	2.39	3.35	3
Cephalanthus occidentalis	2.97	2.50	3.20	2
Ruppia maritime	3.07	3.07	3.07	1
Ludwigia repens	3.12	2.88	3.35	2
Polygonum hydropiperoides	3.27	2.88	3.35	2
Colocasia esculenta	3.30	2.62	3.35	2
Echinochloa muricata	3.35	3.35	3.35	1
Pontederia cordata	3.35	3.35	3.35	1
Juncus effusus	3.35	3.35	3.35	1

Appendix F

Number of quadrats where each species was recorded and the mean, median, minimum and maximum percent cover of each species within those quadrats

Pe

Peace River

	Number of Quadrats	Mean Cover	Median Cover	Minimum Cover	Maximum Cover
Juncus roemerianus	17	45	5	8	70
Rhizophora mangle	15	4	2	1	11
Scirpus californicus	12	39	45	3	65
Sagittaria lancifolia	10	2	11	3	28
Cladium jamaicense	8	34	26	20	70
Acrostichum danaeifolium	7	38	15	3	100
Polygonum hydropiperoides	7	8	5	2	28
Pontederia cordata	6	12	9	3	30
Colocasia esculenta	6	4	4	1	10
Typha domingensis	5	12	15	3	20
Samolus valerandi	5	2	2	1	4
Senecio glabellus	4	7	8	4	10
Bacopa monnieri	3	20	14	3	43
Aster carolinianus	3	5	3	1	10
Cicuta mexicana	3	2	3	1	3
Ludwigia repens	2	21	21	13	30
Sambucus canadensis	2	13	13	5	20
Alternanthera philoxeroides	2	11	11	3	20
Rumex verticillatus	2	7	7	1	13
Laguncularia racemosa	2	6	6	1	10
Amaranthus australis	2	1	1	1	1
Pluchea odorata	2	1	1	1	1
Nuphar luteum	1	30	30	30	30
Zizania aquatica	1	25	25	25	25
Spartina baker	1	15	15	15	15
Phragmites australis	1	9	9	9	9
Mikania scandens	1	5	5	5	5
Triglochin striata	1	5	5	5	5
Sesuvium portulacastrum	1	3	3	3	3
Sagittaria subulata	1	3	3	3	3
Blechnum serrulatum	1	1	1	1	1
Stenotaphrum secundatum	1	1	1	1	1
Taxodium distichum	1	1	1	1	1
Juncus effusus	1	1	1	1	1

Appendix F continued

Myakka River	Number of Quadrats	Mean Cover	Median Cover	Minimum Cover	Maximum Cover
Juncus roemerianus	34	40	44	1	88
Rhizophora mangle	16	6	4	1	36
Scirpus californicus	15	35	33	10	75
Scirpus tabernaemontani	12	12	13	3	25
Eleocharis flavescens	11	15	8	3	60
Typha domingensis	10	15	14	3	43
Polygonum hydropiperoides	10	15	10	3	48
Mikania scandens	8	5	4	1	13
Pontederia cordata	7	10	8	3	20
Urochloa mutica	6	20	20	5	43
Rumex verticillatus	6	19	16	3	40
Sagittaria subulata	6	14	11	3	30
Laguncularia racemosa	6	2	2	1	6
Spartina alterniflora	5	35	30	13	68
Crinum americanum	5	16	23	1	30
Sagittaria lancifolia	5	15	5	1	53
Gratiola virginiana	5	10	5	3	25
Samolus valerandi	4	6	4	1	18
Acrostichum danaeifolium	3	30	35	20	35
Ludwigia repens	3	4	3	3	8
Pluchea odorata	3	3	3	3	3
Iva frutescens	2	9	9	3	16
Acrostichum aureum	2	6	6	3	10
Hydrocotyle umbellata	2	4	4	3	5
Senecio glabellus	2	3	3	3	4
Conocarpus erectus	2	2	2	2	3
Diodia virginiana	2	2	2	1	3
Aster caroliniana	1	25	25	25	25
Cladium jamaicense	1	18	18	18	18
Distichlis spicata	1	18	18	18	18
Phyla nodiflora	1	10	10	10	10
Bacopa monnieri	1	8	8	8	8
Alternanthera philoxeroides	1	5	5	5	5
Ptilimnium capillaceum	1	5	5	5	5
Borrichia frutescens	1	3	3	3	3
Juncus megacephalus	1	3	3	3	3

Appendix F continued

Myakka River continued	Number of Quadrats	Mean Cover	Median Cover	Minimum Cover	Maximum Cover
Spartina bakeri	1	3	3	3	3
Spartina patens	1	3	3	3	3
Isoetes flaccida	1	2	2	2	2
Avicenna germinans	1	1	1	1	1
Iris hexagona	1	1	1	1	1
Panicum rigidulum	1	1	1	1	1

Little Manatee River	Number of Quadrats	Mean Cover	Median Cover	Minimum Cover	Maximum Cover
Juncus roemerianus	41	45	48	5	80
Rhizophora mangle	19	2	2	1	6
Typha domingensis	9	38	45	10	68
Alternanthera philoxeroides	6	18	9	1	70
Crinum americanum	6	2	2	1	3
Urochloa mutica	4	58	65	28	75
Cladium jamaicense	4	53	65	13	70
Acrostichum danaeifolium	4	8	6	1	20
Pontederia cordata	3	5	6	3	8
Laguncularia racemosa	3	2	2	1	3
Avicenna germinans	3	1	1	1	1
Scirpus tabernaemontani	2	17	17	4	30
Aster carolinianus	1	60	60	60	60
Lythrum alatum	1	13	13	13	13
Blechnum serrulatum	1	4	4	4	4
Phragmites australis	1	2	2	2	2
Pluchea odorata	1	2	2	2	2
Myrica cerifera	1	1	1	1	1
Osmunda regalis	1	1	1	1	1
Rumex verticillatus	1	1	1	1	1

Appendix E continued

Weeki Wachee River					
	Number of Quadrats	Mean Cover	Median Cover	Minimum Cover	Maximum Cover
Juncus roemerianus	29	27	18	1	83
Spartina alterniflora	18	10	5	1	35
Cladium jamaicense	16	40	39	5	80
Ruppia maritima	13	12	8	5	35
Typha domingensis	11	16	13	1	55
Sagittaria subulata	4	21	13	3	55
Acrostichum danaeifolium	2	20	20	1	40
Distichlis spicata	2	2	2	1	4
Scirpus californicus	1	15	15	15	15
Sagittaria lancifolia	1	6	6	6	6
Crinum americanum	1	2	2	2	2
Aster subulatus	1	2	2	2	2
Sabal palmetto	1	1	1	1	1

Appendix F continued

Chassahowitzka River

	Number of Sites	Mean Cover	Median Cover	Minimum Cover	Maximum Cover
Cladium jamaicense	56	40	41	1	90
Juncus roemerianus	37	39	45	3	80
Typha domingensis	21	15	5	1	75
Sagittaria lancifolia	10	10	8	1	25
Crinum americanum	9	8	4	1	45
Sagittaria subulata	6	7	5	1	25
Spartina alterniflora	4	14	5	3	43
Scirpus americanus	4	12	9	4	28
Distichlis spicata	4	10	8	5	20
Acrostichum danaeifolium	3	14	15	3	25
Scirpus robustus	2	30	30	30	30
Paspalum repens	2	15	15	4	25
Alternanthera philoxeroides	2	3	3	1	5
Saururus cernuus	2	1	1	1	1
Phragmites australis	1	28	28	28	28
Iris hexagona	1	18	18	18	18
Ampelopsis arborea	1	8	8	8	8
Aster tenuifolius	1	5	5	5	5
Lythrum alatum	1	3	3	3	3
Aster carolinianus	1	3	3	3	3
Cicuta mexicana	1	1	1	1	1
Magnolia virginiana	1	1	1	1	1
Sabal palmetto	1	1	1	1	1

Appendix F continued

Crystal River	Number of Quadrats	Mean Cover	Median Cover	Minimum Cover	Maximum Cover
Spartina alterniflora	47	25	18	1	80
Juncus roemerianus	38	27	20	3	85
Sagittaria subulata	21	25	18	3	80
Typha domingensis	21	22	18	1	60
Cladium jamaicense	13	33	23	1	80
Ruppia maritime	6	6	5	1	10
Sagittaria lancifolia	4	6	8	1	10
Pontederia cordata	2	25	25	5	45
Aster carolinianus	1	3	3	3	3
Distichlis spicata	1	1	1	1	1
Fraxinus caroliniana	1	1	1	1	1

Appendix F continued

Crystal River	Number of Quadrats	Mean Cover	Median Cover	Minimum Cover	Maximum Cover
Spartina alterniflora	47	25	18	1	80
Juncus roemerianus	38	27	20	3	85
Sagittaria subulata	21	25	18	3	80
Typha domingensis	21	22	18	1	60
Cladium jamaicense	13	33	23	1	80
Ruppia maritime	6	6	5	1	10
Sagittaria lancifolia	4	6	8	1	10
Pontederia cordata	2	25	25	5	45
Aster carolinianus	1	3	3	3	3
Distichlis spicata	1	1	1	1	1
Fraxinus caroliniana	1	1	1	1	1

Appendix G

River mile location, median and P95 salinity, and species presence by site for each river.

Asterisks denote species that were recorded adjacent to, but not in, quadrants.

Peace River

Peace River: Site=1 Mile=8.3 medsal=7.3 p95Sal=21.0
- Acrostichum danaeifolium *
- Juncus roemerianus

Peace River: Site=2 Mile=8.45 medsal=6.9 p95Sal=20.7
- Juncus roemerianus
- Laguncularia racemosa *
- Rhizophora mangle

Peace River: Site=3 Mile=8.6 medsal=6.6 p95Sal=20.4
- Ficus aurea *
- Juncus roemerianus
- Rhizophora mangle *

Peace River: Site=4 Mile=8.8 medsal=6.1 p95Sal=19.9
- Acrostichum aureum *
- Rhizophora mangle

Peace River: Site=5 Mile=8.95 medsal=5.7 p95Sal=19.6
- Acrostichum danaeifolium
- Conocarpus erectus *
- Ficus aurea *
- Laguncularia racemosa *
- Rhabdadenia biflora *
- Rhizophora mangle *
- Schinus terebinthifolius *

Peace River: Site=6 Mile=9.1 medsal=5.3 p95Sal=19.3
- Juncus roemerianus
- Rhizophora mangle

Peace River: Site=7 Mile=9.25 medsal=5.0 p95Sal=19.0
- Acrostichum aureum *
- Rhabdadenia biflora *
- Rhizophora mangle

Peace River: Site=8 Mile=9.4 medsal=4.6 p95Sal=18.6
- Rhizophora mangle

Peace River: Site=9 Mile=9.55 medsal=4.2 p95Sal=18.3
- Juncus roemerianus
- Rhizophora mangle

Peace River: Site=10 Mile=9.7 medsal=4.0 p95Sal=18.0
- Bacopa monnieri *
- Juncus roemerianus
- Rhizophora mangle

Peace River: Site=11 Mile=9.9 medsal=3.7 p95Sal=17.6
- Juncus roemerianus
- Laguncularia racemosa
- Rhizophora mangle

Peace River: Site=12 Mile=10.05 medsal=3.5 p95Sal=17.3
- Juncus roemerianus *
- Rhizophora mangle *
- Scirpus californicus

Peace River: Site=13 Mile=10.2 medsal=3.3 p95Sal=17.0
- Bacopa monnieri *
- Distichlis spicata *
- Juncus roemerianus
- Rhizophora mangle

Peace River: Site=14 Mile=10.35 medsal=3.1 p95Sal=16.6
- Bacopa monnieri *
- Cladium jamaicense
- Rhizophora mangle
- Scirpus californicus

Peace River: Site=15 Mile=10.5 medsal=2.9 p95Sal=16.3
- Distichlis spicata *
- Juncus roemerianus
- Rhizophora mangle
- Spartina bakeri *

Peace River: Site=16 Mile=10.65 medsal=2.7 p95Sal=16.0
- Juncus roemerianus
- Typha domingensis

Peace River: Site=17 Mile=10.8 medsal=2.6 p95Sal=15.7
- Acrostichum danaeifolium
- Bacopa monnieri
- Crinum americanum *
- Juncus roemerianus
- Laguncularia racemosa
- Myrica cerifera *
- Persea palustris *
- Rhizophora mangle *
- Sesuvium portulacastrum
- Triglochin striata

Peace River: Site=18 Mile=10.95 medsal=2.4 p95Sal=15.4
- Juncus roemerianus
- Scirpus californicus *

Peace River: Site=19 Mile=11.15 medsal=2.1 p95Sal=15.0
- Cladium jamaicense
- Conocarpus erectus *
- Juncus roemerianus *
- Schinus terebinthifolius *

Peace River: Site=20 Mile=11.35 medsal=1.9 p95Sal=14.6
Scirpus californicus

Peace River: Site=21 Mile=11.48 medsal=1.7 p95Sal=14.3
Baccharis halimifolia *
Scirpus californicus

Peace River: Site=22 Mile=11.6 medsal=1.5 p95Sal=14.1
Acrostichum danaeifolium *
Dalbergia ecastophyllum *
Juncus roemerianus
Rhizophora mangle *
Spartina bakeri

Peace River: Site=23 Mile=11.8 medsal=1.3 p95Sal=13.6
Acrostichum danaeifolium *
Alternanthera philoxeroides *
Bacopa monnieri *
Cladium jamaicense *
Juncus roemerianus
Rhizophora mangle

Peace River: Site=24 Mile=11.95 medsal=1.1 p95Sal=13.3
Ardisia escallonoides *
Juncus roemerianus
Rhizophora mangle
Sabal palmetto *

Peace River: Site=25 Mile=12.2 medsal=0.8 p95Sal=12.8
Bacopa monnieri *
Laguncularia racemosa *
Rhizophora mangle
Scirpus californicus

Peace River: Site=26 Mile=12.35 medsal=0.6 p95Sal=12.5
Cladium jamaicense *
Crinum americanum *
Juncus roemerianus
Typha domingensis

Peace River: Site=27 Mile=12.5 medsal=0.5 p95Sal=12.2
Bacopa monnieri *
Cladium jamaicense *
Scirpus californicus

Peace River: Site=28 Mile=12.7 medsal=0.4 p95Sal=11.7
Scirpus californicus

Peace River: Site=29 Mile=12.85 medsal=0.4 p95Sal=11.4
Cladium jamaicense
Ficus aurea *
Juncus roemerianus *

Peace River: Site=30 Mile=12.95 medsal=0.4 p95Sal=11.1
Acrostichum danaeifolium
Ficus aurea *

Peace River: Site=31 Mile=13.1 medsal=0.4 p95Sal=10.8
Bacopa monnieri
Ficus aurea *
Juncus roemerianus
Persea palustris *

Sabal palmetto *
Solidago sempervirens *
Spartina bakeri *
Teucrium canadense *

Peace River: Site=32 Mile=13.25 medsal=0.3 p95Sal=10.4
Mikania scandens *
Pluchea odorata *
Scirpus californicus

Peace River: Site=33 Mile=13.4 medsal=0.3 p95Sal=10.1
Cladium jamaicense
Juncus roemerianus *
Rhizophora mangle *

Peace River: Site=34 Mile=13.6 medsal=0.3 p95Sal=9.6
Scirpus californicus *
Typha domingensis

Peace River: Site=35 Mile=13.75 medsal=0.3 p95Sal=9.3
Acrostichum danaeifolium
Blechnum serrulatum *
Ficus aurea *
Myrica cerifera *
Persea palustris *

Peace River: Site=36 Mile=13.9 medsal=0.2 p95Sal=9.0
Baccharis halimifolia *
Cladium jamaicense

Peace River: Site=37 Mile=14.05 medsal=0.2 p95Sal=8.6
Alternanthera philoxeroides
Amaranthus australis
Cicuta maculata *
Cladium jamaicense
Colocasia esculenta *
Crinum americanum *
Polygonum hydropiperoides
Typha domingensis *

Peace River: Site=38 Mile=14.2 medsal=0.2 p95Sal=8.3
Acrostichum danaeifolium
Crinum americanum *
Samolus valerandi *

Peace River: Site=40 Mile=14.45 medsal=0.1 p95Sal=7.7
Acrostichum danaeifolium
Aster carolinianus
Blechnum serrulatum
Cicuta maculata *
Colocasia esculenta
Pluchea odorata *
Sagittaria lancifolia
Sambucus canadensis *
Samolus valerandi

Peace River: Site=41 Mile=14.6 medsal=0.1 p95Sal=7.4
Acrostichum danaeifolium *
Aster carolinianus *
Blechnum serrulatum *
Cladium jamaicense
Sambucus canadensi

Peace River: Site=42 Mile=14.75 medsal=0.1 p95Sal=6.9
- Acrostichum danaeifolium *
- Aster carolinianus *
- Colocasia esculenta
- Ficus aurea *
- Juncus effusus
- Pluchea odorata
- Polygonum hydropiperoides
- Rhizophora mangle
- Sabal palmetto *
- Samolus valerandi
- Solidago stricta *
- Stenotaphrum secundatum
- Taxodium distichum
- Triglochin striata *

Peace River: Site=43 Mile=14.85 medsal=0.1 p95Sal=6.6
- Acrostichum danaeifolium *
- Aster carolinianus *
- Cicuta maculata *
- Cladium jamaicense
- Pontederia cordata *
- Sagittaria lancifolia *
- Sambucus canadensis
- Samolus valerandi *

Peace River: Site=44 Mile=15 medsal=0.1 p95Sal=6.2
- Cicuta maculata
- Pontederia cordata
- Sagittaria lancifolia
- Sagittaria subulata

Peace River: Site=45 Mile=15.15 medsal=0.1 p95Sal=5.8
- Acer rubrum *
- Aster carolinianus
- Colocasia esculenta
- Ludwigia repens
- Persea palustris *
- Pluchea odorata
- Polygonum hydropiperoides
- Samolus valerandi
- Senecio glabellus *
- Zizania aquatica

Peace River: Site=46 Mile=15.3 medsal=???? p95Sal=.
- Acrostichum danaeifolium *

Peace River: Site=47 Mile=15.5 medsal=0.1 p95Sal=4.8
- Acrostichum danaeifolium *
- Cephalanthus occidentalis *
- Colocasia esculenta
- Myrica cerifera *
- Rumex verticillatus
- Samolus valerandi

Peace River: Site=48 Mile=15.65 medsal=0.1 p95Sal=4.4
- Acrostichum danaeifolium *
- Alternanthera philoxeroides
- Aster carolinianus
- Cicuta maculata
- Colocasia esculenta
- Mikania scandens

Pontederia cordata
Rumex verticillatus
Sagittaria lancifolia
Samolus valerandi

Peace River: Site=49 Mile=15.85 medsal=???? p95Sal=???
Acrostichum danaeifolium *
Myrica cerifera *
Persea palustris *

Peace River: Site=50 Mile=15.95 medsal=0.1 p95Sal=3.5
Scirpus californicus

Peace River: Site=51 Mile=16.4 medsal=0.1 p95Sal=2.9
Phragmites australis

Peace River: Site=52 Mile=16.6 medsal=0.1 p95Sal=2.7
Acrostichum danaeifolium
Sagittaria lancifolia
Zizania aquatica *

Peace River: Site=53 Mile=16.85 medsal=0.1 p95Sal=2.4
Polygonum hydropiperoides
Pontederia cordata *
Scirpus californicus
Senecio glabellus *
Typha domingensis *

Peace River: Site=54 Mile=17.1 medsal=0.1 p95Sal=2.1
Acrostichum danaeifolium *
Cicuta maculata *
Pontederia cordata
Sagittaria lancifolia
Senecio glabellus

Peace River: Site=55 Mile=17.4 medsal=0.1 p95Sal=1.7
Scirpus californicus *
Typha domingensis

Peace River: Site=56 Mile=17.6 medsal=0.1 p95Sal=1.5
Nuphar luteum

Peace River: Site=57 Mile=17.85 medsal=0.1 p95Sal=1.1
Nuphar luteum *
Pontederia cordata
Sagittaria lancifolia
Scirpus californicus
Typha domingensis

Peace River: Site=58 Mile=18.05 medsal=0.1 p95Sal=0.9
Cicuta maculata *
Nuphar luteum *
Polygonum hydropiperoides
Pontederia cordata *
Rumex verticillatus *
Sagittaria lancifolia

Peace River: Site=59 Mile=18.3 medsal=0.1 p95Sal=0.6
Bacopa monnieri
Cicuta maculata
Ludwigia repens
Pontederia cordata

Sagittaria lancifolia
Senecio glabellus
Typha domingensis *

Peace River: Site=60 Mile=18.5 medsal=0.1 p95Sal=0.5
Amaranthus australis
Cicuta maculata *
Polygonum hydropiperoides
Pontederia cordata
Sagittaria lancifolia
Salix caroliniana *
Samolus valerandi *
Senecio glabellus

Peace River: Site=502 Mile=16.1 medsal=0.1 p95Sal=3.3
Colocasia esculenta
Polygonum hydropiperoides
Sagittaria lancifolia
Senecio glabellus

Peace River: Site=505 Mile=16.25 medsal=0.1 p95Sal=3.1
Acrostichum danaeifolium *
Alternanthera philoxeroides *
Aster carolinianus *
Scirpus californicus

Myakka River

Myakka River: Site=11 Mile=2.7 medsal=19.8 p95Sal=26.1
Avicennia germinans *
Borrichia frutescens *
Cladium jamaicense *
Ficus aurea *
Iva frutescens *
Spartina alterniflora
Spartina bakeri *

Myakka River: Site=12 Mile=2.9 medsal=19.4 p95Sal=26.0
Avicennia germinans *
Borrichia frutescens
Juncus roemerianus
Laguncularia racemosa *
Rhizophora mangle
Solidago stricta *

Myakka River: Site=13 Mile=3.2 medsal=18.9 p95Sal=25.8
Avicennia germinans *
Blutaparon vermiculare *
Ficus aurea *
Juncus roemerianus *
Laguncularia racemosa *
Schinus terebinthifolius *
Spartina alterniflora

Myakka River: Site=14 Mile=3.61 medsal=18.1 p95Sal=25.6
Avicennia germinans *
Spartina alterniflora

Myakka River: Site=15 Mile=3.88 medsal=17.6 p95Sal=25.4
Juncus roemerianus

Myakka River: Site=16 Mile=4.1 medsal=17.1 p95Sal=25.3
Rhizophora mangle

Myakka River: Site=17 Mile=4.38 medsal=16.6 p95Sal=25.1
Acrostichum aureum *
Avicennia germinans *
Borrichia frutescens *
Conocarpus erectus *
Iva frutescens *
Laguncularia racemosa *
Schinus terebinthifolius *
Spartina alterniflora

Myakka River: Site=18 Mile=4.69 medsal=16.0 p95Sal=24.9
Conocarpus erectus
Juncus roemerianus
Laguncularia racemosa
Rhizophora mangle
Spartina alterniflora *

Myakka River: Site=19 Mile=4.94 medsal=15.6 p95Sal=24.7
Conocarpus erectus *
Spartina alterniflora

Myakka River: Site=20 Mile=5.12 medsal=15.3 p95Sal=24.5
Distichlis spicata *
Juncus roemerianus
Rhizophora mangle
Sesuvium portulacastrum *

Myakka River: Site=21 Mile=5.38 medsal=14.8 p95Sal=24.2
Avicennia germinans *
Distichlis spicata
Juncus roemerianus
Laguncularia racemosa
Rhizophora mangle
Sesuvium portulacastrum *
Spartina patens

Myakka River: Site=22 Mile=5.75 medsal=14.2 p95Sal=23.8
Iva frutescens *
Juncus roemerianus
Laguncularia racemosa *
Spartina alterniflora *

Myakka River: Site=23 Mile=5.95 medsal=13.9 p95Sal=23.6
Juncus roemerianus
Laguncularia racemosa *
Rhizophora mangle *
Sabal palmetto *
Spartina alterniflora *
Spartina patens *

Myakka River: Site=24 Mile=6.15 medsal=13.5 p95Sal=23.4
Juncus roemerianus

Myakka River: Site=25 Mile=6.5 medsal=12.9 p95Sal=23.1
Iva frutescens
Juncus roemerianus
Laguncularia racemosa *
Schinus terebinthifolius *

Myakka River: Site=26 Mile=6.92 medsal=12.2 p95Sal=22.6
Acrostichum aureum
Avicennia germinans
Conocarpus erectus
Iva frutescens
Juncus roemerianus
Laguncularia racemosa
Rhizophora mangle

Myakka River: Site=27 Mile=7.1 medsal=11.9 p95Sal=22.5
Iva frutescens *
Juncus roemerianus
Laguncularia racemosa *

Myakka River: Site=28 Mile=7.25 medsal=11.6 p95Sal=22.3
Acrostichum aureum
Iva frutescens *
Juncus roemerianus
Rhizophora mangle

Myakka River: Site=29 Mile=7.5 medsal=11.2 p95Sal=22.1
Juncus roemerianus
Laguncularia racemosa *

Myakka River: Site=30 Mile=7.75 medsal=10.8 p95Sal=21.8
Juncus roemerianus
Laguncularia racemosa
Rhizophora mangle

Myakka River: Site=31 Mile=7.95 medsal=10.4 p95Sal=21.6
Juncus roemerianus

Myakka River: Site=32 Mile=8.25 medsal=9.9 p95Sal=21.3
Ficus aurea *
Scirpus californicus

Myakka River: Site=33 Mile=8.52 medsal=9.5 p95Sal=21.2
Juncus roemerianus
Rhizophora mangle

Myakka River: Site=34 Mile=8.8 medsal=9.1 p95Sal=21.0
Juncus roemerianus
Laguncularia racemosa *
Rhizophora mangle *

Myakka River: Site=35 Mile=9 medsal=8.8 p95Sal=20.9
Juncus roemerianus
Rhizophora mangle

Myakka River: Site=37 Mile=9.12 medsal=8.6 p95Sal=20.8
Juncus roemerianus
Rhizophora mangle

Myakka River: Site=38 Mile=9.46 medsal=8.1 p95Sal=20.6
Juncus roemerianus
Rhizophora mangle *

Scirpus californicus *
Spartina bakeri *

Myakka River: Site=39 Mile=9.75 medsal=7.6 p95Sal=20.4
Acrostichum danaeifolium
Juncus roemerianus
Laguncularia racemosa
Rhizophora mangle

Myakka River: Site=40 Mile=10 medsal=7.3 p95Sal=20.2
Acrostichum danaeifolium *
Juncus roemerianus
Laguncularia racemosa *
Rhizophora mangle

Myakka River: Site=41 Mile=10.23 medsal=6.9 p95Sal=20.1
Acrostichum danaeifolium *
Juncus roemerianus
Laguncularia racemosa
Rhizophora mangle

Myakka River: Site=42 Mile=10.57 medsal=6.1 p95Sal=19.7
Scirpus californicus

Myakka River: Site=43 Mile=10.82 medsal=5.5 p95Sal=19.4
Acrostichum danaeifolium *
Juncus roemerianus
Rhizophora mangle

Myakka River: Site=44 Mile=11 medsal=5.1 p95Sal=19.2
Acrostichum danaeifolium *
Juncus roemerianus
Rhizophora mangle *

Myakka River: Site=45 Mile=11.46 medsal=3.9 p95Sal=18.6
Acrostichum danaeifolium *
Bacopa monnieri *
Juncus roemerianus
Laguncularia racemosa *
Rhizophora mangle
Samolus valerandi
Typha domingensis

Myakka River: Site=46 Mile=11.68 medsal=3.4 p95Sal=18.4
Acrostichum danaeifolium *
Crinum americanum *
Juncus roemerianus

Myakka River: Site=47 Mile=11.92 medsal=2.8 p95Sal=18.1
Scirpus californicus

Myakka River: Site=48 Mile=12.19 medsal=2.5 p95Sal=17.7
Acrostichum danaeifolium
Cladium jamaicense
Juncus roemerianus

Myakka River: Site=49 Mile=12.38 medsal=2.3 p95Sal=17.4
Alternanthera philoxeroides *
Eleocharis flavescens *
Ludwigia repens *
Pluchea odorata *
Sagittaria subulata *

Scirpus californicus
Typha domingensis *

Myakka River: Site=50 Mile=12.61 medsal=2.0 p95Sal=17.1
Acrostichum danaeifolium
Juncus roemerianus

Myakka River: Site=51 Mile=12.81 medsal=1.8 p95Sal=16.8
Juncus roemerianus *
Scirpus californicus

Myakka River: Site=52 Mile=13.2 medsal=1.3 p95Sal=16.2
Scirpus californicus
Typha domingensis

Myakka River: Site=53 Mile=13.53 medsal=0.9 p95Sal=15.7
Crinum americanum
Juncus roemerianus
Mikania scandens
Pluchea odorata
Samolus valerandi
Scirpus californicus *
Spartina bakeri

Myakka River: Site=54 Mile=13.58 medsal=0.9 p95Sal=15.6
Acrostichum danaeifolium *
Juncus roemerianus
Mikania scandens
Scirpus californicus

Myakka River: Site=55 Mile=13.88 medsal=0.5 p95Sal=15.2
Juncus roemerianus *
Lythrum alatum *
Rhizophora mangle *
Rumex verticillatus *
Scirpus californicus
Spartina bakeri *

Myakka River: Site=56 Mile=14.23 medsal=0.4 p95Sal=14.6
Scirpus californicus

Myakka River: Site=57 Mile=14.61 medsal=0.4 p95Sal=13.9
Crinum americanum
Juncus roemerianus
Lythrum alatum *
Mikania scandens *
Polygonum hydropiperoides *
Sagittaria subulata *
Samolus valerandi
Spartina bakeri *
Teucrium canadense *

Myakka River: Site=58 Mile=14.82 medsal=0.3 p95Sal=13.5
Crinum americanum *
Juncus roemerianus
Mikania scandens
Pluchea odorata *
Samolus valerandi
Scirpus californicus *

Myakka River: Site=60 Mile=15.37 medsal=0.2 p95Sal=12.5
Scirpus californicus

Myakka River: Site=61 Mile=15.68 medsal=0.2 p95Sal=12.0
Scirpus californicus

Myakka River: Site=62 Mile=15.95 medsal=0.1 p95Sal=11.5
Scirpus californicus

Myakka River: Site=63 Mile=16.07 medsal=0.1 p95Sal=11.3
Ampelopsis arborea *
Aster carolinianus
Crinum americanum *
Scirpus californicus

Myakka River: Site=64 Mile=16.37 medsal=0.1 p95Sal=10.7
Bacopa monnieri
Eleocharis flavescens
Hydrocotyle umbellata
Juncus roemerianus *
Lobelia feayana *
Ludwigia repens
Polygonum hydropiperoides
Rhynchospora colorata *
Sagittaria subulata

Myakka River: Site=65 Mile=16.63 medsal=0.1 p95Sal=10.3
Bacopa monnieri *
Cicuta maculata *
Eleocharis flavescens
Isoetes flaccida
Juncus roemerianus
Lobelia feayana *
Ludwigia repens
Polygonum hydropiperoides *
Sabatia calycina *
Sagittaria subulata

Myakka River: Site=66 Mile=16.8 medsal=0.1 p95Sal=10.0
Juncus roemerianus *
Polygonum hydropiperoides *
Typha domingensis

Myakka River: Site=67 Mile=17.11 medsal=0.1 p95Sal=9.4
Eleocharis flavescens *
Ludwigia repens *
Pluchea odorata
Polygonum hydropiperoides *
Sagittaria lancifolia
Scirpus californicus

Myakka River: Site=68 Mile=17.42 medsal=0.1 p95Sal=8.9
Crinum americanum *
Eleocharis flavescens
Panicum rigidulum *
Sagittaria subulata
Samolus valerandi *
Scirpus tabernaemontani
Typha domingensis

Myakka River: Site=69 Mile=17.69 medsal=0.1 p95Sal=8.4
Crinum americanum
Eleocharis flavescens

Gratiola virginiana *
Pontederia cordata
Rumex verticillatus
Sagittaria subulata
Scirpus tabernaemontani
Senecio glabellus
Urochloa mutica *

Myakka River: Site=70 Mile=17.87 medsal=0.1 p95Sal=8.1
Eleocharis flavescens
Gratiola virginiana
Mikania scandens
Pluchea odorata
Scirpus tabernaemontani
Senecio glabellus
Urochloa mutica

Myakka River: Site=71 Mile=18.17 medsal=0.1 p95Sal=7.5
Eleocharis flavescens
Gratiola virginiana
Panicum rigidulum *
Polygonum hydropiperoides
Rumex verticillatus
Sagittaria lancifolia
Sagittaria subulata
Scirpus tabernaemontani
Spartina bakeri *
Typha domingensis *

Myakka River: Site=72 Mile=18.48 medsal=0.1 p95Sal=7.0
Crinum americanum
Eleocharis flavescens
Gratiola virginiana
Sagittaria lancifolia
Sagittaria subulata

Myakka River: Site=73 Mile=18.6 medsal=0.1 p95Sal=6.8
Eleocharis flavescens *
Panicum rigidulum *
Scirpus californicus
Senecio glabellus *
Typha domingensis
Urochloa mutica

Myakka River: Site=74 Mile=18.92 medsal=0.1 p95Sal=6.2
Eleocharis flavescens
Gratiola virginiana
Polygonum hydropiperoides
Pontederia cordata
Sagittaria lancifolia
Scirpus tabernaemontani

Myakka River: Site=75 Mile=19.16 medsal=0.1 p95Sal=5.8
Panicum rigidulum
Polygonum hydropiperoides *
Pontederia cordata *
Rumex verticillatus *
Sagittaria lancifolia *
Scirpus californicus *
Typha domingensis
Urochloa mutica

Myakka River: Site=76 Mile=19.54 medsal=0.1 p95Sal=5.1
- Cicuta maculata *
- Gratiola virginiana *
- Iris hexagona *
- Panicum rigidulum *
- Senecio glabellus *
- Typha domingensis

Myakka River: Site=77 Mile=19.71 medsal=0.1 p95Sal=4.8
- Eleocharis flavescens *
- Typha domingensis

Myakka River: Site=78 Mile=20 medsal=0.1 p95Sal=4.3
- Eleocharis flavescens *
- Mikania scandens
- Pontederia cordata
- Sagittaria subulata *
- Scirpus tabernaemontani
- Typha domingensis

Myakka River: Site=82 Mile=21 medsal=0.1 p95Sal=2.5
- Crinum americanum
- Eleocharis flavescens
- Hypericum mutilum *
- Iris hexagona *
- Mikania scandens *
- Polygonum hydropiperoides
- Pontederia cordata
- Scirpus tabernaemontani
- Urochloa mutica *

Myakka River: Site=83 Mile=21.31 medsal=0.1 p95Sal=1.9
- Eleocharis flavescens
- Gratiola virginiana
- Hydrocotyle umbellata
- Iris hexagona
- Ludwigia repens
- Polygonum hydropiperoides *
- Pontederia cordata
- Sagittaria lancifolia
- Urochloa mutica

Myakka River: Site=84 Mile=22 medsal=0.1 p95Sal=0.7
- Carex lupulina *
- Diodia virginiana
- Eleocharis flavescens
- Polygonum hydropiperoides
- Pontederia cordata *
- Rumex verticillatus
- Scirpus tabernaemontani *
- Urochloa mutica

Myakka River: Site=85 Mile=22.25 medsal=0.1 p95Sal=0.3
- Cephalanthus occidentalis *
- Juncus megacephalus
- Lythrum alatum *
- Mikania scandens
- Pluchea odorata *
- Polygonum hydropiperoides
- Pontederia cordata *
- Samolus valerandi *

Typha domingensis
Urochloa mutica

Myakka River: Site=86 Mile=22.69 medsal=0.1 p95Sal=0.0
Diodia virginiana
Mikania scandens
Pontederia cordata *
Scirpus tabernaemontani

Myakka River: Site=87 Mile=23.15 medsal=0.1 p95Sal=0.0
Diodia virginiana *
Gratiola virginiana *
Hydrocotyle umbellata *
Mikania scandens
Polygonum hydropiperoides
Rumex verticillatus
Sagittaria lancifolia *
Salix caroliniana *
Scirpus tabernaemontani

Myakka River: Site=88 Mile=23.61 medsal=0.1 p95Sal=0.0
Mikania scandens *
Polygonum hydropiperoides
Pontederia cordata
Rumex verticillatus
Scirpus tabernaemontani

Myakka River: Site=89 Mile=24.3 medsal=0.1 p95Sal=0.0
Polygonum hydropiperoides
Pontederia cordata
Rumex verticillatus
Scirpus tabernaemontani

Myakka River: Site=90 Mile = . medsal= 0.1 p95Sal= 0.0
Alternanthera philoxeroides
Cephalanthus occidentalis *
Lobelia feayana *
Mikania scandens *
Phyla nodiflora
Polygonum hydropiperoides
Salix caroliniana *
Scirpus tabernaemontani

Little Manatee River

Little Manatee River: Site=27 Mile=2.7 medsal=17.2 p95Sal=26.6
Rhizophora mangle
Sabal palmetto *

Little Manatee River: Site=28 Mile=2.8 medsal=16.9 p95Sal=26.5
Rhizophora mangle

Little Manatee River: Site=29 Mile=2.9 medsal=16.6 p95Sal=26.3
Avicennia germinans
Laguncularia racemosa *
Rhizophora mangle *
Ruppia maritima *

Little Manatee River: Site=30 Mile=3 medsal=16.3 p95Sal=26.2
Juncus roemerianus
Rhizophora mangle *

Little Manatee River: Site=31 Mile=3.1 medsal=16.0 p95Sal=26.1
Avicennia germinans *
Laguncularia racemosa *
Rhizophora mangle

Little Manatee River: Site=32 Mile=3.2 medsal=15.7 p95Sal=26.0
Rhizophora mangle

Little Manatee River: Site=33 Mile=3.3 medsal=15.4 p95Sal=25.9
Avicennia germinans *
Laguncularia racemosa *
Rhizophora mangle
Schinus terebinthifolius *

Little Manatee River: Site=34 Mile=3.4 medsal=15.1 p95Sal=25.8
Juncus roemerianus
Rhizophora mangle *

Little Manatee River: Site=35 Mile=3.5 medsal=14.9 p95Sal=25.6
Juncus roemerianus
Laguncularia racemosa
Rhizophora mangle

Little Manatee River: Site=36 Mile=3.6 medsal=14.6 p95Sal=25.5
Rhizophora mangle

Little Manatee River: Site=37 Mile=3.7 medsal=14.3 p95Sal=25.4
Imonium carolinianum *
Rhizophora mangle

Little Manatee River: Site=38 Mile=3.8 medsal=14.0 p95Sal=25.3
Rhizophora mangle

Little Manatee River: Site=39 Mile=3.86 medsal=13.8 p95Sal=25.2
Acrostichum danaeifolium *
Juncus roemerianus
Laguncularia racemosa *
Rhizophora mangle *

Little Manatee River: Site=40 Mile=4 medsal=13.4 p95Sal=25.1
Juncus roemerianus
Rhizophora mangle *

Little Manatee River: Site=41 Mile=4.1 medsal=13.1 p95Sal=25.0
Acrostichum danaeifolium *
Baccharis halimifolia *
Juncus roemerianus
Laguncularia racemosa *
Rhizophora mangle *

Little Manatee River: Site=42 Mile=4.2 medsal=12.8 p95Sal=24.8
Avicennia germinans
Dalbergia ecastophyllum *
Juncus roemerianus *
Laguncularia racemosa
Rhizophora mangle

Little Manatee River: Site=43 Mile=4.32 medsal=12.2 p95Sal=24.6
Juncus roemerianus
Laguncularia racemosa
Rhizophora mangle

Little Manatee River: Site=44 Mile=4.42 medsal=11.7 p95Sal=24.4
Avicennia germinans
Juncus roemerianus
Rhizophora mangle

Little Manatee River: Site=45 Mile=4.52 medsal=??? p95Sal= ???
Avicennia germinans *
Juncus roemerianus *
Laguncularia racemosa *
Rhizophora mangle *

Little Manatee River: Site=46 Mile=4.6 medsal=10.7 p95Sal=24.1
Dalbergia ecastophyllum *
Juncus roemerianus
Phragmites australis *
Rhizophora mangle

Little Manatee River: Site=47 Mile=4.7 medsal=10.1 p95Sal=23.9
Juncus roemerianus
Rhizophora mangle

Little Manatee River: Site=48 Mile=4.8 medsal=9.5 p95Sal=23.7
Avicennia germinans *
Crinum americanum
Juncus roemerianus
Rhizophora mangle

Little Manatee River: Site=49 Mile=4.96 medsal= ??? p95Sal= ???
Avicennia germinans *
Paspalum vaginatum *
Rhizophora mangle *

Little Manatee River: Site=50 Mile=5 medsal=8.4 p95Sal=23.3
Avicennia germinans *
Dalbergia ecastophyllum *
Juncus roemerianus
Laguncularia racemosa *
Rhizophora mangle

Little Manatee River: Site=51 Mile=5.1 medsal=7.9 p95Sal=23.
Juncus roemerianus
Rhizophora mangle

Little Manatee River: Site=52 Mile=5.2 medsal=7.3 p95Sal=22.
Phragmites australis

Little Manatee River: Site=53 Mile=5.27 medsal=7.1 p95Sal=22.6
Juncus roemerianus

Little Manatee River: Site=54 Mile=5.4 medsal= ??? p95Sal= ???
Rhizophora mangle *

Little Manatee River: Site=55 Mile=5.5 medsal=6.6 p95Sal=21.6
Juncus roemerianus
Rhizophora mangle *

Little Manatee River: Site=56 Mile=5.56 medsal=6.5 p95Sal=21.4
Juncus roemerianus

Little Manatee River: Site=57 Mile=5.72 medsal=6.1 p95Sal=20.7
Juncus roemerianus
Rhizophora mangle *

Little Manatee River: Site=58 Mile=5.8 medsal=5.9 p95Sal=20.3
Juncus roemerianus

Little Manatee River: Site=59 Mile=5.88 medsal=5.7 p95Sal=20.0
Juncus roemerianus

Little Manatee River: Site=60 Mile=5.97 medsal=5.5 p95Sal=19.6
Juncus roemerianus
Rhizophora mangle *

Little Manatee River: Site=61 Mile=6.1 medsal=5.2 p95Sal=19.1
Acrostichum danaeifolium
Dalbergia ecastophyllum *
Juncus roemerianus
Rhizophora mangle

Little Manatee River: Site=62 Mile=6.2 medsal=4.9 p95Sal=18.7
Juncus roemerianus

Little Manatee River: Site=63 Mile=6.7 medsal=3.6 p95Sal=16.9
Dalbergia ecastophyllum *
Juncus roemerianus
Typha domingensis

Little Manatee River: Site=64 Mile=6.4 medsal=4.4 p95Sal=17.9
Juncus roemerianus
Schinus terebinthifolius *

Little Manatee River: Site=65 Mile=6.5 medsal=???p95Sal=???
Rhizophora mangle *

Little Manatee River: Site=66 Mile=6.6 medsal=3.8 p95Sal=17.2
Acrostichum danaeifolium *
Juncus roemerianus

Little Manatee River: Site=68 Mile=6.8 medsal=3.3 p95Sal=16.5
Juncus roemerianus

Little Manatee River: Site=70 Mile=7 medsal=2.7 p95Sal=15.8
Acrostichum danaeifolium
Baccharis halimifolia *
Juncus roemerianus
Myrica cerifera *

Little Manatee River: Site=71 Mile=7.1 medsal=2.4 p95Sal=15.4
Juncus roemerianus
Rhizophora mangle
Typha domingensis *

Little Manatee River: Site=72 Mile=7.2 medsal=2.2 p95Sal=15.1
Juncus roemerianus

Little Manatee River: Site=73 Mile=7.3 medsal=2.1 p95Sal=14.8
Alternanthera philoxeroides
Aster carolinianus
Juncus roemerianus

Little Manatee River: Site=74 Mile=7.38 medsal=2.0 p95Sal=14.6
- Alternanthera philoxeroides
- Juncus roemerianus
- Phragmites australis *

Little Manatee River: Site=75 Mile=7.5 medsal=1.8 p95Sal=14.3
- Juncus roemerianus

Little Manatee River: Site=76 Mile=7.6 medsal=1.7 p95Sal=14.0
- Alternanthera philoxeroides
- Crinum americanum
- Juncus roemerianus

Little Manatee River: Site=77 Mile=7.7 medsal=1.6 p95Sal=13.7
- Crinum americanum
- Juncus roemerianus

Little Manatee River: Site=78 Mile=7.8 medsal=1.5 p95Sal=13.5
- Rhizophora mangle *
- Typha domingensis

Little Manatee River: Site=79 Mile=7.9 medsal=1.4 p95Sal=13.2
- Alternanthera philoxeroides
- Typha domingensis
- Urochloa mutica *

Little Manatee River: Site=80 Mile=8 medsal=1.2 p95Sal=12.9
- Acrostichum danaeifolium *
- Crotalaria incana *
- Juncus roemerianus *
- Myrica cerifera *
- Typha domingensis

Little Manatee River: Site=81 Mile=8.1 medsal=1.1 p95Sal=12.6
- Acrostichum danaeifolium
- Juncus roemerianus

Little Manatee River: Site=82 Mile=8.2 medsal=1.0 p95Sal=12.4
- Cladium jamaicense
- Juncus roemerianus *

Little Manatee River: Site=83 Mile=8.3 medsal=0.9 p95Sal=12.1
- Typha domingensis

Little Manatee River: Site=85 Mile=8.5 medsal=0.8 p95Sal=11.6
- Cladium jamaicense
- Eclipta prostrate *
- Rumex verticillatus *
- Urochloa mutica *

Little Manatee River: Site=86 Mile=8.6 medsal=0.7 p95Sal=11.3
- Juncus roemerianus
- Typha domingensis

Little Manatee River: Site=87 Mile=8.7 medsal=0.7 p95Sal=11.0
- Alternanthera philoxeroides
- Juncus roemerianus
- Lythrum alatum
- Pluchea odorata
- Rumex verticillatus

Little Manatee River: Site=88 Mile=8.8 medsal=0.6 p95Sal=10.8
Juncus roemerianus
Scirpus tabernaemontani
Urochloa mutica *

Little Manatee River: Site=89 Mile=8.9 medsal=0.6 p95Sal=10.5
Typha domingensis

Little Manatee River: Site=90 Mile=9 medsal=0.5 p95Sal=10.2
Acrostichum danaeifolium *
Crinum americanum
Pontederia cordata
Scirpus tabernaemontani
Typha domingensis *

Little Manatee River: Site=91 Mile=9.1 medsal=0.5 p95Sal=10.0
Crinum americanum
Juncus roemerianus
Typha domingensis *
Urochloa mutica

Little Manatee River: Site=93 Mile=9.3 medsal=0.4 p95Sal=9.4
Acrostichum danaeifolium
Cladium jamaicense *
Crinum americanum
Juncus roemerianus
Pontederia cordata

Little Manatee River: Site=94 Mile=9.4 medsal=0.3 p95Sal=9.2
Alternanthera philoxeroides *
Juncus roemerianus
Rumex verticillatus *

Little Manatee River: Site=96 Mile=9.6 medsal=0.2 p95Sal=8.5
Alternanthera philoxeroides *
Blechnum serrulatum *
Crinum americanum *
Crotalaria incana *
Lythrum alatum *
Parthenocissus quinquefolia *
Typha domingensis

Little Manatee River: Site=97 Mile=9.7 medsal=0.2 p95Sal=8.1
Blechnum serrulatum *
Cladium jamaicense
Osmunda regalis

Little Manatee River: Site=98 Mile=9.8 medsal=0.2 p95Sal=7.6
Typha domingensis

Little Manatee River: Site=99 Mile=9.9 medsal=0.2 p95Sal=7.2
Baccharis halimifolia *
Blechnum serrulatum
Cladium jamaicense
Myrica cerifera
Osmunda regalis *
Vitis rotundifolia *

Little Manatee River: Site=100 Mile=10 medsal=0.2 p95Sal=6.7
Urochloa mutica

Little Manatee River: Site=101 Mile=10.1 medsal=0.2 p95Sal=6.3
Acrostichum danaeifolium *

Little Manatee River: Site=102 Mile=10.2 medsal= ??? p95Sal=0.0 –
Alternanthera philoxeroides
Myrica cerifera *
Pontederia cordata *
Urochloa mutica

Little Manatee River: Site=103 Mile=10.3 medsal= ??? p95Sal=0.0
Pontederia cordata

Little Manatee River: Site=104 Mile=10.4 medsal= ??? p95Sal=0.0
Urochloa mutica

Weeki Wachee River

Weeki Wachee River: Site=1 Mile=0.1 medsal=11.2 p95Sal=19.6
Juncus roemerianus
Spartina alterniflora

Weeki Wachee River: Site=2 Mile=0.12 medsal=11.2 p95Sal=19.6
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora *

Weeki Wachee River: Site=3 Mile=0.15 medsal=11.1 p95Sal=19.5
Juncus roemerianus
Spartina alterniflora

Weeki Wachee River: Site=4 Mile=0.18 medsal=11.1 p95Sal=19.5
Juncus roemerianus

Weeki Wachee River: Site=5 Mile=0.21 medsal=11.0 p95Sal=19.5
Juncus roemerianus
Ruppia maritima
Spartina alterniflora

Weeki Wachee River: Site=6 Mile=0.24 medsal=11.0 p95Sal=19.5
Juncus roemerianus
Ruppia maritima

Weeki Wachee River: Site=7 Mile=0.27 medsal=10.9 p95Sal=19.4
Juncus roemerianus
Ruppia maritima
Spartina alterniflora

Weeki Wachee River: Site=8 Mile=0.3 medsal=10.9 p95Sal=19.4
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora

Weeki Wachee River: Site=9 Mile=0.33 medsal=10.8 p95Sal=19.4
Juncus roemerianus
Spartina alterniflora
Typha domingensis *

Weeki Wachee River: Site=10 Mile=0.36 medsal=10.8 p95Sal=19.4
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora *
Typha domingensis

Weeki Wachee River: Site=11 Mile=0.39 medsal=10.7 p95Sal=19.3
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora *
Typha domingensis

Weeki Wachee River: Site=12 Mile=0.44 medsal=10.5 p95Sal=19.3
Distichlis spicata
Juncus roemerianus
Spartina alterniflora

Weeki Wachee River: Site=13 Mile=0.47 medsal=10.2 p95Sal=19.3
Distichlis spicata
Juncus roemerianus
Spartina alterniflora

Weeki Wachee River: Site=14 Mile=0.49 medsal=10.0 p95Sal=19.3
Cladium jamaicense
Ruppia maritima *
Sagittaria lancifolia *
Typha domingensis

Weeki Wachee River: Site=15 Mile=0.51 medsal=9.9 p95Sal=19.3
Crinum americanum
Juncus roemerianus
Ruppia maritima
Spartina alterniflora

Weeki Wachee River: Site=16 Mile=0.55 medsal=9.5 p95Sal=19.2
Juncus roemerianus

Weeki Wachee River: Site=17 Mile=0.58 medsal=9.3 p95Sal=19.2
Ruppia maritima *
Spartina alterniflora

Weeki Wachee River: Site=18 Mile=0.61 medsal=9.0 p95Sal=19.2
Juncus roemerianus
Ruppia maritima *

Weeki Wachee River: Site=19 Mile=0.64 medsal=8.8 p95Sal=19.2
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora

Weeki Wachee River: Site=20 Mile=0.67 medsal=8.5 p95Sal=19.2
Cladium jamaicense
Juncus roemerianus
Sagittaria subulata *
Spartina alterniflora

Weeki Wachee River: Site=21 Mile=0.7 medsal=8.3 p95Sal=19.2
Juncus roemerianus
Ruppia maritima
Spartina alterniflora
Typha domingensis *

Weeki Wachee River: Site=22 Mile=0.73 medsal=8.0 p95Sal=19.1
Cladium jamaicense
Juncus roemerianus
Ruppia maritima

Weeki Wachee River: Site=23 Mile=0.76 medsal=7.8 p95Sal=19.1
Juncus roemerianus
Sagittaria subulata
Spartina alterniflora
Typha domingensis

Weeki Wachee River: Site=24 Mile=0.79 medsal=7.5 p95Sal=19.1
Juncus roemerianus
Ruppia maritima
Spartina alterniflora
Typha domingensis

Weeki Wachee River: Site=25 Mile=0.82 medsal=7.0 p95Sal=18.7
Ruppia maritima
Spartina alterniflora
Typha domingensis

Weeki Wachee River: Site=26 Mile=0.85 medsal=6.4 p95Sal=18.1
Cladium jamaicense
Juncus roemerianus
Sagittaria subulata

Weeki Wachee River: Site=27 Mile=0.88 medsal=5.7 p95Sal=17.5
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Weeki Wachee River: Site=28 Mile=0.91 medsal=5.1 p95Sal=16.9
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora
Vallisneria americana *

Weeki Wachee River: Site=29 Mile=0.94 medsal=4.4 p95Sal=16.3
Acrostichum danaeifolium *
Baccharis halimifolia *
Magnolia virginiana *
Ruppia maritima
Typha domingensis

Weeki Wachee River: Site=30 Mile=0.97 medsal=3.8 p95Sal=15.7
Cladium jamaicense
Juncus roemerianus
Ruppia maritima
Sagittaria subulata

Weeki Wachee River: Site=31 Mile=1 medsal=3.1 p95Sal=15.1
Baccharis angustifolia *
Ilex cassine *
Juncus roemerianus
Ruppia maritima
Typha domingensis

Weeki Wachee River: Site=32 Mile=1.03 medsal=2.6 p95Sal=14.5
Acrostichum danaeifolium *
Cladium jamaicense
Juncus roemerianus

Magnolia virginiana *
Ruppia maritima

Weeki Wachee River: Site=33 Mile=1.06 medsal=2.3 p95Sal=13.7
Cladium jamaicense
Ruppia maritima *
Sagittaria subulata *

Weeki Wachee River: Site=34 Mile=1.09 medsal=2.0 p95Sal=12.9
Cladium jamaicense
Magnolia virginiana *

Weeki Wachee River: Site=35 Mile=1.12 medsal=1.7 p95Sal=12.1
Magnolia virginiana *
Ruppia maritima
Sagittaria subulata
Scirpus californicus
Typha domingensis

Weeki Wachee River: Site=36 Mile=1.15 medsal=1.4 p95Sal=11.3
Cladium jamaicense

Weeki Wachee River: Site=37 Mile=1.18 medsal=1.1 p95Sal=10.5
Aster subulatus
Cladium jamaicense
Juncus roemerianus
Sabal palmetto

Weeki Wachee River: Site=38 Mile=1.21 medsal=0.8 p95Sal=9.7
Acrostichum danaeifolium
Cladium jamaicense
Sagittaria lancifolia *

Weeki Wachee River: Site=39 Mile=1.24 medsal=0.6 p95Sal=8.9
Cladium jamaicense
Magnolia virginiana *
Sabal palmetto *

Weeki Wachee River: Site=40 Mile=1.27 medsal=0.4 p95Sal=8.3
Cladium jamaicense
Persea palustris *

Weeki Wachee River: Site=41 Mile=1.3 medsal=0.4 p95Sal=7.7
Cladium jamaicense
Magnolia virginiana *
Sagittaria lancifolia

Weeki Wachee River: Site=42 Mile=1.33 medsal=0.4 p95Sal=7.2
Cladium jamaicense
Vallisneria americana *

Weeki Wachee River: Site=43 Mile=1.36 medsal=0.3 p95Sal=6.7
Acrostichum danaeifolium
Cladium jamaicense
Vallisneria americana *

Chassahowitzka River

Chassahowitzka River: Site=1 Mile=0 medsal=11.9 p95Sal=18.8
- Aster tenuifolius
- Distichlis spicata
- Juncus roemerianus
- Sagittaria subulata

Chassahowitzka River: Site=2 Mile=0.05 medsal=11.8 p95Sal=18.7
- Crinum americanum
- Distichlis spicata
- Lythrum alatum
- Sagittaria subulata
- Spartina alterniflora

Chassahowitzka River: Site=3 Mile=0.1 medsal=11.8 p95Sal=18.5
- Alternanthera philoxeroides *
- Distichlis spicata *
- Juncus roemerianus
- Sagittaria subulata

Chassahowitzka River: Site=4 Mile=0.15 medsal=11.7 p95Sal=18.4
- Alternanthera philoxeroides *
- Cladium jamaicense
- Distichlis spicata
- Juncus roemerianus
- Spartina alterniflora

Chassahowitzka River: Site=5 Mile=0.2 medsal=11.7 p95Sal=18.3
- Juncus roemerianus
- Lythrum alatum *
- Sagittaria subulata

Chassahowitzka River: Site=6 Mile=0.25 medsal=11.6 p95Sal=18.1
- Juncus roemerianus
- Spartina alterniflora
- Typha domingensis *

Chassahowitzka River: Site=7 Mile=0.3 medsal=11.6 p95Sal=18.0
- Cladium jamaicense
- Juncus roemerianus
- Sagittaria subulata *
- Typha domingensis

Chassahowitzka River: Site=8 Mile=0.35 medsal=11.5 p95Sal=17.9
- Cladium jamaicense
- Juncus roemerianus
- Typha domingensis

Chassahowitzka River: Site=9 Mile=0.4 medsal=11.5 p95Sal=17.7 -
- Acrostichum danaeifolium *
- Juncus roemerianus

Chassahowitzka River: Site=10 Mile=0.45 medsal=11.4 p95Sal=17.6
- Cladium jamaicense
- Juncus roemerianus
- Typha domingensis *

Chassahowitzka River: Site=11 Mile=0.5 medsal=11.4 p95Sal=17.5
Cladium jamaicense
Typha domingensis *

Chassahowitzka River: Site=12 Mile=0.55 medsal=11.3 p95Sal=17.3
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=13 Mile=0.6 medsal=11.3 p95Sal=17.2
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=14 Mile=0.65 medsal=11.1 p95Sal=17.2
Juncus roemerianus
Typha domingensis *

Chassahowitzka River: Site=15 Mile=0.7 medsal=11.0 p95Sal=17.2
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=16 Mile=0.75 medsal=10.9 p95Sal=17.3
Cladium jamaicense
Distichlis spicata
Juncus roemerianus

Chassahowitzka River: Site=17 Mile=0.8 medsal=10.8 p95Sal=17.3
Cladium jamaicense
Typha domingensis *

Chassahowitzka River: Site=18 Mile=0.85 medsal=10.7 p95Sal=17.3
Acrostichum danaeifolium *
Cladium jamaicense
Lycium carolinianum *

Chassahowitzka River: Site=19 Mile=0.9 medsal=10.6 p95Sal=17.3
Acrostichum danaeifolium *
Juncus roemerianus
Lycium carolinianum *
Solidago stricta *

Chassahowitzka River: Site=20 Mile=0.95 medsal=10.5 p95Sal=17.3
Acrostichum danaeifolium *
Cladium jamaicense

Chassahowitzka River: Site=21 Mile=1 medsal=10.4 p95Sal=17.4
Cladium jamaicense *
Juncus roemerianus

Chassahowitzka River: Site=22 Mile=1.05 medsal=10.3 p95Sal=17.4
Cladium jamaicense
Juncus roemerianus
Typha domingensis

Chassahowitzka River: Site=23 Mile=1.1 medsal=10.2 p95Sal=17.4
Acrostichum danaeifolium
Cladium jamaicense
Juncus roemerianus
Lycium carolinianum *
Solidago stricta *

Chassahowitzka River: Site=24 Mile=1.15 medsal=10.1 p95Sal=17.4
Cladium jamaicense *
Juncus roemerianus
Typha domingensis

Chassahowitzka River: Site=25 Mile=1.2 medsal=10.1 p95Sal=17.4
Cladium jamaicense *
Juncus roemerianus

Chassahowitzka River: Site=26 Mile=1.25 medsal=10.0 p95Sal=17.4
Alternanthera philoxeroides
Cladium jamaicense
Juncus roemerianus
Typha domingensis

Chassahowitzka River: Site=27 Mile=1.3 medsal=10.0 p95Sal=17.4
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=28 Mile=1.35 medsal=9.9 p95Sal=17.4
Cladium jamaicense
Juncus roemerianus
Typha domingensis

Chassahowitzka River: Site=29 Mile=1.5 medsal=9.8 p95Sal=17.4
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=30 Mile=1.55 medsal=9.7 p95Sal=17.4
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=31 Mile=1.6 medsal=9.7 p95Sal=17.4
Cladium jamaicense
Juncus roemerianus
Scirpus americanus

Chassahowitzka River: Site=32 Mile=1.65 medsal=9.6 p95Sal=17.4
Alternanthera philoxeroides
Cladium jamaicense
Juncus roemerianus
Scirpus americanus
Typha domingensis

Chassahowitzka River: Site=33 Mile=1.7 medsal=9.6 p95Sal=17.4
Cladium jamaicense
Juncus roemerianus
Sagittaria subulata
Spartina alterniflora
Typha domingensis *

Chassahowitzka River: Site=35 Mile=1.8 medsal=9.4 p95Sal=17.3
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=36 Mile=1.85 medsal=9.0 p95Sal=17.0
Cladium jamaicense
Juncus roemerianus
Typha domingensis *

Chassahowitzka River: Site=37 Mile=1.9 medsal=8.7 p95Sal=16.7
Cladium jamaicense
Typha domingensis

Chassahowitzka River: Site=38 Mile=1.95 medsal=8.4 p95Sal=16.5
Scirpus americanus
Typha domingensis

Chassahowitzka River: Site=39 Mile=2 medsal=8.1 p95Sal=16.2
Cladium jamaicense
Typha domingensis

Chassahowitzka River: Site=40 Mile=2.05 medsal=7.7 p95Sal=15.9
Cladium jamaicense
Juncus roemerianus
Scirpus americanus
Typha domingensis

Chassahowitzka River: Site=41 Mile=2.1 medsal=7.4 p95Sal=15.6
Cladium jamaicense
Juncus roemerianus *

Chassahowitzka River: Site=42 Mile=2.15 medsal=7.1 p95Sal=15.4
Cladium jamaicense
Juncus roemerianus
Typha domingensis

Chassahowitzka River: Site=43 Mile=2.2 medsal=6.8 p95Sal=15.1
Cladium jamaicense
Juncus roemerianus
Typha domingensis

Chassahowitzka River: Site=44 Mile=2.25 medsal=6.5 p95Sal=14.8
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=45 Mile=2.3 medsal=6.2 p95Sal=14.0
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=46 Mile=2.35 medsal=5.9 p95Sal=13.2
Cladium jamaicense
Juncus roemerianus
Pontederia cordata *
Typha domingensis

Chassahowitzka River: Site=47 Mile=2.4 medsal=5.6 p95Sal=12.5
Cladium jamaicense
Juncus roemerianus

Chassahowitzka River: Site=48 Mile=2.45 medsal=5.3 p95Sal=11.7
Cladium jamaicense
Typha domingensis

Chassahowitzka River: Site=49 Mile=2.55 medsal=4.7 p95Sal=10.1
Cladium jamaicense

Chassahowitzka River: Site=50 Mile=2.6 medsal=4.4 p95Sal=9.3
Sagittaria lancifolia
Scirpus robustus
Typha domingensis

Chassahowitzka River: Site=51 Mile=2.65 medsal=4.1 p95Sal=8.7
Cladium jamaicense

Chassahowitzka River: Site=52 Mile=2.7 medsal=4.0 p95Sal=8.5
Cladium jamaicense
Typha domingensis *

Chassahowitzka River: Site=53 Mile=2.75 medsal=3.9 p95Sal=8.3
Cladium jamaicense
Sagittaria lancifolia
Typha domingensis

Chassahowitzka River: Site=54 Mile=2.8 medsal=3.8 p95Sal=8.1
Aster carolinianus *
Baccharis halimifolia *
Typha domingensis

Chassahowitzka River: Site=55 Mile=2.85 medsal=3.7 p95Sal=7.9
Cladium jamaicense
Sagittaria lancifolia

Chassahowitzka River: Site=56 Mile=2.9 medsal=3.5 p95Sal=7.8
Cladium jamaicense
Myrica cerifera *
Persea palustris *
Sagittaria lancifolia

Chassahowitzka River: Site=57 Mile=2.95 medsal=3.4 p95Sal=7.6
Acer rubrum *
Aster carolinianus *
Carya aquatica *
Cicuta maculata
Cladium jamaicense
Persea palustris *
Rumex verticillatus *
Sagittaria lancifolia
Saururus cernuus *
Senecio glabellus *

Chassahowitzka River: Site=58 Mile=3 medsal=3.3 p95Sal=7.4
Cladium jamaicense
Magnolia virginiana *
Myrica cerifera *

Chassahowitzka River: Site=59 Mile=3.05 medsal=3.2 p95Sal=6.8
Cladium jamaicense
Sagittaria lancifolia
Saururus cernuus
Senecio glabellus *

Chassahowitzka River: Site=60 Mile=3.2 medsal=2.9 p95Sal=5.2
Ampelopsis arborea
Baccharis halimifolia *
Cladium jamaicense
Rumex verticillatus *
Typha domingensis

Chassahowitzka River: Site=61 Mile=3.15 medsal=3.0 p95Sal=5.7
Baccharis halimifolia *
Cladium jamaicense
Crinum americanum
Myrica cerifera *

Persea palustris *
Sagittaria lancifolia
Solidago stricta *

Site=62 Mile=3.3 medsal=2.7 p95Sal=4.1
Acrostichum danaeifolium *
Cicuta maculata *
Cladium jamaicense
Crinum americanum *
Iris hexagona *
Myrica cerifera *
Rumex verticillatus *

Chassahowitzka River: Site=63 Mile=3.25 medsal=2.8 p95Sal=4.6
Cladium jamaicense
Myrica cerifera *
Sagittaria lancifolia
Senecio glabellus *

Chassahowitzka River: Site=64 Mile=3.35 medsal=2.6 p95Sal=3.5
Acrostichum danaeifolium
Baccharis halimifolia *
Cladium jamaicense
Myrica cerifera *
Persea palustris *
Solidago stricta *

Chassahowitzka River: Site=65 Mile=3.4 medsal=2.6 p95Sal=3.4
Cladium jamaicense
Crinum americanum
Iris hexagona
Sagittaria lancifolia
Saururus cernuus
Senecio glabellus *

Chassahowitzka River: Site=66 Mile=3.45 medsal=2.6 p95Sal=3.4
Aster carolinianus
Cladium jamaicense
Crinum americanum *
Magnolia virginiana *

Chassahowitzka River: Site=67 Mile=3.5 medsal=??? p95Sal=. ???
Acrostichum danaeifolium *
Aster carolinianus *
Baccharis halimifolia *
Cicuta maculata *
Crinum americanum *
Lythrum alatum *
Sagittaria lancifolia *
Senecio glabellus *

Chassahowitzka River: Site=68 Mile=3.55 medsal=2.6 p95Sal=3.6
Cladium jamaicense
Cornus foemina *
Lythrum alatum *
Rumex verticillatus *
Sagittaria subulata
Samolus valerandi *
Senecio glabellus *

Chassahowitzka River: Site=69 Mile=3.65 medsal=2.4 p95Sal=3.2
Typha domingensis

Chassahowitzka River: Site=70 Mile=3.65 medsal=2.4 p95Sal=3.2
- Acrostichum danaeifolium *
- Baccharis halimifolia *
- Cladium jamaicense
- Crinum americanum
- Pluchea odorata *
- Sagittaria subulata *
- Samolus valerandi *
- Senecio glabellus *

Chassahowitzka River: Site=71 Mile=3.7 medsal=2.4 p95Sal=3.1
- Baccharis halimifolia *
- Crinum americanum
- Myrica cerifera *

Chassahowitzka River: Site=72 Mile=3.8 medsal=2.3 p95Sal=2.9
- Cladium jamaicense
- Crinum americanum
- Myrica cerifera *
- Rumex verticillatus *
- Sagittaria subulata *
- Ulmus americanus *

Chassahowitzka River: Site=73 Mile=3.82 medsal=2.3 p95Sal=2.9
- Cladium jamaicense
- Sagittaria lancifolia
- Scirpus robustus

Chassahowitzka River: Site=74 Mile=3.87 medsal=2.2 p95Sal=2.8
- Typha domingensis

Chassahowitzka River: Site=75 Mile=3.92 medsal=??? p95Sal=. ???
- Aster carolinianus *
- Cornus foemina *
- Samolus valerandi *

Chassahowitzka River: Site=76 Mile=4 medsal=2.1 p95Sal=2.6
- Acrostichum danaeifolium
- Aster carolinianus *
- Ilex cassine *
- Myrica cerifera *
- Samolus valerandi *

Chassahowitzka River: Site=77 Mile=4.08 medsal=??? p95Sal= ???
- Tilia caroliniana *

Chassahowitzka River: - River=Chassahowitzka Site=78 Mile=4.15 medsal=2.0 p95Sal=2.3
- Cladium jamaicense
- Rumex verticillatus *
- Sabal palmetto *
- Samolus valerandi *
- Solidago stricta *

Chassahowitzka River: Site=80 Mile=4.28 medsal=1.8 p95Sal=2.0
- Crinum americanum
- Magnolia virginiana *
- Quercus geminate *
- Sabal palmetto

Chassahowitzka River: Site=81 Mile=4.35 medsal=1.5 p95Sal=1.7
Acer rubrum *
Magnolia virginiana
Persea palustris *
Sabal palmetto *

Chassahowitzka River: Site=82 Mile=4.45 medsal=??? p95Sal= ???
Aster carolinianus *

Chassahowitzka River: Site=83 Mile=4.53 medsal=1.5 p95Sal=2.1
Baccharis halimifolia *
Boehmeria cylindrica *
Crinum americanum
Itea virginica *
Magnolia virginiana *
Persea palustris *

Chassahowitzka River: Site=84 Mile=4.6 medsal=1.5 p95Sal=2.2
Paspalum repens
Pistia stratiotes *

Chassahowitzka River: Site=85 Mile=4.68 medsal=1.5 p95Sal=2.4
Phragmites australis

Chassahowitzka River: Site=86 Mile=4.75 medsal=1.3 p95Sal=1.9
Baccharis halimifolia *
Crinum americanum
Itea virginica *
Paspalidium geminatum

Crystal River

Crystal River: Site=1 Mile=0.02 medsal=16.4 p95Sal=22.1
Spartina alterniflora

Crystal River: Site=2 Mile=0.06 medsal=16.0 p95Sal=21.8
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=3 Mile=0.1 medsal=15.6 p95Sal=21.4
Iva frutescens *

Spartina alterniflora

Crystal River: Site=4 Mile=0.2 medsal=14.6 p95Sal=20.6
Baccharis angustifolia *
Iva frutescens *
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=5 Mile=0.3 medsal=13.5 p95Sal=19.8
Aster tenuifolius *
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=6 Mile=0.4 medsal=12.5 p95Sal=19.0
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=7 Mile=0.5 medsal=11.8 p95Sal=18.5
Aster tenuifolius *
Distichlis spicata
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=8 Mile=0.6 medsal=11.3 p95Sal=18.1
Juncus roemerianus
Laguncularia racemosa *
Spartina alterniflora

Crystal River: Site=9 Mile=0.65 medsal=11.1 p95Sal=17.9
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=10 Mile=0.8 medsal=10.3 p95Sal=17.3
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=11 Mile=0.9 medsal=9.8 p95Sal=16.9
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=12 Mile=1 medsal=9.3 p95Sal=16.5
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=13 Mile=1.1 medsal=9.2 p95Sal=16.4
Spartina alterniflora
Typha domingensis

Crystal River: Site=14 Mile=1.18 medsal=9.2 p95Sal=16.3
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=15 Mile=1.28 medsal=9.1 p95Sal=16.2
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=16 Mile=1.35 medsal=9.1 p95Sal=16.1
Spartina alterniflora

Crystal River: Site=17 Mile=1.43 medsal=9.0 p95Sal=16.0
Iva frutescens *
Juncus roemerianus *
Spartina alterniflora

Crystal River: Site=18 Mile=1.49 medsal=8.9 p95Sal=15.9
Spartina alterniflora

Crystal River: Site=19 Mile=1.6 medsal=8.9 p95Sal=15.8
Spartina alterniflora

Crystal River: Site=20 Mile=1.19 medsal=9.2 p95Sal=16.3
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=21 Mile=1.29 medsal=9.1 p95Sal=16.2
Spartina alterniflora

Crystal River: Site=22 Mile=1.8 medsal=8.7 p95Sal=15.6
Sabal palmetto *
Spartina alterniflora

Crystal River: Site=23 Mile=1.9 medsal=8.6 p95Sal=15.4
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=24 Mile=2 medsal=8.6 p95Sal=15.3
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora

Crystal River: Site=25 Mile=2.08 medsal=8.4 p95Sal=15.2
Spartina alterniflora

Crystal River: Site=26 Mile=2.17 medsal=8.1 p95Sal=15.1
Sagittaria subulata
Spartina alterniflora

Crystal River: Site=27 Mile=2.6 medsal=6.6 p95Sal=14.4
Cladium jamaicense
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora *

Crystal River: Site=28 Mile=2.35 medsal=7.5 p95Sal=14.8
Cladium jamaicense *
Juncus roemerianus
Ruppia maritima *
Spartina alterniflora
Typha domingensis

Crystal River: Site=29 Mile=2.42 medsal=7.2 p95Sal=14.6
Distichlis spicata *
Juncus roemerianus
Ruppia maritima *
Sagittaria subulata
Spartina alterniflora
Typha domingensis *

Crystal River: Site=30 Mile=2.5 medsal=6.9 p95Sal=14.5
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=31 Mile=2.54 medsal=6.8 p95Sal=14.5
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=32 Mile=2.65 medsal=6.4 p95Sal=14.3
Juncus roemerianus
Spartina alterniflora

Crystal River: Site=33 Mile=2.74 medsal=6.1 p95Sal=14.1
Juncus roemerianus
Sagittaria subulata
Spartina alterniflora

Crystal River: Site=34 Mile=2.8 medsal=5.9 p95Sal=14.0
Juncus roemerianus
Ruppia maritima
Sagittaria subulata

Spartina alterniflora
Typha domingensis *

Crystal River: Site=35 Mile=2.9 medsal=5.6 p95Sal=13.9
Juncus roemerianus
Ruppia maritima
Sagittaria subulata
Spartina alterniflora

Crystal River: Site=36 Mile=2.98 medsal=5.4 p95Sal=13.7
Spartina alterniflora

Crystal River: Site=37 Mile=3.08 medsal=5.1 p95Sal=13.5
Cladium jamaicense
Juncus roemerianus
Ruppia maritima
Sagittaria subulata

Crystal River: Site=38 Mile=3.15 medsal=5.0 p95Sal=13.4
Juncus roemerianus
Ruppia maritima *
Sagittaria subulata
Spartina alterniflora
Typha domingensis
Vallisneria americana *

Crystal River: Site=39 Mile=3.22 medsal=4.8 p95Sal=13.3
Spartina alterniflora

Crystal River: Site=40 Mile=3.3 medsal=4.6 p95Sal=13.1
Juncus roemerianus
Sagittaria subulata
Spartina alterniflora
Typha domingensis

Crystal River: Site=41 Mile=3.38 medsal=4.5 p95Sal=13.0
Juncus roemerianus
Ruppia maritima
Sagittaria subulata

Crystal River: Site=42 Mile=3.45 medsal=4.3 p95Sal=12.9
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Crystal River: Site=43 Mile=3.53 medsal=4.1 p95Sal=12.7
Juncus roemerianus
Ruppia maritima
Sagittaria subulata *
Spartina alterniflora

Crystal River: Site=44 Mile=3.61 medsal=4.0 p95Sal=12.6
Ruppia maritima *
Spartina alterniflora

Crystal River: Site=45 Mile=3.71 medsal=3.7 p95Sal=12.4
Juncus roemerianus
Sagittaria subulata
Spartina alterniflora

Crystal River: Site=46 Mile=3.82 medsal=3.5 p95Sal=12.2
Ruppia maritima

Sagittaria subulata
Spartina alterniflora
Typha domingensis

Crystal River: Site=47 Mile=3.92 medsal=3.3 p95Sal=11.9
Cladium jamaicense

Crystal River: Site=48 Mile=4 medsal=3.2 p95Sal=11.3
Sagittaria subulata
Spartina alterniflora *
Typha domingensis

Crystal River: Site=49 Mile=4.08 medsal=3.0 p95Sal=10.8
Juncus roemerianus
Sagittaria subulata
Spartina alterniflora

Crystal River: Site=50 Mile=4.13 medsal=3.0 p95Sal=10.5
Baccharis halimifolia *
Juncus roemerianus
Sagittaria subulata
Spartina alterniflora
Typha domingensis

Crystal River: Site=51 Mile=4.3 medsal=2.7 p95Sal=9.3
Juncus roemerianus
Sagittaria subulata
Spartina alterniflora
Typha domingensis

Crystal River: Site=52 Mile=4.35 medsal=2.6 p95Sal=9.0
Sagittaria subulata
Spartina alterniflora
Typha domingensis

Crystal River: Site=53 Mile=4.41 medsal=2.6 p95Sal=8.6
Aster carolinianus *
Sagittaria subulata
Typha domingensis

Crystal River: Site=54 Mile=4.48 medsal=2.4 p95Sal=8.1
Cladium jamaicense
Typha domingensis *

Crystal River: Site=58 Mile=4.85 medsal=1.9 p95Sal=5.6
Cladium jamaicense
Juncus roemerianus
Sagittaria subulata *
Typha domingensis

Crystal River: Site=59 Mile=4.94 medsal=1.8 p95Sal=5.0
Baccharis halimifolia *
Typha domingensis
Vallisneria americana *

Crystal River: Site=60 Mile=5.05 medsal=1.6 p95Sal=4.2
Cladium jamaicense
Typha domingensis
Vallisneria americana *

Crystal River: Site=61 Mile=5.2 medsal=1.4 p95Sal=3.3
- Magnolia virginiana *
- Ruppia maritima *
- Sagittaria subulata
- Typha domingensis
- Vallisneria americana *

Crystal River: Site=62 Mile=5.29 medsal=1.4 p95Sal=3.2
- Cladium jamaicense
- Sagittaria lancifolia
- Sagittaria subulata

Crystal River: Site=63 Mile=5.4 medsal=1.3 p95Sal=3.0
- Cladium jamaicense
- Typha domingensis

Crystal River: Site=64 Mile=5.48 medsal=1.3 p95Sal=2.9
- Typha domingensis

Crystal River: Site=65 Mile=5.55 medsal=1.2 p95Sal=2.8
- Cladium jamaicense
- Sagittaria subulata *

Crystal River: Site=66 Mile=5.68 medsal=1.2 p95Sal=2.6
- Polygonum hydropiperoides *
- Sagittaria subulata
- Typha domingensis

Crystal River: Site=67 Mile=5.8 medsal=1.1 p95Sal=2.5
- Bidens laevis *
- Cladium jamaicense

Crystal River: Site=69 Mile=6.2 medsal=0.9 p95Sal=1.9
- Cladium jamaicense
- Juncus roemerianus
- Sagittaria lancifolia
- Typha domingensis

Crystal River: Site=70 Mile=6.3 medsal=0.9 p95Sal=1.7
- Aster carolinianus
- Juncus roemerianus
- Sagittaria lancifolia
- Typha domingensis

Crystal River: Site=71 Mile=6.4 medsal=0.8 p95Sal=1.6
- Cladium jamaicense
- Juncus roemerianus
- Myrica cerifera *
- Sagittaria lancifolia

Crystal River: Site=72 Mile=6.5 medsal=0.8 p95Sal=1.4
- Cladium jamaicense
- Pontederia cordata
- Typha domingensis

Crystal River: Site=73 Mile=6.5 medsal=0.8 p95Sal=1.4
- Cladium jamaicense *
- Fraxinus caroliniana
- Lobelia cardinalis *
- Myrica cerifera *

Pontederia cordata
Sagittaria lancifolia *
Sagittaria subulata

Withlacoochee River

Withlacoochee River: Site=1 Mile=0 medsal=13.6 p95Sal=20.2
Spartina alterniflora

Withlacoochee River: Site=2 Mile=0.07 medsal=13.1 p95Sal=20.2
Spartina alterniflora

Withlacoochee River: Site=3 Mile=0.12 medsal=12.7 p95Sal=20.1
Juncus roemerianus
Spartina alterniflora

Withlacoochee River: Site=4 Mile=0.17 medsal=12.3 p95Sal=20.1
Juncus roemerianus
Spartina alterniflora

Withlacoochee River: Site=5 Mile=0.22 medsal=12.0 p95Sal=20.1
Juncus roemerianus
Spartina alterniflora

Withlacoochee River: Site=6 Mile=0.29 medsal=11.4 p95Sal=19.8
Aster subulatus
Distichlis spicata
Juncus roemerianus
Sagittaria subulata *
Spartina alterniflora

Withlacoochee River: Site=7 Mile=0.38 medsal=10.4 p95Sal=18.8
Spartina alterniflora

Withlacoochee River: Site=8 Mile=0.45 medsal=9.6 p95Sal=18.1
Juncus roemerianus
Spartina alterniflora

Withlacoochee River: Site=9 Mile=0.46 medsal=9.5 p95Sal=18.0
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=10 Mile=0.5 medsal=9.3 p95Sal=17.7
Phragmites australis
Typha domingensis

Withlacoochee River: Site=11 Mile=0.55 medsal=9.2 p95Sal=17.6
Baccharis angustifolia
Juncus roemerianus
Solidago stricta *
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=12 Mile=0.7 medsal=8.8 p95Sal=17.0

Phragmites australis
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=13 Mile=0.8 medsal=8.5 p95Sal=16.6
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=14 Mile=0.83 medsal=8.4 p95Sal=16.5
Iva frutescens *
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=15 Mile=0.68 medsal=8.8 p95Sal=17.1
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=16 Mile=0.85 medsal=8.4 p95Sal=16.5
Cladium jamaicense
Juncus roemerianus
Typha domingensis

Withlacoochee River: Site=17 Mile=0.92 medsal=8.2 p95Sal=16.2
Juncus roemerianus
Typha domingensis

Withlacoochee River: Site=18 Mile=0.98 medsal=8.0 p95Sal=16.0
Juncus roemerianus
Phragmites australis
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=19 Mile=1.05 medsal=7.4 p95Sal=15.6
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=20 Mile=1.12 medsal=6.6 p95Sal=15.1
Juncus roemerianus
Typha domingensis

Withlacoochee River: Site=21 Mile=1.16 medsal=6.2 p95Sal=14.8
Cladium jamaicense
Juncus roemerianus
Typha domingensis

Withlacoochee River: Site=22 Mile=1.2 medsal=5.7 p95Sal=14.6
Juncus roemerianus

Withlacoochee River: Site=23 Mile=1.25 medsal=5.2 p95Sal=14.2
Cladium jamaicense
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=24 Mile=1.28 medsal=4.8 p95Sal=14.0
Cladium jamaicense
Juncus roemerianus
Spartina alterniflora
Typha domingensis

Withlacoochee River: Site=25 Mile=1.35 medsal=4.0 p95Sal=13.6
Spartina alterniflora

Withlacoochee River: Site=26 Mile=1.36 medsal=3.9 p95Sal=13.5
Cladium jamaicense
Juncus roemerianus
Typha domingensis

Withlacoochee River: Site=27 Mile=1.42 medsal=3.3 p95Sal=13.1
Cladium jamaicense
Juncus roemerianus

Withlacoochee River: Site=28 Mile=1.48 medsal=3.0 p95Sal=12.8
Cladium jamaicense
Juncus roemerianus
Spartina alterniflora

Withlacoochee River: Site=29 Mile=1.55 medsal=2.6 p95Sal=12.5
Typha domingensis

Withlacoochee River: Site=30 Mile=1.58 medsal=2.5 p95Sal=12.4
Spartina alterniflora

Withlacoochee River: Site=31 Mile=1.64 medsal=2.2 p95Sal=12.1
Juncus roemerianus
Sagittaria subulata *
Typha domingensis

Withlacoochee River: Site=32 Mile=1.68 medsal=2.0 p95Sal=11.9
Cladium jamaicense
Juncus roemerianus
Sagittaria subulata *
Salix caroliniana *
Taxodium distichum *

Withlacoochee River: Site=33 Mile=1.74 medsal=1.7 p95Sal=11.6
Cladium jamaicense
Iva frutescens *
Solidago stricta *
Spartina alterniflora *
Taxodium distichum *
Typha domingensis *

Withlacoochee River: Site=34 Mile=1.77 medsal=1.6 p95Sal=11.5
Juniperus virginiana *
Persea palustris *
Ruppia maritima *
Sagittaria subulata *
Salix caroliniana *
Spartina alterniflora

Withlacoochee River: Site=35 Mile=1.82 medsal=1.3 p95Sal=11.2
Amaranthus australis *
Cladium jamaicense
Spartina alterniflora

Withlacoochee River: Site=36 Mile=1.87 medsal=1.1 p95Sal=10.8
- Cladium jamaicense
- Eleocharis fallax *
- Fraxinus caroliniana *
- Persea palustris *
- Ruppia maritima *
- Sagittaria subulata *
- Spartina alterniflora *

Withlacoochee River: Site=37 Mile=1.92 medsal=1.0 p95Sal=10.0
- Juncus roemerianus
- Ruppia maritima *
- Sagittaria subulata *
- Vallisneria americana *

Withlacoochee River: Site=38 Mile=1.98 medsal=0.9 p95Sal=9.1
- Juncus roemerianus
- Sagittaria subulata *

Withlacoochee River: Site=39 Mile=2.05 medsal=0.8 p95Sal=8.0
- Amaranthus australis *
- Cladium jamaicense
- Magnolia virginiana *
- Ruppia maritima *
- Sagittaria lancifolia *

Withlacoochee River: Site=40 Mile=2.07 medsal=0.7 p95Sal=7.7
- Cladium jamaicense
- Magnolia virginiana *
- Solidago stricta *

Withlacoochee River: Site=41 Mile=2.12 medsal=0.6 p95Sal=6.9
- Cladium jamaicense
- Sagittaria subulata *

Withlacoochee River: Site=42 Mile=2.17 medsal=0.5 p95Sal=6.1
- Cladium jamaicense
- Fraxinus caroliniana
- Ruppia maritima *
- Sagittaria subulata *

Withlacoochee River: Site=43 Mile=2.23 medsal=0.4 p95Sal=5.1
- Cephalanthus occidentalis *
- Cladium jamaicense
- Ilex cassine *
- Persea palustris *
- Solidago stricta *
- Taxodium distichum *

Withlacoochee River: Site=44 Mile=2.27 medsal=0.3 p95Sal=4.5
- Acer rubrum *
- Fraxinus caroliniana
- Magnolia virginiana
- Solidago stricta *

Withlacoochee River: Site=45 Mile=2.32 medsal=0.2 p95Sal=3.7
- Cephalanthus occidentalis *
- Cladium jamaicense
- Fraxinus caroliniana
- Juncus roemerianus *
- Myrica cerifera *
- Sagittaria subulata *

Salix caroliniana *
Solidago stricta *

Withlacoochee River: Site=46 Mile=2.33 medsal=0.2 p95Sal=3.7
Cladium jamaicense
Fraxinus caroliniana *
Sagittaria lancifolia
Sagittaria subulata *
Vallisneria americana *
Zizania aquatica *

Withlacoochee River: Site=47 Mile=2.36 medsal=0.2 p95Sal=3.6
Amaranthus australis *
Echinochloa muricata *
Fraxinus caroliniana
Juncus roemerianus
Polygonum hydropiperoides *
Pontederia cordata *
Rumex verticillatus *
Sagittaria lancifolia *
Sagittaria subulata
Solidago stricta *

Withlacoochee River: Site=48 Mile=2.39 medsal=0.2 p95Sal=3.4
Acer rubrum *
Alternanthera philoxeroides
Aster carolinianus
Baccharis halimifolia *
Cyperus distinctus *
Fraxinus caroliniana *
Ilex cassine *
Magnolia virginiana *
Myrica cerifera *
Panicum anceps
Quercus virginiana *
Saururus cernuus
Solidago stricta

Withlacoochee River: Site=49 Mile=2.43 medsal=0.2 p95Sal=3.2
Acer rubrum *
Cladium jamaicense
Cornus foemina *
Fraxinus caroliniana *
Persea palustris *
Saururus cernuus
Taxodium distichum *

Withlacoochee River: Site=50 Mile=2.45 medsal=0.2 p95Sal=3.1
Fraxinus caroliniana
Ilex cassine *
Isoetes flaccida
Magnolia virginiana
Panicum anceps *
Sagittaria subulata *
Solidago stricta *

Withlacoochee River: Site=51 Mile=2.5 medsal=0.1 p95Sal=2.9
Cephalanthus occidentalis
Cladium jamaicense
Eleocharis fallax
Magnolia virginiana *
Sabal palmetto *

Sagittaria subulata *
Smilax walteri
Taxodium distichum *

Withlacoochee River: Site=52 Mile=2.55 medsal=0.1 p95Sal=2.7
Chasmanthium nitidum
Eleocharis fallax
Fraxinus caroliniana
Myrica cerifera *
Persea palustris *
Smilax walteri *

Withlacoochee River: Site=53 Mile=2.58 medsal=0.1 p95Sal=2.5
Chasmanthium nitidum
Cladium jamaicense
Eleocharis fallax
Fraxinus caroliniana *
Juncus roemerianus *
Solidago stricta
Zizania aquatica *

Withlacoochee River: Site=54 Mile=2.62 medsal=0.1 p95Sal=2.3
Aster carolinianus *
Chasmanthium nitidum
Colocasia esculenta
Crinum americanum
Itea virginica
Lobelia cardinalis
Panicum anceps
Smilax bona-nox
Stenotaphrum secundatum

Withlacoochee River: Site=55 Mile=2.64 medsal=0.1 p95Sal=2.3
Cephalanthus occidentalis *
Cladium jamaicense
Fraxinus caroliniana *
Lobelia cardinalis
Magnolia virginiana
Panicum anceps *
Saururus cernuus

Withlacoochee River: Site=56 Mile=2.67 medsal=0.1 p95Sal=2.1
Acer rubrum *
Fraxinus caroliniana
Sagittaria subulata

Withlacoochee River: Site=57 Mile=2.72 medsal=0.1 p95Sal=1.9
Cladium jamaicense
Sagittaria lancifolia
Sagittaria subulata

Withlacoochee River: Site=58 Mile=2.7 medsal=0.1 p95Sal=2.0
Carya aquatica *
Decumaria barbara *
Eleocharis fallax
Fraxinus caroliniana
Lobelia cardinalis
Saururus cernuus *
Taxodium distichum *
Viburnum obovatum *

Withlacoochee River: Site=59 Mile=2.73 medsal=0.1 p95Sal=1.8
- Acer rubrum *
- Cornus foemina *
- Crinum americanum
- Decumaria barbara *
- Eleocharis fallax
- Fraxinus caroliniana
- Ilex cassine *
- Itea virginica *
- Lobelia cardinalis
- Magnolia virginiana
- Mikania scandens *
- Sagittaria subulata
- Saururus cernuus

Withlacoochee River: Site=60 Mile=2.78 medsal=0.1 p95Sal=1.6
- Cladium jamaicense
- Cornus foemina
- Eleocharis fallax
- Sagittaria lancifolia
- Sagittaria subulata

Withlacoochee River: Site=61 Mile=2.83 medsal=0.1 p95Sal=1.3
- Cornus foemina
- Eleocharis fallax *
- Itea virginica
- Lobelia cardinalis *
- Ophioglossum petiolatum *
- Panicum anceps *
- Sabal palmetto *
- Smilax laurifolia *
- Zizania aquatica *

Withlacoochee River: Site=62 Mile=2.88 medsal=0.1 p95Sal=1.1
- Alternanthera philoxeroides
- Eleocharis fallax
- Ludwigia repens
- Magnolia virginiana
- Polygonum hydropiperoides
- Saururus cernuus

Withlacoochee River: Site=67 Mile=3.07 medsal=0.1 p95Sal=0.6
- Crinum americanum *
- Fraxinus caroliniana
- Lobelia cardinalis
- Ludwigia repens *
- Polygonum hydropiperoides *
- Ruppia maritima

Withlacoochee River: Site=68 Mile=3.15 medsal=0.1 p95Sal=0.5
- Cicuta maculata *
- Fraxinus caroliniana
- Isoetes flaccida

Withlacoochee River: Site=69 Mile=3.2 medsal=0.1 p95Sal=0.5
- Cephalanthus occidentalis
- Crinum americanum
- Eleocharis fallax
- Lobelia cardinalis
- Saururus cernuus

Withlacoochee River: Site=70 Mile=3.35 medsal=0.1 p95Sal=0.4

- Alternanthera philoxeroides
- Colocasia esculenta
- Echinochloa muricata
- Juncus effusus
- Ludwigia repens
- Pluchea odorata *
- Polygonum hydropiperoides
- Pontederia cordata
- Sagittaria lancifolia *
- Sagittaria subulata

Withlacoochee River: Site=111 Mile=0.63 medsal=8.9 p95Sal=17.3

- Juncus roemerianus
- Phragmites australis *
- Spartina alterniflora
- Typha domingensis

Appendix H

Median and P95 Salinity Values for Each Species by River, Site, and Mile.

Asterisk denotes species present adjacent to, but not in, quadrant

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---------- Species = *Acer rubrum* River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
45		15.15	0.1	5.8

----------Species = *Acer rubrum* River=Chassahowitzka -------

Site		River Mile	Median Salinity	P95 Salinity
57	*	2.95	3.4	7.6
81	*	4.35	1.5	1.7

---------- Species = *Acer rubrum* River=Withlacoochee---------

Site		River Mile	Median Salinity	P95 Salinity
44	*	2.27	0.3	4.5
48	*	2.39	0.2	3.4
49	*	2.43	0.2	3.2
56	*	2.67	0.1	2.1
59	*	2.73	0.1	1.8

---------- Species = *Acrostichum aureum* River= Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
4	*	8.80	6.1	19.9
7	*	9.25	5.0	19.0

---------- Species = *Acrostichum aureum* River = Myakka River --

Site		River Mile	Median Salinity	P95 Salinity
17	*	4.38	16.6	25.1
26		6.92	12.2	22.6
28		7.25	11.6	22.3

--------- Species = *Acrostichum danaeifolium* River=Peace ---------

Site		River Mile	Median Salinity	P95 Salinity
1	*	8.30	7.3	21.0
5		8.95	5.7	19.6
17		10.80	2.6	15.7
22	*	11.60	1.5	14.1
23	*	11.80	1.3	13.6
30		12.95	0.4	11.1
35		13.75	0.3	9.3
38		14.20	0.2	8.3
40		14.45	0.1	7.7
41	*	14.60	0.1	7.4
42	*	14.75	0.1	6.9
43	*	14.85	0.1	6.6
46	*	15.30	.	.
47	*	15.50	0.1	4.8
48	*	15.65	0.1	4.4
49	*	15.85	.	.
52		16.60	0.1	2.7
54	*	17.10	0.1	2.1
505	*	16.25	0.1	3.1

-------- Species = *Acrostichum danaeifolium* River = Myakka ---------

Site		River Mile	Median Salinity	P95 Salinity
39		9.75	7.6	20.4
40	*	10.00	7.3	20.2
41	*	10.23	6.9	20.1
43	*	10.82	5.5	19.4
44	*	11.00	5.1	19.2
45	*	11.46	3.9	18.6
46	*	11.68	3.4	18.4
48		12.19	2.5	17.7
50		12.61	2.0	17.1
54	*	13.58	0.9	15.6

---- Species = *Acrostichum danaeifolium* Little Manatee River -----

Site		River Mile	Median Salinity	P95 Salinity
39	*	3.86	13.8	25.2
41	*	4.10	13.1	25.0
61		6.10	5.2	19.1
66	*	6.60	3.8	17.2
70		7.00	2.7	15.8
80	*	8.00	1.2	12.9
81		8.10	1.1	12.6
90	*	9.00	0.5	10.2
93		9.30	0.4	9.4
101	*	10.10	0.2	6.3

----- Species = *Acrostichum danaeifolium* Weeki Wachee River ------

Site		River Mile	Median Salinity	P95 Salinity
29	*	0.94	4.4	16.3
32	*	1.03	2.6	14.5
38		1.21	0.8	9.7
43		1.36	0.3	6.7

---- Species = *Acrostichum danaeifolium* River = Chassahowitzka -----

Site		River Mile	Median Salinity	P95 Salinity
9	*	0.40	11.5	17.7
18	*	0.85	10.7	17.3
19	*	0.90	10.6	17.3
20	*	0.95	10.5	17.3
23		1.10	10.2	17.4
62	*	3.30	2.7	4.1
64		3.35	2.6	3.5
67	*	3.50	.	.
70	*	3.65	2.4	3.2
76		4.00	2.1	2.6

------- Species=Alternanthera philoxeroides River=Peace --------

Site		River Mile	Median Salinity	P95 Salinity
23	*	11.80	1.3	13.6
37		14.05	0.2	8.6
48		15.65	0.1	4.4

505	*	16.25	0.1	3.1

------- Species=Alternanthera philoxeroides River=Myakka -------

Site		River Mile	Median Salinity	P95 Salinity
49	*	12.38	2.3	17.4
90		.	.	0.0

--- Species=Alternanthera philoxeroides River=Little Manatee ---

Site		River Mile	Median Salinity	P95 Salinity
73		7.30	2.1	14.8
74		7.38	2.0	14.6
76		7.60	1.7	14.0
79		7.90	1.4	13.2
87		8.70	0.7	11.0
94	*	9.40	0.3	9.2
96	*	9.60	0.2	8.5
102		10.20	.	0.0

--- Species=Alternanthera philoxeroides River=Chassahowitzka ---

Site		River Mile	Median Salinity	P95 Salinity
3	*	0.10	11.8	18.5
4	*	0.15	11.7	18.4
26		1.25	10.0	17.4
32		1.65	9.6	17.4

--- Species=Alternanthera philoxeroides River=Withlacoochee ----

Site	River Mile	Median Salinity	P95 Salinity
48	2.39	0.2	3.4
62	2.88	0.1	1.1
70	3.35	0.1	0.4

---------- Species=Amaranthus australis River=Peace ----------

Site	River Mile	Median Salinity	P95 Salinity
37	14.05	0.2	8.6
60	18.50	0.1	0.5

------- Species=Amaranthus australis River=Withlacoochee -------

Site	River Mile	Median Salinity	P95 Salinity

35	*	1.82	1.3	11.2
39	*	2.05	0.8	8.0
47	*	2.36	0.2	3.6

---------- Species=Ampelopsis arborea River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
63	*	16.07	0.1	11.3

------- Species=Ampelopsis arborea River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
60		3.20	2.9	5.2

---------- Species=Ardisia escallonoides River=Peace -----------

Site		River Mile	Median Salinity	P95 Salinity
24	*	11.95	1.1	13.3

---------- Species=Aster carolinianus River=Peace ------------

Site		River Mile	Median Salinity	P95 Salinity
40		14.45	0.1	7.7
41	*	14.60	0.1	7.4
42	*	14.75	0.1	6.9
43	*	14.85	0.1	6.6
45		15.15	0.1	5.8
48		15.65	0.1	4.4
505	*	16.25	0.1	3.1

---------- Species=Aster carolinianus River=Myakka ------------

Site		River Mile	Median Salinity	P95 Salinity
63		16.07	0.1	11.3

------- Species=Aster carolinianus River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
73		7.30	2.1	14.8

------- Species=Aster carolinianus River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
54	*	2.80	3.8	8.1
57	*	2.95	3.4	7.6
66		3.45	2.6	3.4
67	*	3.50	.	.
75	*	3.92	.	.
76	*	4.00	2.1	2.6
82	*	4.45	.	.

---------- Species=Aster carolinianus River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
53	*	4.41	2.6	8.6
70		6.30	0.9	1.7

-------- Species=Aster carolinianus River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
48		2.39	0.2	3.4
54	*	2.62	0.1	2.3

---------- Species=Aster subulatus River=Weeki Wachee ----------

Site		River Mile	Median Salinity	P95 Salinity
37		1.18	1.1	10.5

--------- Species=Aster subulatus River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
6		0.29	11.4	19.8

-------- Species=Aster tenuifolius River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
1		0.00	11.9	18.8

---------- Species=Aster tenuifolius River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
5	*	0.30	13.5	19.8

7	*	0.50	11.8	18.5

---------- Species=Avicennia germinans River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
11	*	2.70	19.8	26.1
12	*	2.90	19.4	26.0
13	*	3.20	18.9	25.8
14	*	3.61	18.1	25.6
17	*	4.38	16.6	25.1
21	*	5.38	14.8	24.2
26		6.92	12.2	22.6

------- Species=Avicennia germinans River=Little Manatee -------

Site		River Mile	Median Salinity	P95 Salinity
29		2.90	16.6	26.3
31	*	3.10	16.0	26.1
33	*	3.30	15.4	25.9
42		4.20	12.8	24.8
44		4.42	11.7	24.4
45	*	4.52	.	.
48	*	4.80	9.5	23.7
49	*	4.96	.	.
50	*	5.00	8.4	23.3

------ Species=Baccharis angustifolia River=Weeki Wachee -------

Site		River Mile	Median Salinity	P95 Salinity
31	*	1.00	3.1	15.1

--------- Species=Baccharis angustifolia River=Crystal ---------

Site		River Mile	Median Salinity	P95 Salinity
4	*	0.20	14.6	20.6

------ Species=Baccharis angustifolia River=Withlacoochee ------

Site	River Mile	Median Salinity	P95 Salinity
11	0.55	9.2	17.6

---------- Species=Baccharis halimifolia River=Peace ---------

Site	Mile	Salinity	Salinity

21	*	11.48	1.7	14.3
36	*	13.90	0.2	9.0

------ Species=Baccharis halimifolia River=Little Manatee ------

Site		River Mile	Median Salinity	P95 Salinity
41	*	4.10	13.1	25.0
70	*	7.00	2.7	15.8
99	*	9.90	0.2	7.2

------- Species=Baccharis halimifolia River=Weeki Wachee -------

Site		River Mile	Median Salinity	P95 Salinity
29	*	0.94	4.4	16.3

------ Species=Baccharis halimifolia River=Chassahowitzka ------

Site		River Mile	Median Salinity	P95 Salinity
54	*	2.80	3.8	8.1
60	*	3.20	2.9	5.2
61	*	3.15	3.0	5.7
64	*	3.35	2.6	3.5
67	*	3.50	.	.
70	*	3.65	2.4	3.2
71	*	3.70	2.4	3.1
83	*	4.53	1.5	2.1
86	*	4.75	1.3	1.9

--------- Species=Baccharis halimifolia River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
50	*	4.13	3.0	10.5
59	*	4.94	1.8	5.0

------ Species=Baccharis halimifolia River=Withlacoochee -------

Site		River Mile	Median Salinity	P95 Salinity
48	*	2.39	0.2	3.4

---------- Species=Bacopa monnieri River=Peace ----------

Site	River Mile	Median Salinity	P95 Salinity

10	*	9.70	4.0	18.0
13	*	10.20	3.3	17.0
14	*	10.35	3.1	16.6
17		10.80	2.6	15.7
23	*	11.80	1.3	13.6
25	*	12.20	0.8	12.8
27	*	12.50	0.5	12.2
31		13.10	0.4	10.8
59		18.30	0.1	0.6

---------- Species=Bacopa monnieri River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
45	*	11.46	3.9	18.6
64		16.37	0.1	10.7
65	*	16.63	0.1	10.3

---------- Species=Bidens laevis River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
67	*	5.80	1.1	2.5

---------- Species=Blechnum serrulatum River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
35	*	13.75	0.3	9.3
40		14.45	0.1	7.7
41	*	14.60	0.1	7.4

------- Species=Blechnum serrulatum River=Little Manatee -------

Site		River Mile	Median Salinity	P95 Salinity
96	*	9.60	0.2	8.5
97	*	9.70	0.2	8.1
99		9.90	0.2	7.2

--------- Species=Blutaparon vermiculare River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
13	*	3.20	18.9	25.8

------ Species=Boehmeria cylindrica River=Chassahowitzka -------

Site		River Mile	Median Salinity	P95 Salinity
83	*	4.53	1.5	2.1

---------- Species=Borrichia frutescens River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
11	*	2.70	19.8	26.1
12		2.90	19.4	26.0
17	*	4.38	16.6	25.1

---------- Species=Carex lupulina River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
84	*	22.00	0.1	0.7

--------- Species=Carya aquatica River=Chassahowitzka ----------

Site		River Mile	Median Salinity	P95 Salinity
57	*	2.95	3.4	7.6

---------- Species=Carya aquatica River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
58	*	2.70	0.1	2.0

-------- Species=Cephalanthus occidentalis River=Peace ---------

Site		River Mile	Median Salinity	P95 Salinity
47	*	15.50	0.1	4.8

-------- Species=Cephalanthus occidentalis River=Myakka --------

Site		River Mile	Median Salinity	P95 Salinity
85	*	22.25	0.1	0.3
90	*	.	.	0.0

---- Species=Cephalanthus occidentalis River=Withlacoochee -----

		River	Median	P95

Site		Mile	Salinity	Salinity
43	*	2.23	0.4	5.1
45	*	2.32	0.2	3.7
51		2.50	0.1	2.9
55	*	2.64	0.1	2.3
69		3.20	0.1	0.5

------- Species=Chasmanthium nitidum River=Withlacoochee -------

Site	River Mile	Median Salinity	P95 Salinity
52	2.55	0.1	2.7
53	2.58	0.1	2.5
54	2.62	0.1	2.3

------------- Species=Cicuta maculata River=Peace -------------

Site		River Mile	Median Salinity	P95 Salinity
37	*	14.05	0.2	8.6
40	*	14.45	0.1	7.7
43	*	14.85	0.1	6.6
44		15.00	0.1	6.2
48		15.65	0.1	4.4
54	*	17.10	0.1	2.1
58	*	18.05	0.1	0.9
59		18.30	0.1	0.6
60	*	18.50	0.1	0.5

------------- Species=Cicuta maculata River=Myakka -------------

Site		River Mile	Median Salinity	P95 Salinity
65	*	16.63	0.1	10.3
76	*	19.54	0.1	5.1

--------- Species=Cicuta maculata River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity
57		2.95	3.4	7.6
62	*	3.30	2.7	4.1
67	*	3.50	.	.

--------- Species=Cicuta maculata River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
68	*	3.15	0.1	0.5

---------- Species=Cladium jamaicense River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
14		10.35	3.1	16.6
19		11.15	2.1	15.0
23	*	11.80	1.3	13.6
26	*	12.35	0.6	12.5
27	*	12.50	0.5	12.2
29		12.85	0.4	11.4
33		13.40	0.3	10.1
36		13.90	0.2	9.0
37		14.05	0.2	8.6
41		14.60	0.1	7.4
43		14.85	0.1	6.6

---------- Species=Cladium jamaicense River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
11	*	2.70	19.8	26.1
48		12.19	2.5	17.7

------- Species=Cladium jamaicense River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
82		8.20	1.0	12.4
85		8.50	0.8	11.6
93	*	9.30	0.4	9.4
97		9.70	0.2	8.1
99		9.90	0.2	7.2

-------- Species=Cladium jamaicense River=Weeki Wachee ---------

Site		River Mile	Median Salinity	P95 Salinity
14		0.49	10.0	19.3
20		0.67	8.5	19.2
22		0.73	8.0	19.1
26		0.85	6.4	18.1
30		0.97	3.8	15.7
32		1.03	2.6	14.5
33		1.06	2.3	13.7
34		1.09	2.0	12.9
36		1.15	1.4	11.3
37		1.18	1.1	10.5
38		1.21	0.8	9.7
39		1.24	0.6	8.9
40		1.27	0.4	8.3
41		1.30	0.4	7.7
42		1.33	0.4	7.2

43	1.36	0.3	6.7

------- Species=Cladium jamaicense River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
4		0.15	11.7	18.4
7		0.30	11.6	18.0
8		0.35	11.5	17.9
10		0.45	11.4	17.6
11		0.50	11.4	17.5
12		0.55	11.3	17.3
13		0.60	11.3	17.2
15		0.70	11.0	17.2
16		0.75	10.9	17.3
17		0.80	10.8	17.3
18		0.85	10.7	17.3
20		0.95	10.5	17.3
21	*	1.00	10.4	17.4
22		1.05	10.3	17.4
23		1.10	10.2	17.4
24	*	1.15	10.1	17.4
25	*	1.20	10.1	17.4
26		1.25	10.0	17.4
27		1.30	10.0	17.4
28		1.35	9.9	17.4
29		1.50	9.8	17.4
30		1.55	9.7	17.4
31		1.60	9.7	17.4
32		1.65	9.6	17.4
33		1.70	9.6	17.4
35		1.80	9.4	17.3
36		1.85	9.0	17.0
37		1.90	8.7	16.7
39		2.00	8.1	16.2
40		2.05	7.7	15.9
41		2.10	7.4	15.6
42		2.15	7.1	15.4
43		2.20	6.8	15.1
44		2.25	6.5	14.8
45		2.30	6.2	14.0
46		2.35	5.9	13.2
47		2.40	5.6	12.5
48		2.45	5.3	11.7
49		2.55	4.7	10.1
51		2.65	4.1	8.7
52		2.70	4.0	8.5
53		2.75	3.9	8.3
55		2.85	3.7	7.9
56		2.90	3.5	7.8
57		2.95	3.4	7.6
58		3.00	3.3	7.4
59		3.05	3.2	6.8
60		3.20	2.9	5.2
61		3.15	3.0	5.7
62		3.30	2.7	4.1
63		3.25	2.8	4.6
64		3.35	2.6	3.5

65	3.40	2.6	3.4
66	3.45	2.6	3.4
68	3.55	2.6	3.6
70	3.65	2.4	3.2
72	3.80	2.3	2.9
73	3.82	2.3	2.9
78	4.15	2.0	2.3

---------- Species=Cladium jamaicense River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
27		2.60	6.6	14.4
28	*	2.35	7.5	14.8
37		3.08	5.1	13.5
47		3.92	3.3	11.9
54		4.48	2.4	8.1
58		4.85	1.9	5.6
60		5.05	1.6	4.2
62		5.29	1.4	3.2
63		5.40	1.3	3.0
65		5.55	1.2	2.8
67		5.80	1.1	2.5
69		6.20	0.9	1.9
71		6.40	0.8	1.6
72		6.50	0.8	1.4
73	*	6.50	0.8	1.4

-------- Species=Cladium jamaicense River=Withlacoochee --------

Site	River Mile	Median Salinity	P95 Salinity
16	0.85	8.4	16.5
21	1.16	6.2	14.8
23	1.25	5.2	14.2
24	1.28	4.8	14.0
26	1.36	3.9	13.5
27	1.42	3.3	13.1
28	1.48	3.0	12.8
32	1.68	2.0	11.9
33	1.74	1.7	11.6
35	1.82	1.3	11.2
36	1.87	1.1	10.8
39	2.05	0.8	8.0
40	2.07	0.7	7.7
41	2.12	0.6	6.9
42	2.17	0.5	6.1
43	2.23	0.4	5.1
45	2.32	0.2	3.7
46	2.33	0.2	3.7
49	2.43	0.2	3.2
51	2.50	0.1	2.9
53	2.58	0.1	2.5
55	2.64	0.1	2.3
57	2.72	0.1	1.9
60	2.78	0.1	1.6

---------- Species=Colocasia esculenta River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
37	*	14.05	0.2	8.6
40		14.45	0.1	7.7
42		14.75	0.1	6.9
45		15.15	0.1	5.8
47		15.50	0.1	4.8
48		15.65	0.1	4.4
502		16.10	0.1	3.3

------- Species=Colocasia esculenta River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
54		2.62	0.1	2.3
70		3.35	0.1	0.4

---------- Species=Conocarpus erectus River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
5	*	8.95	5.7	19.6
19	*	11.15	2.1	15.0

---------- Species=Conocarpus erectus River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
17	*	4.38	16.6	25.1
18		4.69	16.0	24.9
19	*	4.94	15.6	24.7
26		6.92	12.2	22.6

--------- Species=Cornus foemina River=Chassahowitzka ----------

Site		River Mile	Median Salinity	P95 Salinity
68	*	3.55	2.6	3.6
75	*	3.92	.	.

---------- Species=Cornus foemina River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
49	*	2.43	0.2	3.2
59	*	2.73	0.1	1.8

60	2.78	0.1	1.6
61	2.83	0.1	1.3

---------- Species=Crinum americanum River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
17	*	10.80	2.6	15.7
26	*	12.35	0.6	12.5
37	*	14.05	0.2	8.6
38	*	14.20	0.2	8.3

---------- Species=Crinum americanum River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
46	*	11.68	3.4	18.4
53		13.53	0.9	15.7
57		14.61	0.4	13.9
58	*	14.82	0.3	13.5
63	*	16.07	0.1	11.3
68	*	17.42	0.1	8.9
69		17.69	0.1	8.4
72		18.48	0.1	7.0
82		21.00	0.1	2.5

-------- Species=Crinum americanum River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
48		4.80	9.5	23.7
76		7.60	1.7	14.0
77		7.70	1.6	13.7
90		9.00	0.5	10.2
91		9.10	0.5	10.0
93		9.30	0.4	9.4
96	*	9.60	0.2	8.5

--------- Species=Crinum americanum River=Weeki Wachee ---------

Site		River Mile	Median Salinity	P95 Salinity
15		0.51	9.9	19.3

-------- Species=Crinum americanum River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
2		0.05	11.8	18.7
61		3.15	3.0	5.7
62	*	3.30	2.7	4.1

65		3.40	2.6	3.4
66	*	3.45	2.6	3.4
67	*	3.50	.	.
70		3.65	2.4	3.2
71		3.70	2.4	3.1
72		3.80	2.3	2.9
80		4.28	1.8	2.0
83		4.53	1.5	2.1
86		4.75	1.3	1.9

-------- Species=Crinum americanum River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
54		2.62	0.1	2.3
59		2.73	0.1	1.8
67	*	3.07	0.1	0.6
69		3.20	0.1	0.5

-------- Species=Crotalaria incana River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
80	*	8.00	1.2	12.9
96	*	9.60	0.2	8.5

-------- Species=Cyperus distinctus River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
48	*	2.39	0.2	3.4

--------- Species=Dalbergia ecastophyllum River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
22	*	11.60	1.5	14.1

----- Species=Dalbergia ecastophyllum River=Little Manatee -----

Site		River Mile	Median Salinity	P95 Salinity
42	*	4.20	12.8	24.8
46	*	4.60	10.7	24.1
50	*	5.00	8.4	23.3
61	*	6.10	5.2	19.1
63	*	6.70	3.6	16.9

-------- Species=Decumaria barbara River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
58	*	2.70	0.1	2.0
59	*	2.73	0.1	1.8

---------- Species=Diodia virginiana River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
84		22.00	0.1	0.7
86		22.69	0.1	0.0
87	*	23.15	0.1	0.0

---------- Species=Distichlis spicata River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
13	*	10.20	3.3	17.0
15	*	10.50	2.9	16.3

---------- Species=Distichlis spicata River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
20	*	5.12	15.3	24.5
21		5.38	14.8	24.2

-------- Species=Distichlis spicata River=Weeki Wachee ---------

Site		River Mile	Median Salinity	P95 Salinity
12		0.44	10.5	19.3
13		0.47	10.2	19.3

------- Species=Distichlis spicata River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
1		0.00	11.9	18.8
2		0.05	11.8	18.7
3	*	0.10	11.8	18.5
4		0.15	11.7	18.4
16		0.75	10.9	17.3

---------- Species=Distichlis spicata River=Crystal ----------

		River	Median	P95

Site		Mile	Salinity	Salinity
7		0.50	11.8	18.5
29	*	2.42	7.2	14.6

-------- Species=Distichlis spicata River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
6		0.29	11.4	19.8

------- Species=Echinochloa muricata River=Withlacoochee -------

Site		River Mile	Median Salinity	P95 Salinity
47	*	2.36	0.2	3.6
70		3.35	0.1	0.4

-------- Species=Eclipta prostrate River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
85	*	8.50	0.8	11.6

-------- Species=Eleocharis fallax River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
36	*	1.87	1.1	10.8
51		2.50	0.1	2.9
52		2.55	0.1	2.7
53		2.58	0.1	2.5
58		2.70	0.1	2.0
59		2.73	0.1	1.8
60		2.78	0.1	1.6
61	*	2.83	0.1	1.3
62		2.88	0.1	1.1
69		3.20	0.1	0.5

---------- Species=Eleocharis flavescens River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
49	*	12.38	2.3	17.4
64		16.37	0.1	10.7
65		16.63	0.1	10.3
67	*	17.11	0.1	9.4
68		17.42	0.1	8.9
69		17.69	0.1	8.4
70		17.87	0.1	8.1

71		18.17	0.1	7.5
72		18.48	0.1	7.0
73	*	18.60	0.1	6.8
74		18.92	0.1	6.2
77	*	19.71	0.1	4.8
78	*	20.00	0.1	4.3
82		21.00	0.1	2.5
83		21.31	0.1	1.9
84		22.00	0.1	0.7

---------- Species=Ficus aurea River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
3	*	8.60	6.6	20.4
5	*	8.95	5.7	19.6
29	*	12.85	0.4	11.4
30	*	12.95	0.4	11.1
31	*	13.10	0.4	10.8
35	*	13.75	0.3	9.3
42	*	14.75	0.1	6.9

---------- Species=Ficus aurea River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
11	*	2.70	19.8	26.1
13	*	3.20	18.9	25.8
32	*	8.25	9.9	21.3

---------- Species=Fraxinus caroliniana River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
73		6.50	0.8	1.4

------- Species=Fraxinus caroliniana River=Withlacoochee -------

Site		River Mile	Median Salinity	P95 Salinity
36	*	1.87	1.1	10.8
42		2.17	0.5	6.1
44		2.27	0.3	4.5
45		2.32	0.2	3.7
46	*	2.33	0.2	3.7
47		2.36	0.2	3.6
48	*	2.39	0.2	3.4
49	*	2.43	0.2	3.2
50		2.45	0.2	3.1
52		2.55	0.1	2.7
53	*	2.58	0.1	2.5
55	*	2.64	0.1	2.3

56		2.67	0.1	2.1
58		2.70	0.1	2.0
59		2.73	0.1	1.8
67		3.07	0.1	0.6
68		3.15	0.1	0.5

---------- Species=Gratiola virginiana River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
69	*	17.69	0.1	8.4
70		17.87	0.1	8.1
71		18.17	0.1	7.5
72		18.48	0.1	7.0
74		18.92	0.1	6.2
76	*	19.54	0.1	5.1
83		21.31	0.1	1.9
87	*	23.15	0.1	0.0

---------- Species=Hydrocotyle umbellata River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
64		16.37	0.1	10.7
83		21.31	0.1	1.9
87	*	23.15	0.1	0.0

---------- Species=Hypericum mutilum River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
82	*	21.00	0.1	2.5

---------- Species=Ilex cassine River=Weeki Wachee ----------

Site		River Mile	Median Salinity	P95 Salinity
31	*	1.00	3.1	15.1

---------- Species=Ilex cassine River=Chassahowitzka ----------

Site		River Mile	Median Salinity	P95 Salinity
76	*	4.00	2.1	2.6

---------- Species=Ilex cassine River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity

43	*	2.23	0.4	5.1
48	*	2.39	0.2	3.4
50	*	2.45	0.2	3.1
59	*	2.73	0.1	1.8

---------- Species=Iris hexagona River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
76	*	19.54	0.1	5.1
82	*	21.00	0.1	2.5
83		21.31	0.1	1.9

---------- Species=Iris hexagona River=Chassahowitzka ----------

Site		River Mile	Median Salinity	P95 Salinity
62	*	3.30	2.7	4.1
65		3.40	2.6	3.4

---------- Species=Isoetes flaccida River=Myakka ----------

Site	River Mile	Median Salinity	P95 Salinity
65	16.63	0.1	10.3

--------- Species=Isoetes flaccida River=Withlacoochee ---------

Site	River Mile	Median Salinity	P95 Salinity
50	2.45	0.2	3.1
68	3.15	0.1	0.5

--------- Species=Itea virginica River=Chassahowitzka ----------

Site		River Mile	Median Salinity	P95 Salinity
83	*	4.53	1.5	2.1
86	*	4.75	1.3	1.9

---------- Species=Itea virginica River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
54		2.62	0.1	2.3
59	*	2.73	0.1	1.8
61		2.83	0.1	1.3

---------- Species=Iva frutescens River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
11	*	2.70	19.8	26.1
17	*	4.38	16.6	25.1
22	*	5.75	14.2	23.8
25		6.50	12.9	23.1
26		6.92	12.2	22.6
27	*	7.10	11.9	22.5
28	*	7.25	11.6	22.3

---------- Species=Iva frutescens River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
3	*	0.10	15.6	21.4
4	*	0.20	14.6	20.6
17	*	1.43	9.0	16.0

---------- Species=Iva frutescens River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
14	*	0.83	8.4	16.5
33	*	1.74	1.7	11.6

---------- Species=Juncus effusus River=Peace ----------

Site	River Mile	Median Salinity	P95 Salinity
42	14.75	0.1	6.9

---------- Species=Juncus effusus River=Withlacoochee ----------

Site	River Mile	Median Salinity	P95 Salinity
70	3.35	0.1	0.4

---------- Species=Juncus megacephalus River=Myakka ----------

Site	River Mile	Median Salinity	P95 Salinity
85	22.25	0.1	0.3

---------- Species=Juncus roemerianus River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
1		8.30	7.3	21.0
2		8.45	6.9	20.7
3		8.60	6.6	20.4
6		9.10	5.3	19.3
9		9.55	4.2	18.3
10		9.70	4.0	18.0
11		9.90	3.7	17.6
12	*	10.05	3.5	17.3
13		10.20	3.3	17.0
15		10.50	2.9	16.3
16		10.65	2.7	16.0
17		10.80	2.6	15.7
18		10.95	2.4	15.4
19	*	11.15	2.1	15.0
22		11.60	1.5	14.1
23		11.80	1.3	13.6
24		11.95	1.1	13.3
26		12.35	0.6	12.5
29	*	12.85	0.4	11.4
31		13.10	0.4	10.8
33	*	13.40	0.3	10.1

---------- Species=Juncus roemerianus River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
12		2.90	19.4	26.0
13	*	3.20	18.9	25.8
15		3.88	17.6	25.4
18		4.69	16.0	24.9
20		5.12	15.3	24.5
21		5.38	14.8	24.2
22		5.75	14.2	23.8
23		5.95	13.9	23.6
24		6.15	13.5	23.4
25		6.50	12.9	23.1
26		6.92	12.2	22.6
27		7.10	11.9	22.5
28		7.25	11.6	22.3
29		7.50	11.2	22.1
30		7.75	10.8	21.8
31		7.95	10.4	21.6
33		8.52	9.5	21.2
34		8.80	9.1	21.0
35		9.00	8.8	20.9
37		9.12	8.6	20.8
38		9.46	8.1	20.6
39		9.75	7.6	20.4
40		10.00	7.3	20.2
41		10.23	6.9	20.1
43		10.82	5.5	19.4
44		11.00	5.1	19.2
45		11.46	3.9	18.6
46		11.68	3.4	18.4
48		12.19	2.5	17.7

50		12.61	2.0	17.1
51	*	12.81	1.8	16.8
53		13.53	0.9	15.7
54		13.58	0.9	15.6
55	*	13.88	0.5	15.2
57		14.61	0.4	13.9
58		14.82	0.3	13.5
64	*	16.37	0.1	10.7
65		16.63	0.1	10.3
66	*	16.80	0.1	10.0

------- Species=Juncus roemerianus River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
30		3.00	16.3	26.2
34		3.40	15.1	25.8
35		3.50	14.9	25.6
39		3.86	13.8	25.2
40		4.00	13.4	25.1
41		4.10	13.1	25.0
42	*	4.20	12.8	24.8
43		4.32	12.2	24.6
44		4.42	11.7	24.4
45	*	4.52	.	.
46		4.60	10.7	24.1
47		4.70	10.1	23.9
48		4.80	9.5	23.7
50		5.00	8.4	23.3
51		5.10	7.9	23.1
53		5.27	7.1	22.6
55		5.50	6.6	21.6
56		5.56	6.5	21.4
57		5.72	6.1	20.7
58		5.80	5.9	20.3
59		5.88	5.7	20.0
60		5.97	5.5	19.6
61		6.10	5.2	19.1
62		6.20	4.9	18.7
63		6.70	3.6	16.9
64		6.40	4.4	17.9
66		6.60	3.8	17.2
68		6.80	3.3	16.5
70		7.00	2.7	15.8
71		7.10	2.4	15.4
72		7.20	2.2	15.1
73		7.30	2.1	14.8
74		7.38	2.0	14.6
75		7.50	1.8	14.3
76		7.60	1.7	14.0
77		7.70	1.6	13.7
80	*	8.00	1.2	12.9
81		8.10	1.1	12.6
82	*	8.20	1.0	12.4
86		8.60	0.7	11.3
87		8.70	0.7	11.0
88		8.80	0.6	10.8
91		9.10	0.5	10.0

93	9.30	0.4	9.4
94	9.40	0.3	9.2

-------- Species=Juncus roemerianus River=Weeki Wachee ---------

Site	River Mile	Median Salinity	P95 Salinity
1	0.10	11.2	19.6
2	0.12	11.2	19.6
3	0.15	11.1	19.5
4	0.18	11.1	19.5
5	0.21	11.0	19.5
6	0.24	11.0	19.5
7	0.27	10.9	19.4
8	0.30	10.9	19.4
9	0.33	10.8	19.4
10	0.36	10.8	19.4
11	0.39	10.7	19.3
12	0.44	10.5	19.3
13	0.47	10.2	19.3
15	0.51	9.9	19.3
16	0.55	9.5	19.2
18	0.61	9.0	19.2
19	0.64	8.8	19.2
20	0.67	8.5	19.2
21	0.70	8.3	19.2
22	0.73	8.0	19.1
23	0.76	7.8	19.1
24	0.79	7.5	19.1
26	0.85	6.4	18.1
27	0.88	5.7	17.5
28	0.91	5.1	16.9
30	0.97	3.8	15.7
31	1.00	3.1	15.1
32	1.03	2.6	14.5
37	1.18	1.1	10.5

------- Species=Juncus roemerianus River=Chassahowitzka --------

Site	River Mile	Median Salinity	P95 Salinity
1	0.00	11.9	18.8
3	0.10	11.8	18.5
4	0.15	11.7	18.4
5	0.20	11.7	18.3
6	0.25	11.6	18.1
7	0.30	11.6	18.0
8	0.35	11.5	17.9
9	0.40	11.5	17.7
10	0.45	11.4	17.6
12	0.55	11.3	17.3
13	0.60	11.3	17.2
14	0.65	11.1	17.2
15	0.70	11.0	17.2
16	0.75	10.9	17.3
19	0.90	10.6	17.3

21		1.00	10.4	17.4
22		1.05	10.3	17.4
23		1.10	10.2	17.4
24		1.15	10.1	17.4
25		1.20	10.1	17.4
26		1.25	10.0	17.4
27		1.30	10.0	17.4
28		1.35	9.9	17.4
29		1.50	9.8	17.4
30		1.55	9.7	17.4
31		1.60	9.7	17.4
32		1.65	9.6	17.4
33		1.70	9.6	17.4
35		1.80	9.4	17.3
36		1.85	9.0	17.0
40		2.05	7.7	15.9
41	*	2.10	7.4	15.6
42		2.15	7.1	15.4
43		2.20	6.8	15.1
44		2.25	6.5	14.8
45		2.30	6.2	14.0
46		2.35	5.9	13.2
47		2.40	5.6	12.5

---------- Species=Juncus roemerianus River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
2		0.06	16.0	21.8
4		0.20	14.6	20.6
5		0.30	13.5	19.8
6		0.40	12.5	19.0
7		0.50	11.8	18.5
8		0.60	11.3	18.1
9		0.65	11.1	17.9
10		0.80	10.3	17.3
11		0.90	9.8	16.9
12		1.00	9.3	16.5
14		1.18	9.2	16.3
15		1.28	9.1	16.2
17	*	1.43	9.0	16.0
20		1.19	9.2	16.3
23		1.90	8.6	15.4
24		2.00	8.6	15.3
27		2.60	6.6	14.4
28		2.35	7.5	14.8
29		2.42	7.2	14.6
30		2.50	6.9	14.5
31		2.54	6.8	14.5
32		2.65	6.4	14.3
33		2.74	6.1	14.1
34		2.80	5.9	14.0
35		2.90	5.6	13.9
37		3.08	5.1	13.5
38		3.15	5.0	13.4
40		3.30	4.6	13.1
41		3.38	4.5	13.0
42		3.45	4.3	12.9

43	3.53	4.1	12.7
45	3.71	3.7	12.4
49	4.08	3.0	10.8
50	4.13	3.0	10.5
51	4.30	2.7	9.3
58	4.85	1.9	5.6
69	6.20	0.9	1.9
70	6.30	0.9	1.7
71	6.40	0.8	1.6

-------- Species=Juncus roemerianus River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
3		0.12	12.7	20.1
4		0.17	12.3	20.1
5		0.22	12.0	20.1
6		0.29	11.4	19.8
8		0.45	9.6	18.1
9		0.46	9.5	18.0
11		0.55	9.2	17.6
13		0.80	8.5	16.6
14		0.83	8.4	16.5
15		0.68	8.8	17.1
16		0.85	8.4	16.5
17		0.92	8.2	16.2
18		0.98	8.0	16.0
19		1.05	7.4	15.6
20		1.12	6.6	15.1
21		1.16	6.2	14.8
22		1.20	5.7	14.6
23		1.25	5.2	14.2
24		1.28	4.8	14.0
26		1.36	3.9	13.5
27		1.42	3.3	13.1
28		1.48	3.0	12.8
31		1.64	2.2	12.1
32		1.68	2.0	11.9
37		1.92	1.0	10.0
38		1.98	0.9	9.1
45	*	2.32	0.2	3.7
47		2.36	0.2	3.6
53	*	2.58	0.1	2.5
111		0.63	8.9	17.3

------- Species=Juniperus virginiana River=Withlacoochee -------

Site		River Mile	Median Salinity	P95 Salinity
34	*	1.77	1.6	11.5

---------- Species=Laguncularia racemosa River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity

2	*	8.45	6.9	20.7
5	*	8.95	5.7	19.6
11		9.90	3.7	17.6
17		10.80	2.6	15.7
25	*	12.20	0.8	12.8

---------- Species=Laguncularia racemosa River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
12	*	2.90	19.4	26.0
13	*	3.20	18.9	25.8
17	*	4.38	16.6	25.1
18		4.69	16.0	24.9
21		5.38	14.8	24.2
22	*	5.75	14.2	23.8
23	*	5.95	13.9	23.6
25	*	6.50	12.9	23.1
26		6.92	12.2	22.6
27	*	7.10	11.9	22.5
29	*	7.50	11.2	22.1
30		7.75	10.8	21.8
34	*	8.80	9.1	21.0
39		9.75	7.6	20.4
40	*	10.00	7.3	20.2
41		10.23	6.9	20.1
45	*	11.46	3.9	18.6

------ Species=Laguncularia racemosa River=Little Manatee ------

Site		River Mile	Median Salinity	P95 Salinity
29	*	2.90	16.6	26.3
31	*	3.10	16.0	26.1
33	*	3.30	15.4	25.9
35		3.50	14.9	25.6
39	*	3.86	13.8	25.2
41	*	4.10	13.1	25.0
42		4.20	12.8	24.8
43		4.32	12.2	24.6
45	*	4.52	.	.
50	*	5.00	8.4	23.3

--------- Species=Laguncularia racemosa River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
8	*	0.60	11.3	18.1

------ Species=Limonium carolinianum River=Little Manatee -------

		River	Median	P95

Site		Mile	Salinity	Salinity
37	*	3.70	14.3	25.4

---------- Species=Lobelia cardinalis River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
73	*	6.50	0.8	1.4

-------- Species=Lobelia cardinalis River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
54		2.62	0.1	2.3
55		2.64	0.1	2.3
58		2.70	0.1	2.0
59		2.73	0.1	1.8
61	*	2.83	0.1	1.3
67		3.07	0.1	0.6
69		3.20	0.1	0.5

---------- Species=Lobelia feayana River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
64	*	16.37	0.1	10.7
65	*	16.63	0.1	10.3
90	*	.	.	0.0

---------- Species=Ludwigia repens River=Peace ----------

Site	River Mile	Median Salinity	P95 Salinity
45	15.15	0.1	5.8
59	18.30	0.1	0.6

---------- Species=Ludwigia repens River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
49	*	12.38	2.3	17.4
64		16.37	0.1	10.7
65		16.63	0.1	10.3
67	*	17.11	0.1	9.4
83		21.31	0.1	1.9

--------- Species=Ludwigia repens River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
62		2.88	0.1	1.1
67	*	3.07	0.1	0.6
70		3.35	0.1	0.4

------- Species=Lycium carolinianum River=Chassahowitzka -------

Site		River Mile	Median Salinity	P95 Salinity
18	*	0.85	10.7	17.3
19	*	0.90	10.6	17.3
23	*	1.10	10.2	17.4

------------- Species=Lythrum alatum River=Myakka -------------

Site		River Mile	Median Salinity	P95 Salinity
55	*	13.88	0.5	15.2
57	*	14.61	0.4	13.9
85	*	22.25	0.1	0.3

--------- Species=Lythrum alatum River=Little Manatee ----------

Site		River Mile	Median Salinity	P95 Salinity
87		8.70	0.7	11.0
96	*	9.60	0.2	8.5

--------- Species=Lythrum alatum River=Chassahowitzka ----------

Site		River Mile	Median Salinity	P95 Salinity
2		0.05	11.8	18.7
5	*	0.20	11.7	18.3
67	*	3.50	.	.
68	*	3.55	2.6	3.6

-------- Species=Magnolia virginiana River=Weeki Wachee --------

Site		River Mile	Median Salinity	P95 Salinity
29	*	0.94	4.4	16.3
32	*	1.03	2.6	14.5
34	*	1.09	2.0	12.9
35	*	1.12	1.7	12.1
39	*	1.24	0.6	8.9
41	*	1.30	0.4	7.7

------- Species=Magnolia virginiana River=Chassahowitzka -------

Site		River Mile	Median Salinity	P95 Salinity
58	*	3.00	3.3	7.4
66	*	3.45	2.6	3.4
80	*	4.28	1.8	2.0
81		4.35	1.5	1.7
83	*	4.53	1.5	2.1

---------- Species=Magnolia virginiana River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
61	*	5.20	1.4	3.3

------- Species=Magnolia virginiana River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
39	*	2.05	0.8	8.0
40	*	2.07	0.7	7.7
44		2.27	0.3	4.5
48	*	2.39	0.2	3.4
50		2.45	0.2	3.1
51	*	2.50	0.1	2.9
55		2.64	0.1	2.3
59		2.73	0.1	1.8
62		2.88	0.1	1.1

---------- Species=Mikania scandens River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
32	*	13.25	0.3	10.4
48		15.65	0.1	4.4

---------- Species=Mikania scandens River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
53		13.53	0.9	15.7
54		13.58	0.9	15.6
57	*	14.61	0.4	13.9
58		14.82	0.3	13.5
70		17.87	0.1	8.1
78		20.00	0.1	4.3
82	*	21.00	0.1	2.5
85		22.25	0.1	0.3
86		22.69	0.1	0.0
87		23.15	0.1	0.0

88	*	23.61	0.1	0.0
90	*	.	.	0.0

--------- Species=Mikania scandens River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
59	*	2.73	0.1	1.8

---------- Species=Myrica cerifera River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
17	*	10.80	2.6	15.7
35	*	13.75	0.3	9.3
47	*	15.50	0.1	4.8
49	*	15.85	.	.

--------- Species=Myrica cerifera River=Little Manatee ---------

Site		River Mile	Median Salinity	P95 Salinity
70	*	7.00	2.7	15.8
80	*	8.00	1.2	12.9
99		9.90	0.2	7.2
102	*	10.20	.	0.0

--------- Species=Myrica cerifera River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity
56	*	2.90	3.5	7.8
58	*	3.00	3.3	7.4
61	*	3.15	3.0	5.7
62	*	3.30	2.7	4.1
63	*	3.25	2.8	4.6
64	*	3.35	2.6	3.5
71	*	3.70	2.4	3.1
72	*	3.80	2.3	2.9
76	*	4.00	2.1	2.6

---------- Species=Myrica cerifera River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
71	*	6.40	0.8	1.6
73	*	6.50	0.8	1.4

--------- Species=Myrica cerifera River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
45	*	2.32	0.2	3.7
48	*	2.39	0.2	3.4
52	*	2.55	0.1	2.7

---------- Species=Nuphar luteum River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
56		17.60	0.1	1.5
57	*	17.85	0.1	1.1
58	*	18.05	0.1	0.9

----- Species=Ophioglossum petiolatum River=Withlacoochee ------

Site		River Mile	Median Salinity	P95 Salinity
61	*	2.83	0.1	1.3

--------- Species=Osmunda regalis River=Little Manatee ---------

Site		River Mile	Median Salinity	P95 Salinity
97		9.70	0.2	8.1
99	*	9.90	0.2	7.2

---------- Species=Panicum anceps River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
48		2.39	0.2	3.4
50	*	2.45	0.2	3.1
54		2.62	0.1	2.3
55	*	2.64	0.1	2.3
61	*	2.83	0.1	1.3

---------- Species=Panicum rigidulum River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
68	*	17.42	0.1	8.9
71	*	18.17	0.1	7.5
73	*	18.60	0.1	6.8
75		19.16	0.1	5.8
76	*	19.54	0.1	5.1

--- Species=Parthenocissus quinquefolia River=Little Manatee ---

Site		River Mile	Median Salinity	P95 Salinity
96	*	9.60	0.2	8.5

--------- Species=Paspalidium geminatum River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity
84		4.60	1.5	2.2
86		4.75	1.3	1.9

------- Species=Paspalum vaginatum River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
49	*	4.96	.	.

------------- Species=Persea palustris River=Peace -------------

Site		River Mile	Median Salinity	P95 Salinity
17	*	10.80	2.6	15.7
31	*	13.10	0.4	10.8
35	*	13.75	0.3	9.3
45	*	15.15	0.1	5.8
49	*	15.85	.	.

--------- Species=Persea palustris River=Weeki Wachee ----------

Site		River Mile	Median Salinity	P95 Salinity
40	*	1.27	0.4	8.3

-------- Species=Persea palustris River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity
56	*	2.90	3.5	7.8
57	*	2.95	3.4	7.6
61	*	3.15	3.0	5.7
64	*	3.35	2.6	3.5
81	*	4.35	1.5	1.7
83	*	4.53	1.5	2.1

--------- Species=Persea palustris River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
34	*	1.77	1.6	11.5
36	*	1.87	1.1	10.8
43	*	2.23	0.4	5.1
49	*	2.43	0.2	3.2
52	*	2.55	0.1	2.7

---------- Species=Phragmites australis River=Peace ----------

Site	River Mile	Median Salinity	P95 Salinity
51	16.40	0.1	2.9

------ Species=Phragmites australis River=Little Manatee -------

Site		River Mile	Median Salinity	P95 Salinity
46	*	4.60	10.7	24.1
52		5.20	7.3	22.9
74	*	7.38	2.0	14.6

------ Species=Phragmites australis River=Chassahowitzka -------

Site	River Mile	Median Salinity	P95 Salinity
85	4.68	1.5	2.4

------- Species=Phragmites australis River=Withlacoochee -------

Site		River Mile	Median Salinity	P95 Salinity
10		0.50	9.3	17.7
12		0.70	8.8	17.0
18		0.98	8.0	16.0
111	*	0.63	8.9	17.3

------------ Species=Phyla nodiflora River=Myakka ------------

Site	River Mile	Median Salinity	P95 Salinity
90	.	.	.

-------- Species=Pistia stratiotes River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
84	*	4.60	1.5	2.2

---------- Species=Pluchea odorata River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
32	*	13.25	0.3	10.4
40	*	14.45	0.1	7.7
42		14.75	0.1	6.9
45		15.15	0.1	5.8

---------- Species=Pluchea odorata River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
49	*	12.38	2.3	17.4
53		13.53	0.9	15.7
58	*	14.82	0.3	13.5
67		17.11	0.1	9.4
70		17.87	0.1	8.1
85	*	22.25	0.1	0.3

--------- Species=Pluchea odorata River=Little Manatee ---------

Site		River Mile	Median Salinity	P95 Salinity
87		8.70	0.7	11.0

--------- Species=Pluchea odorata River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity
70	*	3.65	2.4	3.2

--------- Species=Pluchea odorata River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
70	*	3.35	0.1	0.4

-------- Species=Polygonum hydropiperoides River=Peace ---------

Site		River Mile	Median Salinity	P95 Salinity
37		14.05	0.2	8.6
42		14.75	0.1	6.9
45		15.15	0.1	5.8
53		16.85	0.1	2.4
58		18.05	0.1	0.9

60	18.50	0.1	0.5
502	16.10	0.1	3.3

-------- Species=Polygonum hydropiperoides River=Myakka --------

Site		River Mile	Median Salinity	P95 Salinity
57	*	14.61	0.4	13.9
64		16.37	0.1	10.7
65	*	16.63	0.1	10.3
66	*	16.80	0.1	10.0
67	*	17.11	0.1	9.4
71		18.17	0.1	7.5
74		18.92	0.1	6.2
75	*	19.16	0.1	5.8
82		21.00	0.1	2.5
83	*	21.31	0.1	1.9
84		22.00	0.1	0.7
85		22.25	0.1	0.3
87		23.15	0.1	0.0
88		23.61	0.1	0.0
89		24.30	0.1	0.0
90		.	.	0.0

------- Species=Polygonum hydropiperoides River=Crystal --------

Site		River Mile	Median Salinity	P95 Salinity
66	*	5.68	1.2	2.6

---- Species=Polygonum hydropiperoides River=Withlacoochee -----

Site		River Mile	Median Salinity	P95 Salinity
47	*	2.36	0.2	3.6
62		2.88	0.1	1.1
67	*	3.07	0.1	0.6
70		3.35	0.1	0.4

---------- Species=Pontederia cordata River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
43	*	14.85	0.1	6.6
44		15.00	0.1	6.2
48		15.65	0.1	4.4
53	*	16.85	0.1	2.4
54		17.10	0.1	2.1
57		17.85	0.1	1.1
58	*	18.05	0.1	0.9
59		18.30	0.1	0.6
60		18.50	0.1	0.5

---------- Species=Pontederia cordata River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
69		17.69	0.1	8.4
74		18.92	0.1	6.2
75	*	19.16	0.1	5.8
78		20.00	0.1	4.3
82		21.00	0.1	2.5
83		21.31	0.1	1.9
84	*	22.00	0.1	0.7
85	*	22.25	0.1	0.3
86	*	22.69	0.1	0.0
88		23.61	0.1	0.0
89		24.30	0.1	0.0

------- Species=Pontederia cordata River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
90		9.00	0.5	10.2
93		9.30	0.4	9.4
102	*	10.20	.	0.0
103		10.30	.	0.0

------- Species=Pontederia cordata River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
46	*	2.35	5.9	13.2

---------- Species=Pontederia cordata River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
72		6.50	0.8	1.4
73		6.50	0.8	1.4

-------- Species=Pontederia cordata River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
47	*	2.36	0.2	3.6
70		3.35	0.1	0.4

-------- Species=Quercus geminata River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity

Site		River Mile	Median Salinity	P95 Salinity
80	*	4.28	1.8	2.0

-------- Species=Quercus virginiana River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
48	*	2.39	0.2	3.4

---------- Species=Rhabdadenia biflora River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
5	*	8.95	5.7	19.6
7	*	9.25	5.0	19.0

---------- Species=Rhizophora mangle River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
2		8.45	6.9	20.7
3	*	8.60	6.6	20.4
4		8.80	6.1	19.9
5	*	8.95	5.7	19.6
6		9.10	5.3	19.3
7		9.25	5.0	19.0
8		9.40	4.6	18.6
9		9.55	4.2	18.3
10		9.70	4.0	18.0
11		9.90	3.7	17.6
12	*	10.05	3.5	17.3
13		10.20	3.3	17.0
14		10.35	3.1	16.6
15		10.50	2.9	16.3
17	*	10.80	2.6	15.7
22	*	11.60	1.5	14.1
23		11.80	1.3	13.6
24		11.95	1.1	13.3
25		12.20	0.8	12.8
33	*	13.40	0.3	10.1
42		14.75	0.1	6.9

---------- Species=Rhizophora mangle River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
12		2.90	19.4	26.0
16		4.10	17.1	25.3
18		4.69	16.0	24.9
20		5.12	15.3	24.5
21		5.38	14.8	24.2
23	*	5.95	13.9	23.6

26		6.92	12.2	22.6
28		7.25	11.6	22.3
30		7.75	10.8	21.8
33		8.52	9.5	21.2
34	*	8.80	9.1	21.0
35		9.00	8.8	20.9
37		9.12	8.6	20.8
38	*	9.46	8.1	20.6
39		9.75	7.6	20.4
40		10.00	7.3	20.2
41		10.23	6.9	20.1
43		10.82	5.5	19.4
44	*	11.00	5.1	19.2
45		11.46	3.9	18.6
55	*	13.88	0.5	15.2

-------- Species=Rhizophora mangle River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
27		2.70	17.2	26.6
28		2.80	16.9	26.5
29	*	2.90	16.6	26.3
30	*	3.00	16.3	26.2
31		3.10	16.0	26.1
32		3.20	15.7	26.0
33		3.30	15.4	25.9
34	*	3.40	15.1	25.8
35		3.50	14.9	25.6
36		3.60	14.6	25.5
37		3.70	14.3	25.4
38		3.80	14.0	25.3
39	*	3.86	13.8	25.2
40	*	4.00	13.4	25.1
41	*	4.10	13.1	25.0
42		4.20	12.8	24.8
43		4.32	12.2	24.6
44		4.42	11.7	24.4
45	*	4.52	.	.
46		4.60	10.7	24.1
47		4.70	10.1	23.9
48		4.80	9.5	23.7
49	*	4.96	.	.
50		5.00	8.4	23.3
51		5.10	7.9	23.1
54	*	5.40	.	.
55	*	5.50	6.6	21.6
57	*	5.72	6.1	20.7
60	*	5.97	5.5	19.6
61		6.10	5.2	19.1
65	*	6.50	.	.
71		7.10	2.4	15.4
78	*	7.80	1.5	13.5

---------- Species=Rhynchospora colorata River=Myakka ----------

	River	Median	P95

Site		River Mile	Median Salinity	P95 Salinity
64	*	16.37	0.1	10.7

---------- Species=Rumex verticillatus River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
47		15.50	0.1	4.8
48		15.65	0.1	4.4
58	*	18.05	0.1	0.9

---------- Species=Rumex verticillatus River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
55	*	13.88	0.5	15.2
69		17.69	0.1	8.4
71		18.17	0.1	7.5
75	*	19.16	0.1	5.8
84		22.00	0.1	0.7
87		23.15	0.1	0.0
88		23.61	0.1	0.0
89		24.30	0.1	0.0

------- Species=Rumex verticillatus River=Little Manatee -------

Site		River Mile	Median Salinity	P95 Salinity
85	*	8.50	0.8	11.6
87		8.70	0.7	11.0
94	*	9.40	0.3	9.2

------- Species=Rumex verticillatus River=Chassahowitzka -------

Site		River Mile	Median Salinity	P95 Salinity
57	*	2.95	3.4	7.6
60	*	3.20	2.9	5.2
62	*	3.30	2.7	4.1
68	*	3.55	2.6	3.6
72	*	3.80	2.3	2.9
78	*	4.15	2.0	2.3

------- Species=Rumex verticillatus River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
47	*	2.36	0.2	3.6

--------- Species=Ruppia maritima River=Little Manatee ---------

Site		River Mile	Median Salinity	P95 Salinity
29	*	2.90	16.6	26.3

---------- Species=Ruppia maritima River=Weeki Wachee ----------

Site		River Mile	Median Salinity	P95 Salinity
2	*	0.12	11.2	19.6
5		0.21	11.0	19.5
6		0.24	11.0	19.5
7		0.27	10.9	19.4
8	*	0.30	10.9	19.4
10	*	0.36	10.8	19.4
11	*	0.39	10.7	19.3
14	*	0.49	10.0	19.3
15		0.51	9.9	19.3
17	*	0.58	9.3	19.2
18	*	0.61	9.0	19.2
19	*	0.64	8.8	19.2
21		0.70	8.3	19.2
22		0.73	8.0	19.1
24		0.79	7.5	19.1
25		0.82	7.0	18.7
28	*	0.91	5.1	16.9
29		0.94	4.4	16.3
30		0.97	3.8	15.7
31		1.00	3.1	15.1
32		1.03	2.6	14.5
33	*	1.06	2.3	13.7
35		1.12	1.7	12.1

---------- Species=Ruppia maritima River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
24	*	2.00	8.6	15.3
27	*	2.60	6.6	14.4
28	*	2.35	7.5	14.8
29	*	2.42	7.2	14.6
34		2.80	5.9	14.0
35		2.90	5.6	13.9
37		3.08	5.1	13.5
38	*	3.15	5.0	13.4
41		3.38	4.5	13.0
43		3.53	4.1	12.7
44	*	3.61	4.0	12.6
46		3.82	3.5	12.2
61	*	5.20	1.4	3.3

--------- Species=Ruppia maritima River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
34	*	1.77	1.6	11.5
36	*	1.87	1.1	10.8
37	*	1.92	1.0	10.0
39	*	2.05	0.8	8.0
42	*	2.17	0.5	6.1
67		3.07	0.1	0.6

---------- Species=Sabal palmetto River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
24	*	11.95	1.1	13.3
31	*	13.10	0.4	10.8
42	*	14.75	0.1	6.9

---------- Species=Sabal palmetto River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
23	*	5.95	13.9	23.6

--------- Species=Sabal palmetto River=Little Manatee ----------

Site		River Mile	Median Salinity	P95 Salinity
27	*	2.70	17.2	26.6

---------- Species=Sabal palmetto River=Weeki Wachee ----------

Site		River Mile	Median Salinity	P95 Salinity
37		1.18	1.1	10.5
39	*	1.24	0.6	8.9

--------- Species=Sabal palmetto River=Chassahowitzka ----------

Site		River Mile	Median Salinity	P95 Salinity
78	*	4.15	2.0	2.3
80		4.28	1.8	2.0
81	*	4.35	1.5	1.7

---------- Species=Sabal palmetto River=Crystal ----------

Site	River Mile	Median Salinity	P95 Salinity

22	*	1.80	8.7	15.6

---------- Species=Sabal palmetto River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
51	*	2.50	0.1	2.9
61	*	2.83	0.1	1.3

---------- Species=Sabatia calycina River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
65	*	16.63	0.1	10.3

---------- Species=Sagittaria lancifolia River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
40		14.45	0.1	7.7
43	*	14.85	0.1	6.6
44		15.00	0.1	6.2
48		15.65	0.1	4.4
52		16.60	0.1	2.7
54		17.10	0.1	2.1
57		17.85	0.1	1.1
58		18.05	0.1	0.9
59		18.30	0.1	0.6
60		18.50	0.1	0.5
502		16.10	0.1	3.3

---------- Species=Sagittaria lancifolia River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
67		17.11	0.1	9.4
71		18.17	0.1	7.5
72		18.48	0.1	7.0
74		18.92	0.1	6.2
75	*	19.16	0.1	5.8
83		21.31	0.1	1.9
87	*	23.15	0.1	0.0

------- Species=Sagittaria lancifolia River=Weeki Wachee -------

Site		River Mile	Median Salinity	P95 Salinity
14	*	0.49	10.0	19.3
38	*	1.21	0.8	9.7

41		1.30	0.4	7.7

------ Species=Sagittaria lancifolia River=Chassahowitzka ------

Site		River Mile	Median Salinity	P95 Salinity
50		2.60	4.4	9.3
53		2.75	3.9	8.3
55		2.85	3.7	7.9
56		2.90	3.5	7.8
57		2.95	3.4	7.6
59		3.05	3.2	6.8
61		3.15	3.0	5.7
63		3.25	2.8	4.6
65		3.40	2.6	3.4
67	*	3.50	.	.
73		3.82	2.3	2.9

--------- Species=Sagittaria lancifolia River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
62		5.29	1.4	3.2
69		6.20	0.9	1.9
70		6.30	0.9	1.7
71		6.40	0.8	1.6
73	*	6.50	0.8	1.4

------ Species=Sagittaria lancifolia River=Withlacoochee -------

Site		River Mile	Median Salinity	P95 Salinity
39	*	2.05	0.8	8.0
46		2.33	0.2	3.7
47	*	2.36	0.2	3.6
57		2.72	0.1	1.9
60		2.78	0.1	1.6
70	*	3.35	0.1	0.4

---------- Species=Sagittaria subulata River=Peace ------------

Site		River Mile	Median Salinity	P95 Salinity
44		15.00	0.1	6.2

---------- Species=Sagittaria subulata River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
49	*	12.38	2.3	17.4
57	*	14.61	0.4	13.9

64		16.37	0.1	10.7
65		16.63	0.1	10.3
68		17.42	0.1	8.9
69		17.69	0.1	8.4
71		18.17	0.1	7.5
72		18.48	0.1	7.0
78	*	20.00	0.1	4.3

-------- Species=Sagittaria subulata River=Weeki Wachee --------

Site		River Mile	Median Salinity	P95 Salinity
20	*	0.67	8.5	19.2
23		0.76	7.8	19.1
26		0.85	6.4	18.1
30		0.97	3.8	15.7
33	*	1.06	2.3	13.7
35		1.12	1.7	12.1

------- Species=Sagittaria subulata River=Chassahowitzka -------

Site		River Mile	Median Salinity	P95 Salinity
1		0.00	11.9	18.8
2		0.05	11.8	18.7
3		0.10	11.8	18.5
5		0.20	11.7	18.3
7	*	0.30	11.6	18.0
33		1.70	9.6	17.4
68		3.55	2.6	3.6
70	*	3.65	2.4	3.2
72	*	3.80	2.3	2.9

---------- Species=Sagittaria subulata River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
26		2.17	8.1	15.1
29		2.42	7.2	14.6
33		2.74	6.1	14.1
34		2.80	5.9	14.0
35		2.90	5.6	13.9
37		3.08	5.1	13.5
38		3.15	5.0	13.4
40		3.30	4.6	13.1
41		3.38	4.5	13.0
43	*	3.53	4.1	12.7
45		3.71	3.7	12.4
46		3.82	3.5	12.2
48		4.00	3.2	11.3
49		4.08	3.0	10.8
50		4.13	3.0	10.5
51		4.30	2.7	9.3
52		4.35	2.6	9.0
53		4.41	2.6	8.6

Site		River Mile	Median Salinity	P95 Salinity
58	*	4.85	1.9	5.6
61		5.20	1.4	3.3
62		5.29	1.4	3.2
65	*	5.55	1.2	2.8
66		5.68	1.2	2.6
73		6.50	0.8	1.4

------- Species=Sagittaria subulata River=Withlacoochee --------

Site		River Mile	Median Salinity	P95 Salinity
6	*	0.29	11.4	19.8
31	*	1.64	2.2	12.1
32	*	1.68	2.0	11.9
34	*	1.77	1.6	11.5
36	*	1.87	1.1	10.8
37	*	1.92	1.0	10.0
38	*	1.98	0.9	9.1
41	*	2.12	0.6	6.9
42	*	2.17	0.5	6.1
45	*	2.32	0.2	3.7
46	*	2.33	0.2	3.7
47		2.36	0.2	3.6
50	*	2.45	0.2	3.1
51	*	2.50	0.1	2.9
56		2.67	0.1	2.1
57		2.72	0.1	1.9
59		2.73	0.1	1.8
60		2.78	0.1	1.6
70		3.35	0.1	0.4

---------- Species=Salix caroliniana River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
60	*	18.50	0.1	0.5

---------- Species=Salix caroliniana River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
87	*	23.15	0.1	0.0
90	*	.	.	0.0

-------- Species=Salix caroliniana River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
32	*	1.68	2.0	11.9
34	*	1.77	1.6	11.5
45	*	2.32	0.2	3.7

---------- Species=Sambucus canadensis River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
40	*	14.45	0.1	7.7
41		14.60	0.1	7.4
43		14.85	0.1	6.6

---------- Species=Samolus valerandi River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
38	*	14.20	0.2	8.3
40		14.45	0.1	7.7
42		14.75	0.1	6.9
43	*	14.85	0.1	6.6
45		15.15	0.1	5.8
47		15.50	0.1	4.8
48		15.65	0.1	4.4
60	*	18.50	0.1	0.5

---------- Species=Samolus valerandi River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
45		11.46	3.9	18.6
53		13.53	0.9	15.7
57		14.61	0.4	13.9
58		14.82	0.3	13.5
68	*	17.42	0.1	8.9
85	*	22.25	0.1	0.3

-------- Species=Samolus valerandi River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
68	*	3.55	2.6	3.6
70	*	3.65	2.4	3.2
75	*	3.92	.	.
76	*	4.00	2.1	2.6
78	*	4.15	2.0	2.3

-------- Species=Saururus cernuus River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity
57	*	2.95	3.4	7.6
59		3.05	3.2	6.8
65		3.40	2.6	3.4

--------- Species=Saururus cernuus River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
48		2.39	0.2	3.4
49		2.43	0.2	3.2
55		2.64	0.1	2.3
58	*	2.70	0.1	2.0
59		2.73	0.1	1.8
62		2.88	0.1	1.1
69		3.20	0.1	0.5

--------- Species=Schinus terebinthifolius River=Peace ---------

Site		River Mile	Median Salinity	P95 Salinity
5	*	8.95	5.7	19.6
19	*	11.15	2.1	15.0

-------- Species=Schinus terebinthifolius River=Myakka ---------

Site		River Mile	Median Salinity	P95 Salinity
13	*	3.20	18.9	25.8
17	*	4.38	16.6	25.1
25	*	6.50	12.9	23.1

---- Species=Schinus terebinthifolius River=Little Manatee -----

Site		River Mile	Median Salinity	P95 Salinity
33	*	3.30	15.4	25.9
64	*	6.40	4.4	17.9

------- Species=Scirpus americanus River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
31		1.60	9.7	17.4
32		1.65	9.6	17.4
38		1.95	8.4	16.5
40		2.05	7.7	15.9

---------- Species=Scirpus californicus River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
12		10.05	3.5	17.3
14		10.35	3.1	16.6

18	*	10.95	2.4	15.4
20		11.35	1.9	14.6
21		11.48	1.7	14.3
25		12.20	0.8	12.8
27		12.50	0.5	12.2
28		12.70	0.4	11.7
32		13.25	0.3	10.4
34	*	13.60	0.3	9.6
50		15.95	0.1	3.5
53		16.85	0.1	2.4
55	*	17.40	0.1	1.7
57		17.85	0.1	1.1
505		16.25	0.1	3.1

---------- Species=Scirpus californicus River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
32		8.25	9.9	21.3
38	*	9.46	8.1	20.6
42		10.57	6.1	19.7
47		11.92	2.8	18.1
49		12.38	2.3	17.4
51		12.81	1.8	16.8
52		13.20	1.3	16.2
53	*	13.53	0.9	15.7
54		13.58	0.9	15.6
55		13.88	0.5	15.2
56		14.23	0.4	14.6
58	*	14.82	0.3	13.5
60		15.37	0.2	12.5
61		15.68	0.2	12.0
62		15.95	0.1	11.5
63		16.07	0.1	11.3
67		17.11	0.1	9.4
73		18.60	0.1	6.8
75	*	19.16	0.1	5.8

------- Species=Scirpus californicus River=Weeki Wachee --------

Site	River Mile	Median Salinity	P95 Salinity
35	1.12	1.7	12.1

-------- Species=Scirpus robustus River=Chassahowitzka ---------

Site	River Mile	Median Salinity	P95 Salinity
50	2.60	4.4	9.3
73	3.82	2.3	2.9

--------- Species=Scirpus tabernaemontani River=Myakka ---------

	River	Median	P95

Site		Mile	Salinity	Salinity
68		17.42	0.1	8.9
69		17.69	0.1	8.4
70		17.87	0.1	8.1
71		18.17	0.1	7.5
74		18.92	0.1	6.2
78		20.00	0.1	4.3
82		21.00	0.1	2.5
84	*	22.00	0.1	0.7
86		22.69	0.1	0.0
87		23.15	0.1	0.0
88		23.61	0.1	0.0
89		24.30	0.1	0.0
90		.	.	0.0

----- Species=Scirpus tabernaemontani River=Little Manatee -----

Site		River Mile	Median Salinity	P95 Salinity
88		8.80	0.6	10.8
90		9.00	0.5	10.2

---------- Species=Senecio glabellus River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
45	*	15.15	0.1	5.8
53	*	16.85	0.1	2.4
54		17.10	0.1	2.1
59		18.30	0.1	0.6
60		18.50	0.1	0.5
502		16.10	0.1	3.3

---------- Species=Senecio glabellus River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
69		17.69	0.1	8.4
70		17.87	0.1	8.1
73	*	18.60	0.1	6.8
76	*	19.54	0.1	5.1

-------- Species=Senecio glabellus River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
57	*	2.95	3.4	7.6
59	*	3.05	3.2	6.8
63	*	3.25	2.8	4.6
65	*	3.40	2.6	3.4
67	*	3.50	.	.

68	*	3.55	2.6	3.6
70	*	3.65	2.4	3.2

--------- Species=Sesuvium portulacastrum River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
17		10.80	2.6	15.7

--------- Species=Sesuvium portulacastrum River=Myakka ---------

Site		River Mile	Median Salinity	P95 Salinity
20	*	5.12	15.3	24.5
21	*	5.38	14.8	24.2

--------- Species=Smilax bona-nox River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
54		2.62	0.1	2.3

-------- Species=Smilax laurifolia River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
61	*	2.83	0.1	1.3

---------- Species=Smilax walteri River=Withlacoochee ----------

Site		River Mile	Median Salinity	P95 Salinity
51		2.50	0.1	2.9
52	*	2.55	0.1	2.7

---------- Species=Solidago sempervirens River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
31	*	13.10	0.4	10.8

------------ Species=Solidago stricta River=Peace ------------

Site		River Mile	Median Salinity	P95 Salinity
42	*	14.75	0.1	6.9

---------- Species=Solidago stricta River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
12	*	2.90	19.4	26.0

-------- Species=Solidago stricta River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity
19	*	0.90	10.6	17.3
23	*	1.10	10.2	17.4
61	*	3.15	3.0	5.7
64	*	3.35	2.6	3.5
78	*	4.15	2.0	2.3

--------- Species=Solidago stricta River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
11	*	0.55	9.2	17.6
33	*	1.74	1.7	11.6
40	*	2.07	0.7	7.7
43	*	2.23	0.4	5.1
44	*	2.27	0.3	4.5
45	*	2.32	0.2	3.7
47	*	2.36	0.2	3.6
48		2.39	0.2	3.4
50	*	2.45	0.2	3.1
53		2.58	0.1	2.5

---------- Species=Spartina alterniflora River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
11		2.70	19.8	26.1
13		3.20	18.9	25.8
14		3.61	18.1	25.6
17		4.38	16.6	25.1
18	*	4.69	16.0	24.9
19		4.94	15.6	24.7
22	*	5.75	14.2	23.8
23	*	5.95	13.9	23.6

------- Species=Spartina alterniflora River=Weeki Wachee -------

Site		River Mile	Median Salinity	P95 Salinity
1		0.10	11.2	19.6
2	*	0.12	11.2	19.6
3		0.15	11.1	19.5

5		0.21	11.0	19.5
7		0.27	10.9	19.4
8		0.30	10.9	19.4
9		0.33	10.8	19.4
10	*	0.36	10.8	19.4
11	*	0.39	10.7	19.3
12		0.44	10.5	19.3
13		0.47	10.2	19.3
15		0.51	9.9	19.3
17		0.58	9.3	19.2
19		0.64	8.8	19.2
20		0.67	8.5	19.2
21		0.70	8.3	19.2
23		0.76	7.8	19.1
24		0.79	7.5	19.1
25		0.82	7.0	18.7
27		0.88	5.7	17.5
28		0.91	5.1	16.9

------ Species=Spartina alterniflora River=Chassahowitzka ------

Site	River Mile	Median Salinity	P95 Salinity
2	0.05	11.8	18.7
4	0.15	11.7	18.4
6	0.25	11.6	18.1
33	1.70	9.6	17.4

--------- Species=Spartina alterniflora River=Crystal ----------

Site	River Mile	Median Salinity	P95 Salinity
1	0.02	16.4	22.1
2	0.06	16.0	21.8
3	0.10	15.6	21.4
4	0.20	14.6	20.6
5	0.30	13.5	19.8
6	0.40	12.5	19.0
7	0.50	11.8	18.5
8	0.60	11.3	18.1
9	0.65	11.1	17.9
10	0.80	10.3	17.3
11	0.90	9.8	16.9
12	1.00	9.3	16.5
13	1.10	9.2	16.4
14	1.18	9.2	16.3
15	1.28	9.1	16.2
16	1.35	9.1	16.1
17	1.43	9.0	16.0
18	1.49	8.9	15.9
19	1.60	8.9	15.8
20	1.19	9.2	16.3
21	1.29	9.1	16.2
22	1.80	8.7	15.6
23	1.90	8.6	15.4
24	2.00	8.6	15.3

25		2.08	8.4	15.2
26		2.17	8.1	15.1
27	*	2.60	6.6	14.4
28		2.35	7.5	14.8
29		2.42	7.2	14.6
30		2.50	6.9	14.5
31		2.54	6.8	14.5
32		2.65	6.4	14.3
33		2.74	6.1	14.1
34		2.80	5.9	14.0
35		2.90	5.6	13.9
36		2.98	5.4	13.7
38		3.15	5.0	13.4
39		3.22	4.8	13.3
40		3.30	4.6	13.1
42		3.45	4.3	12.9
43		3.53	4.1	12.7
44		3.61	4.0	12.6
45		3.71	3.7	12.4
46		3.82	3.5	12.2
48	*	4.00	3.2	11.3
49		4.08	3.0	10.8
50		4.13	3.0	10.5
51		4.30	2.7	9.3
52		4.35	2.6	9.0

------ Species=Spartina alterniflora River=Withlacoochee -------

Site		River Mile	Median Salinity	P95 Salinity
1		0.00	13.6	20.2
2		0.07	13.1	20.2
3		0.12	12.7	20.1
4		0.17	12.3	20.1
5		0.22	12.0	20.1
6		0.29	11.4	19.8
7		0.38	10.4	18.8
8		0.45	9.6	18.1
9		0.46	9.5	18.0
11		0.55	9.2	17.6
12		0.70	8.8	17.0
13		0.80	8.5	16.6
14		0.83	8.4	16.5
15		0.68	8.8	17.1
18		0.98	8.0	16.0
19		1.05	7.4	15.6
23		1.25	5.2	14.2
24		1.28	4.8	14.0
25		1.35	4.0	13.6
28		1.48	3.0	12.8
30		1.58	2.5	12.4
33	*	1.74	1.7	11.6
34		1.77	1.6	11.5
35		1.82	1.3	11.2
36	*	1.87	1.1	10.8
111		0.63	8.9	17.3

---------- Species=Spartina bakeri River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
15	*	10.50	2.9	16.3
22		11.60	1.5	14.1
31	*	13.10	0.4	10.8

---------- Species=Spartina bakeri River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
11	*	2.70	19.8	26.1
38	*	9.46	8.1	20.6
53		13.53	0.9	15.7
55	*	13.88	0.5	15.2
57	*	14.61	0.4	13.9
71	*	18.17	0.1	7.5

---------- Species=Spartina patens River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
21		5.38	14.8	24.2
23	*	5.95	13.9	23.6

--------- Species=Stenotaphrum secundatum River=Peace ----------

Site	River Mile	Median Salinity	P95 Salinity
42	14.75	0.1	6.9

----- Species=Stenotaphrum secundatum River=Withlacoochee ------

Site	River Mile	Median Salinity	P95 Salinity
54	2.62	0.1	2.3

---------- Species=Taxodium distichum River=Peace ----------

Site	River Mile	Median Salinity	P95 Salinity
42	14.75	0.1	6.9

-------- Species=Taxodium distichum River=Withlacoochee --------

Site	River Mile	Median Salinity	P95 Salinity

32	*	1.68	2.0	11.9
33	*	1.74	1.7	11.6
43	*	2.23	0.4	5.1
49	*	2.43	0.2	3.2
51	*	2.50	0.1	2.9
58	*	2.70	0.1	2.0

---------- Species=Teucrium canadense River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
31	*	13.10	0.4	10.8

---------- Species=Teucrium canadense River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
57	*	14.61	0.4	13.9

-------- Species=Tilia caroliniana River=Chassahowitzka --------

Site		River Mile	Median Salinity	P95 Salinity
77	*	4.08	.	.

---------- Species=Triglochin striata River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
17		10.80	2.6	15.7
42	*	14.75	0.1	6.9

---------- Species=Typha domingensis River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
16		10.65	2.7	16.0
26		12.35	0.6	12.5
34		13.60	0.3	9.6
37	*	14.05	0.2	8.6
53	*	16.85	0.1	2.4
55		17.40	0.1	1.7
57		17.85	0.1	1.1
59	*	18.30	0.1	0.6

---------- Species=Typha domingensis River=Myakka ----------

		River	Median	P95

Site		Mile	Salinity	Salinity
45		11.46	3.9	18.6
49	*	12.38	2.3	17.4
52		13.20	1.3	16.2
66		16.80	0.1	10.0
68		17.42	0.1	8.9
71	*	18.17	0.1	7.5
73		18.60	0.1	6.8
75		19.16	0.1	5.8
76		19.54	0.1	5.1
77		19.71	0.1	4.8
78		20.00	0.1	4.3
85		22.25	0.1	0.3

-------- Species=Typha domingensis River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
63		6.70	3.6	16.9
71	*	7.10	2.4	15.4
78		7.80	1.5	13.5
79		7.90	1.4	13.2
80		8.00	1.2	12.9
83		8.30	0.9	12.1
86		8.60	0.7	11.3
89		8.90	0.6	10.5
90	*	9.00	0.5	10.2
91	*	9.10	0.5	10.0
96		9.60	0.2	8.5
98		9.80	0.2	7.6

--------- Species=Typha domingensis River=Weeki Wachee ---------

Site		River Mile	Median Salinity	P95 Salinity
9	*	0.33	10.8	19.4
10		0.36	10.8	19.4
11		0.39	10.7	19.3
14		0.49	10.0	19.3
18		0.61	9.0	19.2
21	*	0.70	8.3	19.2
23		0.76	7.8	19.1
24		0.79	7.5	19.1
25		0.82	7.0	18.7
27		0.88	5.7	17.5
29		0.94	4.4	16.3
31		1.00	3.1	15.1
35		1.12	1.7	12.1

-------- Species=Typha domingensis River=Chassahowitzka --------

Site	River Mile	Median Salinity	P95 Salinity

6	*	0.25	11.6	18.1
7		0.30	11.6	18.0
8		0.35	11.5	17.9
10	*	0.45	11.4	17.6
11	*	0.50	11.4	17.5
14	*	0.65	11.1	17.2
17	*	0.80	10.8	17.3
22		1.05	10.3	17.4
24		1.15	10.1	17.4
26		1.25	10.0	17.4
28		1.35	9.9	17.4
32		1.65	9.6	17.4
33	*	1.70	9.6	17.4
36	*	1.85	9.0	17.0
37		1.90	8.7	16.7
38		1.95	8.4	16.5
39		2.00	8.1	16.2
40		2.05	7.7	15.9
42		2.15	7.1	15.4
43		2.20	6.8	15.1
46		2.35	5.9	13.2
48		2.45	5.3	11.7
50		2.60	4.4	9.3
52	*	2.70	4.0	8.5
53		2.75	3.9	8.3
54		2.80	3.8	8.1
60		3.20	2.9	5.2
69		3.65	2.4	3.2
74		3.87	2.2	2.8

---------- Species=Typha domingensis River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
13		1.10	9.2	16.4
28		2.35	7.5	14.8
29	*	2.42	7.2	14.6
34	*	2.80	5.9	14.0
38		3.15	5.0	13.4
40		3.30	4.6	13.1
42		3.45	4.3	12.9
46		3.82	3.5	12.2
48		4.00	3.2	11.3
50		4.13	3.0	10.5
51		4.30	2.7	9.3
52		4.35	2.6	9.0
53		4.41	2.6	8.6
54	*	4.48	2.4	8.1
58		4.85	1.9	5.6
59		4.94	1.8	5.0
60		5.05	1.6	4.2
61		5.20	1.4	3.3
63		5.40	1.3	3.0
64		5.48	1.3	2.9
66		5.68	1.2	2.6
69		6.20	0.9	1.9
70		6.30	0.9	1.7
72		6.50	0.8	1.4

-------- Species=Typha domingensis River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
9		0.46	9.5	18.0
10		0.50	9.3	17.7
11		0.55	9.2	17.6
12		0.70	8.8	17.0
13		0.80	8.5	16.6
14		0.83	8.4	16.5
15		0.68	8.8	17.1
16		0.85	8.4	16.5
17		0.92	8.2	16.2
18		0.98	8.0	16.0
19		1.05	7.4	15.6
20		1.12	6.6	15.1
21		1.16	6.2	14.8
23		1.25	5.2	14.2
24		1.28	4.8	14.0
26		1.36	3.9	13.5
29		1.55	2.6	12.5
31		1.64	2.2	12.1
33	*	1.74	1.7	11.6
111		0.63	8.9	17.3

-------- Species=Ulmus americanus River=Chassahowitzka ---------

Site		River Mile	Median Salinity	P95 Salinity
72	*	3.80	2.3	2.9

---------- Species=Urochloa mutica River=Myakka ----------

Site		River Mile	Median Salinity	P95 Salinity
69	*	17.69	0.1	8.4
70		17.87	0.1	8.1
73		18.60	0.1	6.8
75		19.16	0.1	5.8
82	*	21.00	0.1	2.5
83		21.31	0.1	1.9
84		22.00	0.1	0.7
85		22.25	0.1	0.3

--------- Species=Urochloa mutica River=Little Manatee ---------

Site		River Mile	Median Salinity	P95 Salinity
79	*	7.90	1.4	13.2
85	*	8.50	0.8	11.6
88	*	8.80	0.6	10.8

91	9.10	0.5	10.0
100	10.00	0.2	6.7
102	10.20	.	0.0
104	10.40	.	0.0

------- Species=Vallisneria americana River=Weeki Wachee -------

Site		River Mile	Median Salinity	P95 Salinity
28	*	0.91	5.1	16.9
42	*	1.33	0.4	7.2
43	*	1.36	0.3	6.7

--------- Species=Vallisneria americana River=Crystal ----------

Site		River Mile	Median Salinity	P95 Salinity
38	*	3.15	5.0	13.4
59	*	4.94	1.8	5.0
60	*	5.05	1.6	4.2
61	*	5.20	1.4	3.3

------ Species=Vallisneria americana River=Withlacoochee -------

Site		River Mile	Median Salinity	P95 Salinity
37	*	1.92	1.0	10.0
46	*	2.33	0.2	3.7

-------- Species=Viburnum obovatum River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
58	*	2.70	0.1	2.0

------- Species=Vitis rotundifolia River=Little Manatee --------

Site		River Mile	Median Salinity	P95 Salinity
99	*	9.90	0.2	7.2

---------- Species=Zizania aquatica River=Peace ----------

Site		River Mile	Median Salinity	P95 Salinity
45		15.15	0.1	5.8
52	*	16.60	0.1	2.7

--------- Species=Zizania aquatica River=Withlacoochee ---------

Site		River Mile	Median Salinity	P95 Salinity
46	*	2.33	0.2	3.7
53	*	2.58	0.1	2.5
61	*	2.83	0.1	1.3

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Relationships of freshwater inflow to chlorophyll *a* in the Little Manatee River in relation to the determination of flow-based blocks for the lower river

Submitted by Sid Flannery

This document discusses relationships of freshwater inflow rates with chlorophyll *a* concentrations in the tidal reach of the Little Manatee River and how it may pertain to the determination of flow-based blocks for minimum flow rules for the lower river. As the District knows, I strongly recommend that flow-based blocks be determined separately for the upper and lower sections of the Little Manatee River because it provides greater resource protection, is practical and easily applied from the water management perspective, and is a better scientific approach that applies the findings of many years of District research in estuarine rivers.

I suggest that a number of important relationships could potentially be examined to determine flow-based blocks for the lower river. The most critical relationships will involve analyzing the output from models the District is utilizing to evaluate changes in salinity zones predicted by the EFDC model for the lower river and favorable fish habit predicted using EFF models.

As discussed in previous correspondence, once revisions to these models are completed, I would like to receive output for a number of predicted values corresponding to baseline flows and a series of flow reduction scenarios. The analyses I plan to do will examine if these predicted values vary with freshwater inflow in a nonlinear manner, and if so, is there an inflexion between the sensitive and less sensitive ranges in the response of these values to freshwater inflow. This, in turn, can be useful for assessing if the flow duration characteristics of the years used for minimum flow analysis may have influenced the results.

It would also be helpful to examine how other variables respond to freshwater inflow. In addition to the analyses of chlorophyll *a* presented in this document, later this month I may submit analyses of other variables that are important to the ecology of the lower river. Although the determination of flow-based blocks might ultimately come down to one or two variables or model predicted values, the relationships of other important variables can provide valuable ecological information that can be used to justify the flow-based blocks that are finally determined.

Before presenting the results of the chlorophyll relationships with freshwater inflow, I want to reiterate a point I made at the most recent meeting of the District's Environmental Advisory Committee. That is, the District should move the adoption of minimum flows for the Little Manatee River to 2023 if that is necessary to complete a though analysis of the data and address comments from the peer review panel and the public.

The lower section of the Little Manatee River is the least impacted and most ecologically valuable tidal river flowing to Tampa Bay. It is also one of the most thoroughly researched rivers in the District and one of the three rivers on which the percent-of-flow approach for estuarine rivers was initially based. As such, it warrants a very careful analysis and presentation of the data. I appreciate that the District has a heavy workload for minimum flows, but suggest that gradually taking the time over the next few months to carefully revise the minimum flows report for the Little Manatee River would be just as time-efficient as trying to hurry the process.

Relationships of chlorophyll *a* to freshwater inflow rates and the ecology of the Lower Little Manatee River

The information below is to supplement material that was presented regarding chlorophyll *a* in the District's draft minimum flows report. Chlorophyll *a* is routinely used as an indicator of phytoplankton biomass is water bodies. Phytoplankton are critical components of food webs in aquatic systems and are important to overall biological productivity, but excessive phytoplankton blooms can lead to problems with hypoxia, or low dissolved oxygen (DO) concentrations. This can particularly be a problem in systems that have been enriched with nutrients, such as the Little Manatee. Fortunately, the Little Manatee does not now have frequent or widespread problems with hypoxia, but caution must be applied in how reductions in freshwater inflow could affect the distribution and concentration of phytoplankton populations (as indicated by chlorophyll *a*) in the lower river.

Two data sets are useful for assessing relationships of freshwater inflow to chlorophyll *a* in the Little Manatee. The first are data collected at four fixed-location stations monitored by the Environmental Protection Commission of Hillsborough County (EPCHC). The other data set is two years of semi-monthly (every two weeks) and monthly chlorophyll *a* data collected as part of an inter-disciplinary study of the lower river conducted by the District that was funded by the Florida Department of Environmental Protection (FDEP).

The EPCHC has measured full water quality including chlorophyll *a* concentrations at four stations in the lower river since 2009, with data for one of these stations (#112) going back to 1974. The station numbers, river kilometer locations, means, geometric means, standard deviations, minima and maxima for chlorophyll *a* at these stations are listed in Table 1. It is clear that chlorophyll a is typically higher and more variable at the two uppermost stations at kilometers 9.6 and 10.8 than for the downstream stations at kilometers 1.7 and 4.8. On page 54 the draft minimum flows report states this is typical in estuaries where the initial zone of mixing of fresh and estuarine waters creates a zone of primary productivity. This is largely true, but as discussed on the following page, the Little Manatee is somewhat unusual in that regard.

Table 1. Statistics for chlorophyll *a* concentrations at four stations in the lower Little Manatee River monitored by the EPCHC for the period January 2009 to August 2021.

Station	Kilometer	N	Mean	Geometric Mean	Standard Deviation	Minimum	Maximum
180	1.7	148	6.1	5.1	3.7	1.2	20.4
112	4.8	149	6.6	5.8	3.4	1.6	18.6
181	9.6	149	15.3	11.2	14.8	1.4	93.8
182	10.8	149	14.2	10.8	10.9	1.7	61.5

This pattern of high phytoplankton biomass in low salinity waters was also described by the aforementioned District study of the Little Manatee River that was conducted primarily in 1988 and 1989. On a semi-monthly basis for year 1 and a monthly basis for year 2, chlorophyll *a* was measured at four moving salinity-based stations in the lower river with samples collected at the locations of the 0.5, 6, 12, and 18 psu surface salinity concentrations. Mean values for those stations are listed in Table 2, along with mean values at similar moving salinity-based stations in separate studies of the tidal reaches of the Alafia and Peace Rivers that used a similar sampling design.

The values in Table 2 (which was previously submitted to the District) confirm the pattern reported in the draft minimum flows report, in that the highest mean chlorophyll *a* values in the Little Manatee were at low salinity stations which occur in the upper reaches of the lower river. Mean values consistently decreased with salinity, with means ranging from 20.5 µg/l at the 0.5 psu station to 4.0 µg/l at the 18 psu station.

In that regard, the Little Manatee shows a different pattern than for the Peace and Alafia Rivers, where the highest mean values were at the 6 and 12 psu salinity zones. A comparison of chlorophyll *a* and phytoplankton count data in these rivers was presented in a report prepared for the District by the University of South Florida (Vargo et al. 2004). References and brief summaries of this and other related studies of the Little Manatee River were provided to the District in previous correspondence.

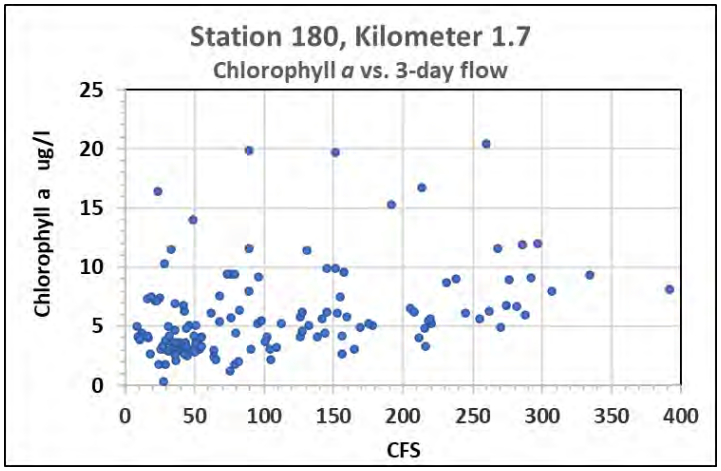
These studies have shown that the spatial distribution of chlorophyll *a* concentrations in tidal rivers is strongly affected by a number of factors, including nutrient loading, light penetration, and residence time. In turn, all of these factors are strongly affected by the rate and volume of freshwater inflow. Residence time simulations have been performed in each of these rivers and the higher chlorophyll *a* concentrations in the lowest salinity zones in the Little Manatee River are likely related to the comparatively longer residence times in the upper reaches of lower river, where the braided zone above Interstate 75 bridge slows the water down considerably compared to the upper reaches of the other tidal rivers.

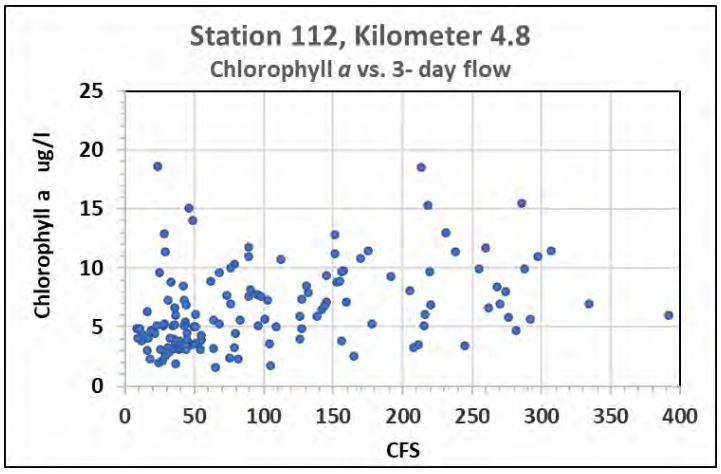
Table 2. Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers, adapted from Vargo et al. (2004).

		Salinity-based stations			
	N	**0.5 psu**	**6 psu**	**12 psu**	**18 psu or 20 psu (Peace only)**
		Chlorophyll a (µg/l)			
Little Manatee (12/87 - 01/90)	36	20.5	13.7	8.5	4.0
Peace - same time period as Little Manatee	24	8.9	22.1	31.5	7.9
Peace - same time period as Alafia	36	6.3	23.4	22.6	15.2
Alafia (01/99 - 12/01)	36	15.3	63.4	95.7	43.7

Because freshwater inflow plays a dominant role in the factors affecting chlorophyll *a* concentrations, what is important for a minimum flows analysis is to examine how chlorophyll concentrations respond to changes in freshwater inflow in different reaches of a tidal river. Given its long period of record including recent years, the data from the four stations in the lower river monitored by the EPCHC are particularly useful. Plots of chlorophyll *a* at the four EPCHC stations versus the average freshwater inflow for the previous 3 days are shown on this page and the next. For graphical clarity the x axis is limited to a flow rate of 400 cfs, although there were 10 sampling days with 3-day flows greater than 400 cfs with a maximum 3-day flow of 756 cfs.

Plots of chlorophyll *a* versus 3-day inflow are shown in Figures 1 and 2 for the two stations closest to the mouth of the river at kilometers 1.7 and 4.8. At both of these locations there is a generally positive relationship of chlorophyll *a* with freshwater inflow, as each had a significant ($p < 0.05$) positive correlation with inflow ($r = 0.34$ at kilometer 1.7 and $r = 0.20$ at kilometer 4.8). These positive relationships are likely due to increased nutrient loading during higher flows, combined with sufficiently long residence times and good light penetration at the stations close to the bay. Also note the maximum concentrations at these stations were not very high, rarely exceeding 15 µg/l, with maximum values of 20.4 and 18.2 µg/l at kilometers 1.7 and 4.8, respectively.



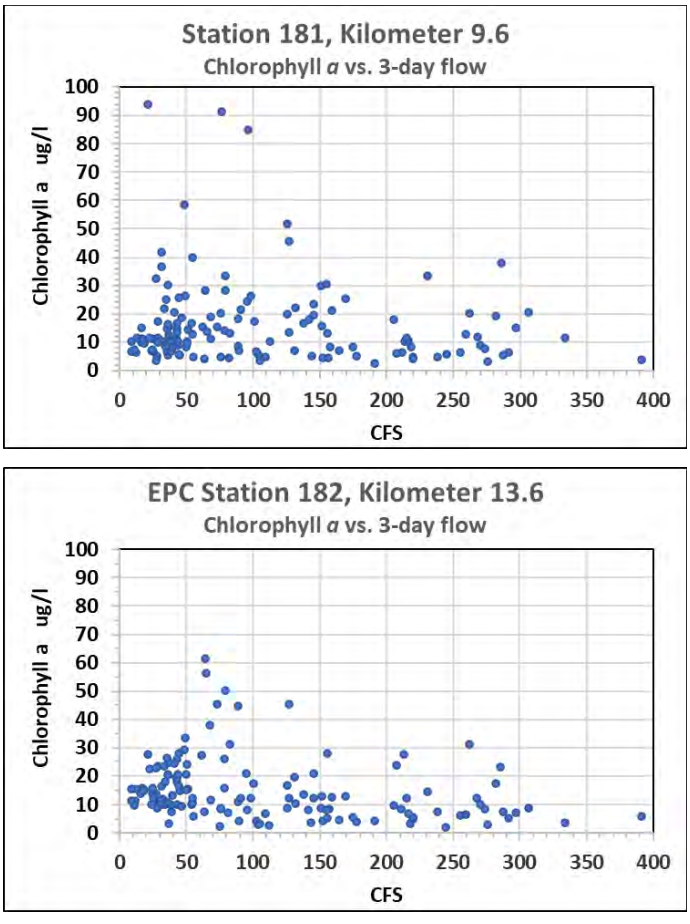


Figures 1 and 2. Chlorophyll *a* concentrations at EPCHC stations at kilometers 1.7 and 4.8 in the Lower Little Manatee River vs. the preceding three-day average flow at the US 301 gage.

A very different pattern is observed at the two EPCHC stations in the upper part of the lower river at kilometers 9.6 and 13.6 First, note the much higher chlorophyll *a* concentrations at these stations. In contrast to Figures 1 and 2, in which the y axes were limited to 25 µg/l, the y axes in these plots extend to 100 µg/l to allow visual comparison between these two stations. Peak chlorophyll concentrations are highest at kilometer 9.6, with three observations between 85 and 94 µg/l, whereas the six highest values were between 45 and 62 µg/l at kilometer 13.6.

What is notable is the different response to freshwater inflow at these stations compared to the lower reach of the tidal river. At these two upper stations, there was a generally negative relationship with flow with a significant ($p < 0.05$) negative correlation at each site ($r = -0.23$ at kilometer 9.6 and $r = -0.37$ at kilometer 13.6) At each station there is a flow range where very high concentrations occur, with values above 40 µg/l occurring between 3-day flows of 21 and 127 cfs at kilometer 9.6 and between 3-day flows of 64 and 127 cfs at kilometer 13.6.

The threshold to switch from 20% withdrawals to 30% withdrawals proposed in the minimum flow report the lower river is 72 cfs, which was based solely on the inundation of the floodplain in the freshwater section of the river. When conditions in the tidal lower river are examined, it shows that 72 cfs lies in the flow range in which very high chlorophyll *a* values occur at these stations, with the ecological considerations of this discussed on page 7.



Figures 3 and 4. Chlorophyll *a* concentrations at EPCHC stations at kilometers 9.6 and 13.6 in the Lower Little Manatee River vs. the preceding three-day average flow at the US 301 gage.

Another informative way to examine the relationships of freshwater inflow to chlorophyll *a* concentrations in tidal rivers is to plot the location of the peak chlorophyll concentration on each sampling day vs. the rate of freshwater inflow. Optimally, it would be best to have chlorophyll measured at many stations in a river on each sampling day, but if that is not the case, some data sets can be used to approximate this relationship. The data from the District study in 1988 and 1989 is useful for this purpose as chlorophyll *a* was measured at four moving salinity-based stations that covered the salinity range between 0.5 and 18 psu in the river on each sampling date. By selecting the location of the highest chlorophyll concentration among these stations on each sampling date, a reasonable approximation can be determined of where the maximum chlorophyll *a* concentration occurred in the river.

The location of peak chlorophyll *a* concentrations in the lower river vs. the preceding 5-day average inflow is shown in Figure 5, with a significant regression fitted to the data. As inflow increases, the location of the chlorophyll maximum moves downstream due largely to changes in nutrient loading, light penetration, and residence time in the different reaches of the tidal river. Below a five-day flow of about 160 cfs, the observed locations of peak chlorophyll *a* concentrations were predominantly upstream of kilometer 10, with more scatter in the data and several of the peak chlorophyll concentrations located considerably farther downstream at flow rates between about 180 and 330 cfs.

The regression fitted to these data used the square root of the inflow, making the relationship nonlinear with the response of peak chlorophyll location to freshwater inflow most sensitive at low flows. Significant nonlinear regressions with a sensitive response at low flows have also been developed for the location of the chlorophyll *a* maximum in the tidal estuarine reaches of the Peace and Alafia Rivers.* Given the importance of these relationships, consideration should be given to including the graphic below for the Little Manatee in the minimum flows report.

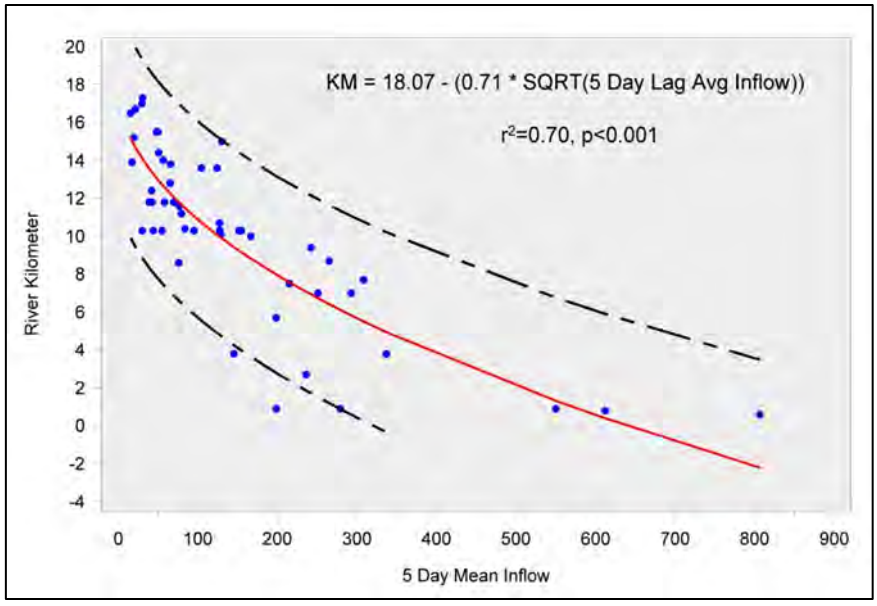


Figure 5. Scatter plot and regression of the location of maximum chlorophyll *a* concentrations measured among four moving salinity-based stations in the Lower Little Manatee River vs. the preceding five-day average inflow for each sampling date.

*** The evaluation of relationships of freshwater inflow with chlorophyll *a* concentrations, movement of the chlorophyll maximum, and residence time in the Lower Alafia minimum flows report is most informative.**

Importance of the chlorophyll response to freshwater inflow to the water quality characteristics and biological productivity of the Lower Little Manatee River and the determination of flow-based blocks for the application of minimum flows

As previously discussed, phytoplankton are a critical component of food webs and biological productivity, contributing to both planktonic food webs (e.g., zooplankton grazing) and the organic enrichment of bottom sediments which can contribute to benthic production. Again, however, excessive phytoplankton blooms can result in an overproduction of autochthonous organic matter and problems with low dissolved oxygen concentrations, particularly in bottom waters.

Even if no water supply withdrawals are taken from the Little Manatee, large phytoplankton blooms will continue to periodically occur in the lower river. It would be helpful to have more spatially extensive data, but the existing data indicate with the occurrence of such blooms will be primarily located in the upper reaches of the lower river. However, at all locations in the lower river, the magnitude of phytoplankton populations (as indicated by chlorophyll *a*) will be affected one way or another by the rate of freshwater inflow and the physicochemical variables that are affected by it.

In that regard, it is useful to think of flow rates that will occur under baseline flows and flows after withdrawals allowed by the proposed minimum flows. The proposed minimum flow rule for the lower river allows a 20% withdrawal rate for flows between 35 and 72 cfs. Therefore, a baseline flow rate of 50 cfs would become be minimum flow of 40 cfs and a baseline flow of 70 cfs would be minimum flow of 56 cfs.

The switch to allow a withdrawal rate of 30 percent withdrawal proposed in the draft minimum flows report is 72 cfs, so a full 30% can be taken when baseline flows exceed a rate of 103 cfs. Under this scenario, a baseline flow of 110 cfs would result in a minimum flow of 77 cfs, while a baseline flow of 150 cfs would result in a minimum flow of 105 cfs. Flow reductions such as these will likely result in an increase in large phytoplankton blooms in the upper reaches of the lower river, as they will act to reduce residence time and flushing in what is a very reactive flow range for chlorophyll *a* concentrations in that part of the river.

Conversely, in the lower reaches of the tidal river where chlorophyll concentrations are typically much lower and positively correlated with flow, flow reductions will often act to reduce low to moderate chlorophyll concentrations. As with other tidal rivers, the cross-sectional area and volume of the Little Manatee increases toward the river mouth, plus this section of the river is generally shallower and less prone to hypoxia. As a result, it is a relatively large and important zone for secondary production (e.g., fish and invertebrates) in the lower river. Reductions in low to moderate chlorophyll concentrations in this part of the river as a result of lower freshwater inflows due to minimum flows could potentially result in a reduction in the overall biological productivity of the lower river.

Given these relationships and possible effects on the ecology of the lower river, the response of chlorophyll *a* to freshwater inflow should be closely examined to determine the flow rate where the response to flow reductions becomes less sensitive in order to allow an increase in the percentage withdrawal rate. In my opinion, it is clear that 72 cfs is too low to serve as a threshold to switch to a higher percentage withdrawal rate, because the response of chlorophyll *a* to freshwater inflow remains in very sensitive flow range for the upper part of the tidal river.

Preliminarily, it appears that a switch to a higher withdrawal percentage in the range of 150 to 200 cfs would be a more appropriate high flow threshold to protect the resources of the lower river that are associated with phytoplankton production. A flow rate of 150 cfs corrected for withdrawals by the Florida Power and Light Corporation corresponds to the 70th percentile flow for a recent twenty-year period from 2001 to 2020, while a flow rate of 200 cfs is the 78th percentile flow for this same period. As described in previous correspondence, a flow rate of 72 cfs corrected for FP&L withdrawals corresponds to the 47th percentile flow for this twenty-year period. It seems clear that both hydrologically and ecologically, 72 cfs does not correspond to an appropriate high flow threshold for the Lower Little Manatee River.

When considering what are appropriate flow-based thresholds, it is important to consider what would be the resulting actual flows in the river after the withdrawals allowed by the minimum flow rule. For example, if 30% withdrawals are allowed above the high flow threshold, a baseline flow of 150 cfs corresponds to an actual flow of 105 cfs in the river while a baseline flow of 200 cfs corresponds to an actual flow of 140 cfs.

Any findings or conclusions coming from an assessment of relationships of chlorophyll *a* with freshwater inflow should be compared to analyses of the response of other important variables to freshwater inflow. As such, I hope that such analyses can proceed once the revisions to the EFDC and EFF models for the lower river are completed. In addition, in the coming weeks I may assess the relationship other variables, such as residence time and salinity at a series of fixed location stations in the lower river to freshwater inflow to provide information that may be relevant to the determination of flow-based blocks for the Lower Little Manatee River.

From:	Sid Flannery
To:	Kym Holzwart; Gabe I. Herrick; Xinjian Chen; Jordan D. Miller; Lei Yang; Kristina Deak; Doug Leeper; Danielle Rogers; Chris Zajac; Randy Smith
Subject:	Relationships of freshwater inflows to chlorophyll a concentrations in the Lower Little Manatee River and application to the determination of flow based blocks
Date:	Wednesday, September 7, 2022 1:19:21 PM
Attachments:	Little Manatee chlorophyll relationships related to flow-based blocks for the lower river.pdf

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[EXTERNAL SENDER] Use caution before opening.

Hello District staff working on minimum flows,

Attached is a document I prepared that examines relationships between freshwater inflows and chlorophyll *a* concentrations in the lower section of the Little Manatee River and discusses how it may pertain to the determination of flow based blocks for minimum flows for the lower river. These findings may also have some general application to other tidal rivers in the District that experience a wide range in freshwater inflow.

As the first page of the document describes, I maintain that flow based blocks for minimum flows for freshwater and estuarine rivers should be determined separately. Also, the District should consider moving the adoption of minimum flows for the Little Manatee River to 2023 to allow the time necessary to revise the draft minimum flows report.

Sid Flannery

From: Ed Sherwood
To: "jim anderson"; abrown@ut.edu; mburke
Cc: Kym Holzwart
Subject: RE: TBEP LMR meeting this morning comment
Date: Thursday, January 20, 2022 12:53:45 PM
Attachments: image001.png

[EXTERNAL SENDER] Use caution before opening.

Hi Jim,

Glad you were able to attend yesterday and good to hear from you. The SWFWMD is the organization conducting and overseeing the Peer Review of the LMR MFL, so I'm forwarding your comments to Kym Holzwart (the DISTRICT lead on the LMR MFL). I believe you can also directly post comments to a 'WebForum' they maintain specific to the LMR MFL here: https://swfwmd.discussion.community/categories .

To address your other points: As we (TBEP and partners) implement habitat restoration projects in the LMR according to recommendations developed in this Master Plan report (https://drive.google.com/file/d/1tKDWAMQqOtFeju2gh7MkA3wT_-0dCN0S/view), I think your ideas could come into play. Grant proposals through the Tampa Bay Environmental Restoration Fund are currently welcomed and accepted through Match 11 (https://tbep.org/tberf-2022), so you might take a look at that opportunity for habitat restoration partnerships with entities along the LMR.

-Ed

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Ph: (727) 893-2765
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esherwood@tbep.org
www.tbep.org

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From: jim anderson <jim@seaandshoreline.com>
Sent: Wednesday, January 19, 2022 10:50 AM
To: abrown@ut.edu; Maya Burke <mburke@tbep.org>; esherwood@tbep.org
Subject: TBEP LMR meeting this morning comment

Aaron, Maya, Ed

Great meeting this morning, I was going to make a comment on the call but decided to e-mail you to see if I could contact the Peer review committee. I have lived on the Little Manatee River 40 years same location and have seen many changes. My house is a calving area for Manatees and live across from Camp Bayou on 24th st. We have been restoring Crystal River sense 2017 by removing the algae with vacuum dredges and replanting with our restoration technology for SAV. We also open up spring vents in Crystal Riverover (700) documented as our divers do there work. I know of some springs in Little Manatee River, this would open up these vents for more Flow. I did not hear any comments of this simple step only collecting data. I know the river very well, as its in my best interest with local knowledge and history that has changed in the last 40 years that maybe I could add some information and detail if needed. We also did a small pillot planting which I attached a grant from EPC we completed on revegetating SAV as a pilot project. The SAV has expanded and shows this is another step down the road to consider when planning is considered. The erosion along the shoreline is a problem with the vessel traffic at high speeds, and weather. With no vegetation along the shoreline the river is getting shallowerer. Threre are tools for this like envirolok technology to stabilizing the shoreline with vegetation like paspalum and native marsh grass. Thank you again for inviting me on this Meeting.

Thank You in Advance
Jim



Jim Anderson
Founder / Partner
jim@seaandshoreline.com
Phone: (813) 918-7373

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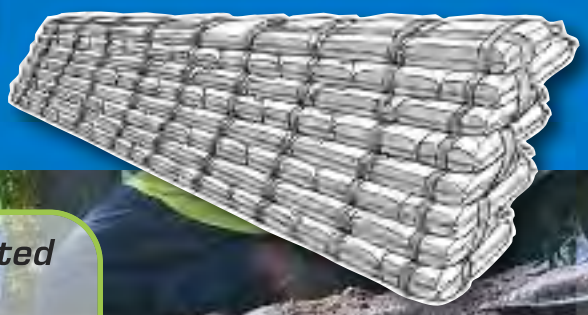


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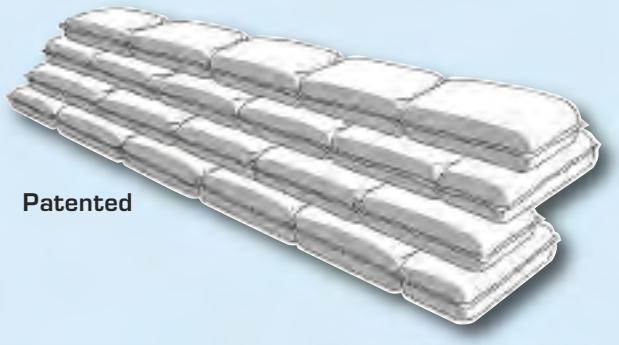
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STORMWATER MANAGEMENT
SHORELINE RESTORATION
VEGETATED SLOPE STABILIZATION
RESIDENTIAL LANDSCAPES



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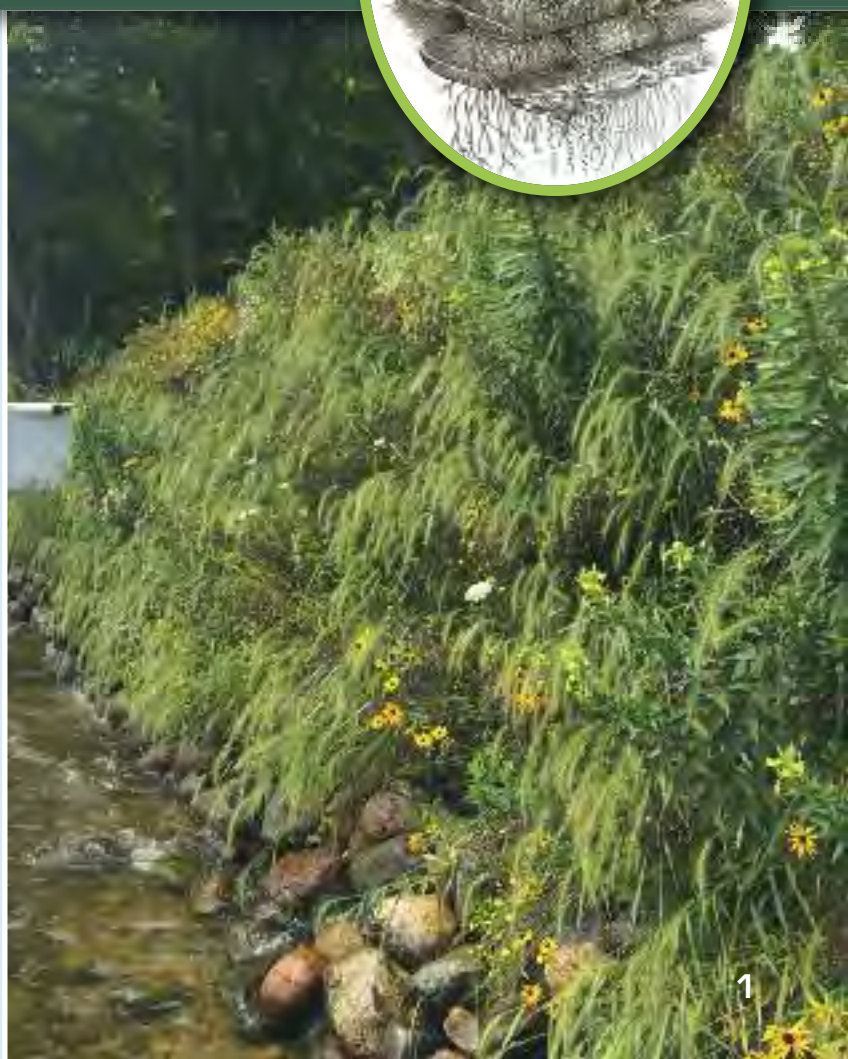
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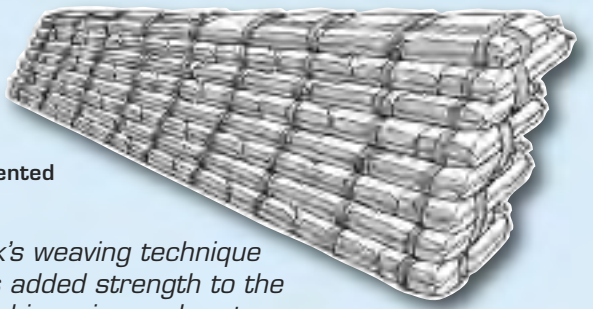


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Envirolok's patented system provides support over soft, saturated streambeds and shoreline environments while allowing construction to follow existing contours.

Envirolok supplies a permanent vegetated solution to persistent shoreline erosion which contributes to the bioaccumulation of sediment in our lakes and rivers.





Patented

Envirolok's weaving technique provides added strength to the modular bioengineered system







+ Planted with native vegetation, Envirolok provides structural root support that allows establishment of habitat along sensitive environmental corridors
+ Envirolok effortlessly conforms to natural contours

STORMWATER MANAGEMENT



Stormwater management historically focuses on the collection of stormwater in pipes or concrete channels to transport it off site as quickly as possible. This contributes to downstream flooding, streambank erosion, increased turbidity, habitat destruction, sewer overflows, infrastructure damage and contaminated lakes, rivers and coastal waters.

Low Impact Development (LID) *and Green Infrastructure utilize methods and technologies to better manage stormwater through the use of vegetation and soil, preferring to keep rainwater where it falls. Envirolok incorporates ecological principles in the construction environment.*







+ Emergency repairs are a quick fix with Envirolok's onsite adaptability

+ Fits with any culvert without use of forms or specialized tools

+ Encapsulate soil in washout areas with Envirolok



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Vegetated Environmental Solutions



• RETAINING WALLS

Envirolok enhances the natural surroundings and turns what was once unstable soil into a beautiful focal point. Gravity walls or Mechanically Stabilized Earth (MSE) walls are great applications for this environmentally sound system.

• HYDROSEEDING

Once thought only for use on barren slopes hydroseeding is now used on a variety of applications including Envirolok. Achieving vegetation through hydroseeding is a quick way to grow vegetative cover on the system.

• SWALE PROTECTION

Promote infiltration and slow run-off with an Envirolok swale lining. Envirolok combines the protection of a turf reinforcement mat and the encapsulation of high quality soils to grow more robust vegetation in hydraulic conveyance systems.

"Discontent is the first necessity for progress" - Thomas Edison



• STORMWATER

Decrease stormwater volume through infiltration and increase its quality with native vegetation planted in the Envirolok system. Help keep our lakes, streams and rivers clean for generations to come.

• SLOPE RETENTION

Restore and strengthen slopes damaged in storm events with Envirolok. Absorb rain drop impact and surface run-off velocity to prevent further erosion. For difficult access sites try Envirolok with earth anchors.

• BRUSH LAYERING

Increase vegetative cover and improve resident habitat communities with commonly found woody species such as dogwood and willow. Consult locally for preferred planting times and species selections.

Envirolok is dedicated to sustainability through the preservation of shorelines, streambanks, stormwater passages, and landscapes.

Don't settle for the status quo.

Eroding shorelines are often stabilized with hard armor, such as rip rap, concrete bulkheads, treated timber, and seawalls. Ironically, these structures increase the erosion rate by reflecting wave energy to adjacent properties. Hardened structures provide little habitat and keep the shoreline from carrying out its natural processes.

Envirolok's living shorelines utilize native seed and plants, soil encapsulation and engineering methods when necessary to naturally enhance the shoreline. Envirolok protects the riparian environment, filters runoff and creates habitat.

SHORELINE RESTORATION



+ Envirolok restores your shoreline to its original condition, while stabilizing soil, promoting drainage and providing sustainable erosion control

+ Diverse native vegetation grown into the Envirolok system creates a buffer zone, mitigating effects of lakeshore development and increasing water quality in our lakes, rivers and wetlands

+ Envirolok protects your property while preserving an attractive natural appearance

+ Envirolok's living shorelines use natural shoreline ecosystems to absorb wave energy reducing erosion on adjacent properties



VEGETATED
SLOPE STABILIZATION



+ Use Envirolok for Mechanically Reinforced Slopes (MSE) or Reinforced Soil Slopes (RSS)
+ Native plant roots reinforce soil by growing across failure planes and limiting surface erosion
+ Envirolok allows for soil stabilization in hard to access areas



+ Envirolok minimizes soil disturbance in sensitive areas through various methods of anchoring
+ Create landscape designs with ease

RESIDENTIAL
LANDSCAPE



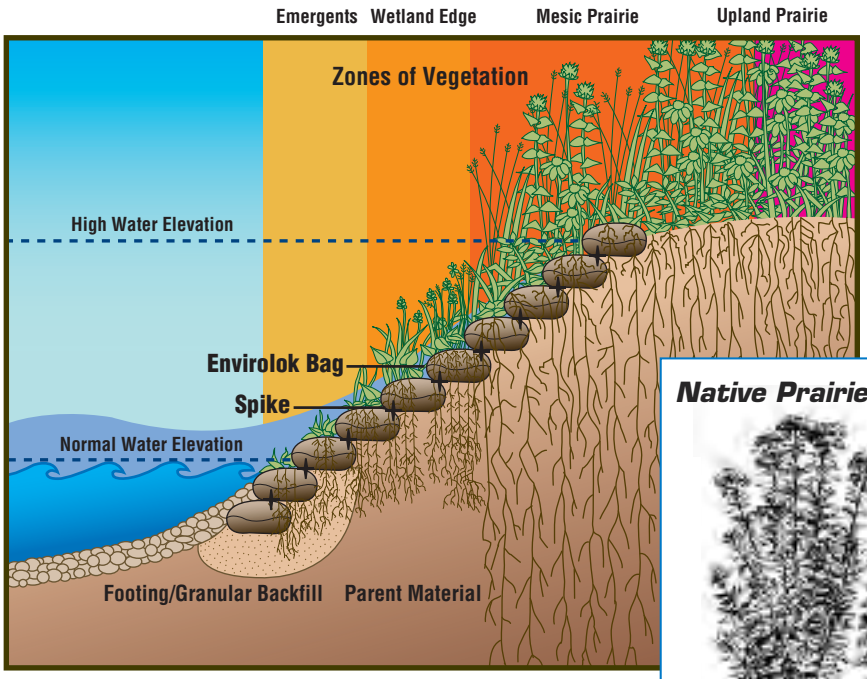


VEGETATION

Once established, native plants do not need fertilizers, herbicides, pesticides or watering, thus benefiting the environment and reducing maintenance costs. A diverse mix of sedges, grasses, wildflowers and live stakes creates sustainable vegetation when combined with the Envirolok system. Native species in shoreline transitional zones allow for ecological restoration of habitat for game fish, amphibious life, birds, butterflies, and other animals.



PermaMatrix, a biotic soil amendment, is recommended when seeding. PermaMatrix is a blend of pure organics and recycled materials for use in all native plant communities to improve plant health without the fear of contaminating waterways.

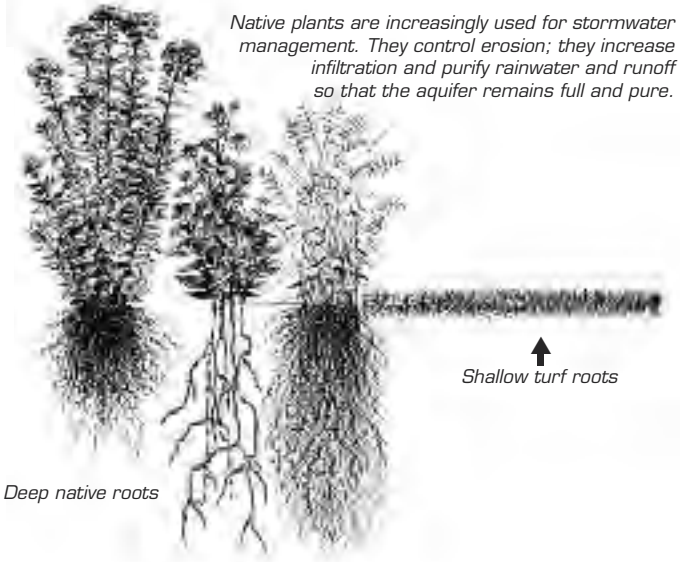


Shoreline With Wave Action

+ WHY NATIVES?

Native Prairie Root System vs. Turf Root System

Native plants are increasingly used for stormwater management. They control erosion; they increase infiltration and purify rainwater and runoff so that the aquifer remains full and pure.

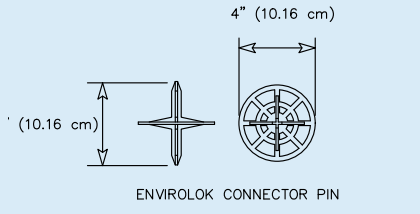


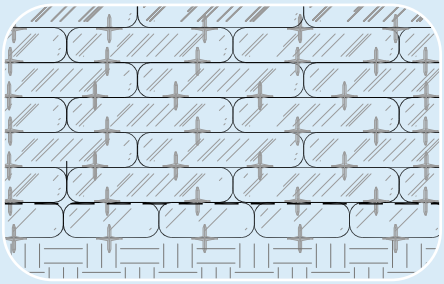
Preferred Planting Program:
Envirolok recommends planting three plants per unit. Plants may be herbaceous or woody species. Speak with a professional consultant with intimate knowledge of the local environment regarding appropriate species for your project.

Envirolok encapsulation of engineered soil is designed to support vegetation

Hydroseeding or hand seeding over the top of the plantings is recommended. Use a complimentary seed mixture to match plantings, sun exposure and local habitat. A cover crop, erosion control blanket and hydration may also be necessary for successful vegetation establishment.



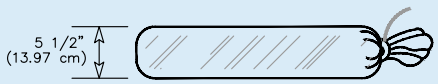




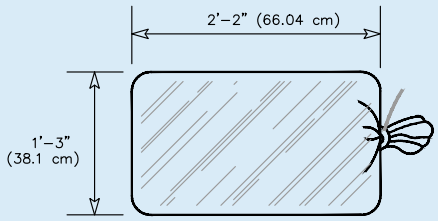
Standard Construction

You'll find commonality between Envirolok's construction methods and traditional retaining wall construction. Envirolok is built in a common or American bond pattern, staggering the units above and below. A unique, open-face connection pin is used to bond the courses together horizontally. This provides shear strength and allows deep root development to occur without disruption.

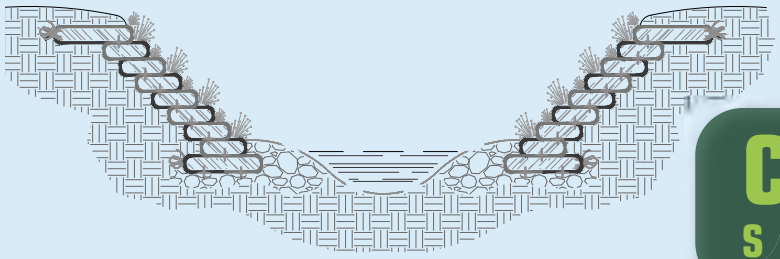
Envirolok slopes can be built from a 0:1 to 1/5:1 (V:H) slope, meaning Envirolok can accommodate almost any unstable slope. A single Envirolok unit contains 2 connection pins and 1 Envirolok bag. When filled with 1.25 cu. ft. of material a single Envirolok unit will provide 1 sq. ft. of face.



ENVIROLOK SPECIFICATION:
Calculated Unit Fill: 1.25 cu ft (.0354 m³) / unit
Face Area: 1 sq ft (.093 m²)
Mattress Face Area: 2.7 sq ft (.25 m²) / unit



NOTE:
* Quantities required vary based on unit filling
* One Envirolok Unit consists of;
One Envirolok Bag
Two Connector Pins
One Zip Tie Bag Closure

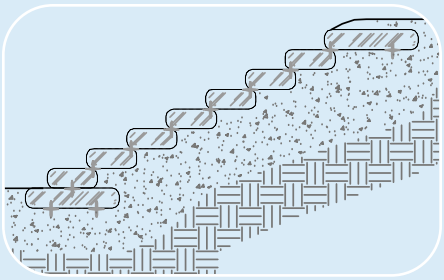


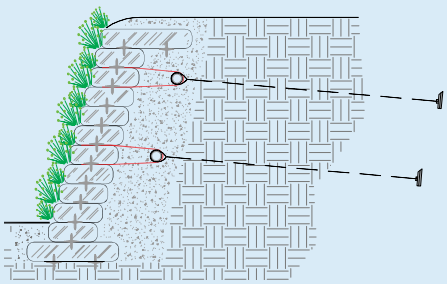
CONSTRUCTION STANDARDS

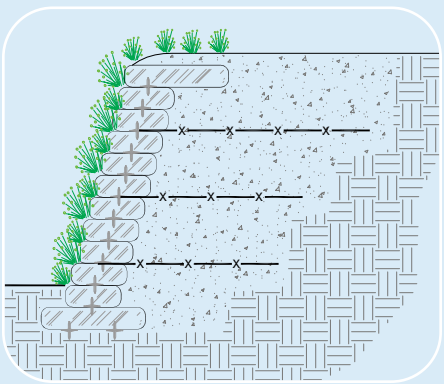
Advanced Construction

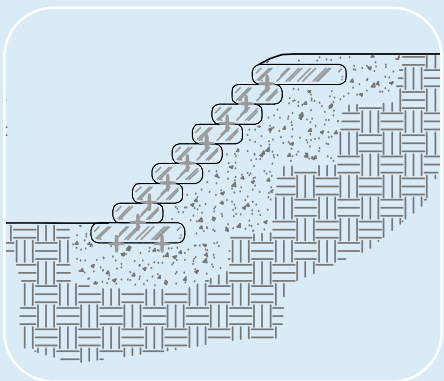
For use on unstable slopes Envirolok is constructed using a variety of techniques. Common methods include geogrid stabilization, earth anchoring and a weaving method that is exclusive to the Envirolok vegetated system. Seek assistance from a licensed professional engineer for walls exceeding 4' in height.

Envirolok's patented modular system and encapsulated structural soils allows for near vertical construction that can be contoured to the existing non-load bearing soils, unlike hard armor.









INSTALLATION

1. Filling and Closing Envirolok Bags

Fill the Envirolok bags with an engineered soil using an Envirolok Bag Filler. The soil properties should consist of 60% sand, 20% high grade compost and 20% top soil. The engineered soil may change to meet the specific project needs. Excavated material may be used to backfill during construction. Clay and silt are not appropriate fill material. All bags should be filled consistently and will be closed with a UV resistant zip tie. Bags may also be sewn or closed using hog-rings.





2. Preparation

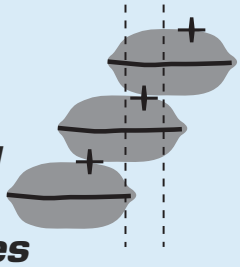
Dig a trench no less than 3" deep, 16" wide for the length of the structure. Embedment depth will be specific to the project. Compact bottom of foundation using hand tamper or vibratory plate compactor. This trench serves as toe stabilization and will protect the structure from undermining. Larger structures will require engineering.





3. Placing Bags

The foundation course will begin with placing spikes in the excavated trench at the desired location of the first row. Place filled bags next to each other, seam side in, horizontally, the full length of the structure. The "snorkel" of the bag will land on top of the previously placed bag.



4. Placing Additional Bag Courses

After laying one entire course of bags, compact the soil ensuring a solid and uniform structure.

Insert two spikes in the top of each bag evenly spaced. The spike placement will vary with the slope of the structure and should be placed in the center of the bag contact area between courses.



These installation steps are for general guidance only. It is the responsibility of the project owner to ensure the application of Envirolok into the overall project through a design specification. The specification should include factors which affect the overall integrity of the retaining wall such as location, interaction with other project components, and engineering aspects including but not limited to global slope stability, site soil bearing capacity, presence of underground or surface water, etc.

5. Backfilling and Compacting the Structure

Backfill and compacting after each course ensures strength and stability of the system. Backfill should be compacted to the specifications of the wall design. Backfill must support vegetation and be free draining.



6. Geogrid Placement

Structures that require geogrid reinforcement will be specified by an engineer. After compaction, geogrid placement will begin at the front of the bag course and will go towards the existing material. Place spikes on top of the geogrid and continue placing bag course. Geogrid should be pulled tight prior to backfill. Continue with course compaction.

*Some structures may require additional strength using Envirolok's geo-grid weaving technique; for installation instructions please refer to engineer's drawings or contact an Envirolok distributor near you.



7. Top Row

Install the top row of the structure the same way the other courses have been placed. Tuck the "snorkel" under to give a finished look to the last course. If specified, the top row may need to be anchored into the existing landscape.



8. Vegetation Establishment

Once the wall is completed, vegetation is the final step. Native vegetation is recommended because of its adept root structures that will bind the wall together forming a monolithic structure that will renew itself year after year. Using vegetation suitable for your local climate is necessary for a successful project. You may build the wall and place live plants in the courses as you build the structure. Live plant material should always be placed in between the courses. Cutting the bags open and planting into this cavity is NOT recommended. It is recommended that a combination of live plants and seed are used to ensure proper vegetation.



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Case Studies
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Vegetation Selection
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www.envirolok.com **E-mail** ecosolutions@envirolok.com

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From: jim anderson
To: Kym Holzwart
Subject: Fwd: TBEP LMR meeting this morning comment
Date: Monday, January 24, 2022 12:32:25 PM
Attachments: Little Manatee River SAV Year 3 Monitoring (1).pdf
EnvirolokBrochure.pdf

[EXTERNAL SENDER] Use caution before opening.

Hi Kym

Chris Anastasiou is a big supporter of our technology with the springs Team restoration as well. Most have moved on Ed Call, Sean King all were with swfwmd when we started restoring Crystal River with our SAV technology and dredging combination. Do you get out in the field where I could show you a site on LMR where there is a planting that would be of interest if restoration is a goal for LMR. Its actually at Camp Bayou. Hillsborough County Park. I would like to be on the planning part for restoration of LMR. I live on LMR and know it very well. One of my daughters as well lives by Camp Bayou on the LMR river too. local knowledge has lots of great information that if planning and water quality is the goal, is always good information. We have supporting science at Sea and Shoreline that someone on your Team might want to review or take a look at? I hate failure and with good proper planning this can be avoided doing restoration twice. Please just keep me in mind is all.

That was a great TEBEP zoom meeting and all the super scientists were on it and made good comments. Thank you for the invite as always and thank you for reaching out to me.

Thank You in Advance
Have A Great Week.
Jim

Jim Anderson
Founder / Partner
jim@seaandshoreline.com
Phone: (813) 918-7373

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---------- Forwarded message ---------
From: **jim anderson** <jim@seaandshoreline.com>
Date: Wed, Jan 19, 2022 at 10:50 AM
Subject: TBEP LMR meeting this morning comment
To: <abrown@ut.edu>, Maya Burke <mburke@tbep.org>, <esherwood@tbep.org>

Aaron, Maya, Ed

Great meeting this morning, I was going to make a comment on the call but decided to e-mail you to see if I could contact the Peer review committee. I have lived on the Little Manatee River 40 years same location and have seen many changes. My house is a calving area for Manatees and live across from Camp Bayou on 24th st. We have been restoring Crystal River sense 2017 by removing the algae with vacuum dredges and replanting with our restoration technology for SAV. We also open up spring vents in Crystal Riverover (700) documented as our divers do there work. I know of some springs in Little Manatee River, this would open up these vents for more Flow. I did not hear any comments of this simple step only collecting data. I know the river very well, as its in my best interest with local knowledge and history that has changed in the last 40 years that maybe I could add some information and detail if needed. We also did a small pillot planting which I attached a grant from EPC we completed on revegetating SAV as a pilot project. The SAV has expanded and shows this is another step down the road to consider when planning is considered. The erosion along the shoreline is a problem with the vessel traffic at high speeds, and weather. With no vegetation along the shoreline the river is getting shallowerer. Threre are tools for this like envirolok technology to stabilizing the shoreline with vegetation like paspalum and native marsh grass. Thank you again for inviting me on this Meeting.

Thank You in Advance
Jim



Jim Anderson
Founder / Partner
jim@seaandshoreline.com
Phone: (813) 918-7373

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Little Manatee River SAV Restoration Project

Three Year Post Installation Monitoring Report

FDEP Permit No. 29-0357091-001-EI

Port Tampa Bay Minor Work Permit No. 16-030

ACOE Permit No. SAJ-2017-02792

Prepared On:

October 15th, 2020

Prepared For:

Attn: Chris Pratt
EPC Water Management Division/ Environmental Restoration Section
3629 Queen Palm Drive
Tampa, FL 33619

Prepared By:

Katie Kramer
Sea & Shoreline, LLC
P.O. Box 783549
Winter Garden, FL 34778
Phone: 888-464-6991
seaandshoreline.com

Introduction

The Little Manatee River (LMR) flows over 40 miles through Hillsborough County, Florida, and is one of four major tributaries to Tampa Bay. Falling within the Cockroach Bay Aquatic Preserve, the river has been designated as an Outstanding Florida Water 700 F.A.C, which affords the waters special protection under Florida state law. The purpose of the Little Manatee River SAV Restoration Project was to directly restore 1.95 acres of submerged aquatic vegetation (SAV) in two sites within the LMR utilizing a variety of proven transplanting techniques that had been previously tested in similar restoration projects. Restoring native SAV habitat has been shown to provide ecological benefits that include, but are not limited to, sequestering excess nutrients, improving overall water quality, and providing fish habitat.

The Little Manatee River SAV Restoration Project began in December 2017 with the installation of 3,833 nursery grown Eelgrass, *Vallisneria americana (V. americana),* planting units and 100 GrowSAV™ Herbivory Exclusion Devices. Planting units consisted of 500 4-inch (4”) peat pot units, which were installed in clusters of five below protective GrowSAV Herbivory Exclusion Devices, and 3,333 mechanical planting units (MPU) which were installed with a mechanical planting vessel (Maps 1 to 3). Monitoring events took place quarterly for a period of one year to document project success and compare transplanting techniques. A one-year post-installation monitoring event took place in December 2018, and all GrowSAV Herbivory Exclusion Devices were removed at that time. The Year 2 monitoring event occurred on October 4th, 2019 to collect data one year after GrowSAV Herbivory Exclusion Device removal, and two years after initial installation.

The data presented in this report was collected on October 14th, 2020, and represents three years since initial installation, and two years since the removal of GrowSAV Herbivory Exclusion Devices.

Methodology

A 0.25 m^2 quadrat was used to assess benthic community at each selected monitoring and reference point by a Sea & Shoreline biologist utilizing a mask and snorkel. Data was collected on October 14th, 2020, during low tide (0.7 MLLW) with good visibility. Supplementary photo-quadrat representations were obtained at each selected monitoring and reference point. Collected photos were further examined in-lab to verify field observations. Photos were archived by Sea & Shoreline, and are presented on pages 13-19. The following biological parameters were assessed and only data for monitoring sites, not reference sites, is displayed.

1. Survival of *V. americana* planting units

Survival was assessed by noting the absence or presence of at least a single shoot of *V. americana*. Survival rate was determined by dividing the number of samples determined to have survived by the total number of samples.

2. *V. americana* shoot density

Shoot density was estimated by randomly placing a 10 cm x 10 cm quadrat inside each 0.25 m^2 quadrat and manually counting the number of shoots present within that 10 x 10 cm area. An estimated number of shoots/m^2 was quantified by multiplying the obtained value by 100. Data are presented as mean shoots/m^2 for selected monitoring (N=15) and reference (N=15) sites.

3. Braun-Blanquet Frequency, Abundance and Density assessment

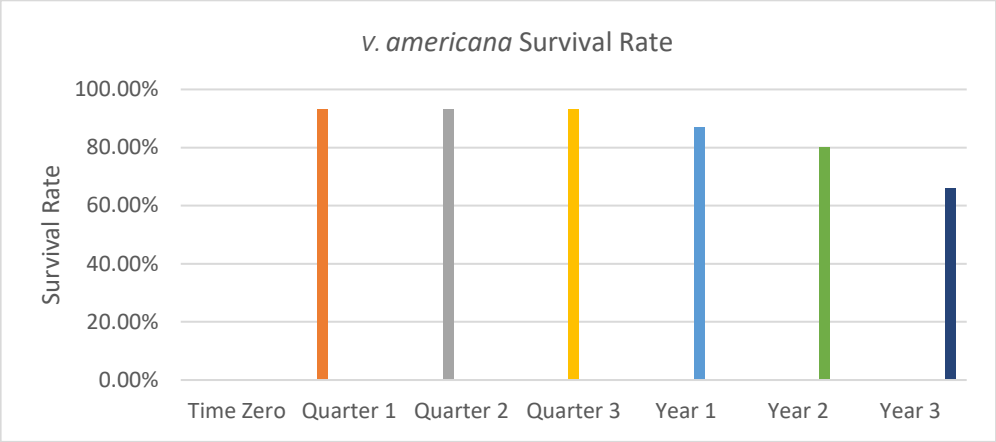
Total SAV and *V. americana* coverages were assessed within a 0.25 m^2 quadrat at each selected monitoring and reference site using the Braun-Blanquet visual assessment method. Each examined quadrat was assigned a coverage score between zero and five corresponding to the percent coverage values listed in **Figure. 1.** *V. americana* frequency, abundance, and density were determined using the formulas provided in **Figure 3.**

4. *V. americana* canopy height

V. americana blades located within the same 10 x 10 cm quadrat, used to determine shoot count, were measured in-water using a metric ruler. Data are recorded as a mean value canopy height (cm) per sample for selected monitoring (N=15) and reference sites (N=15).

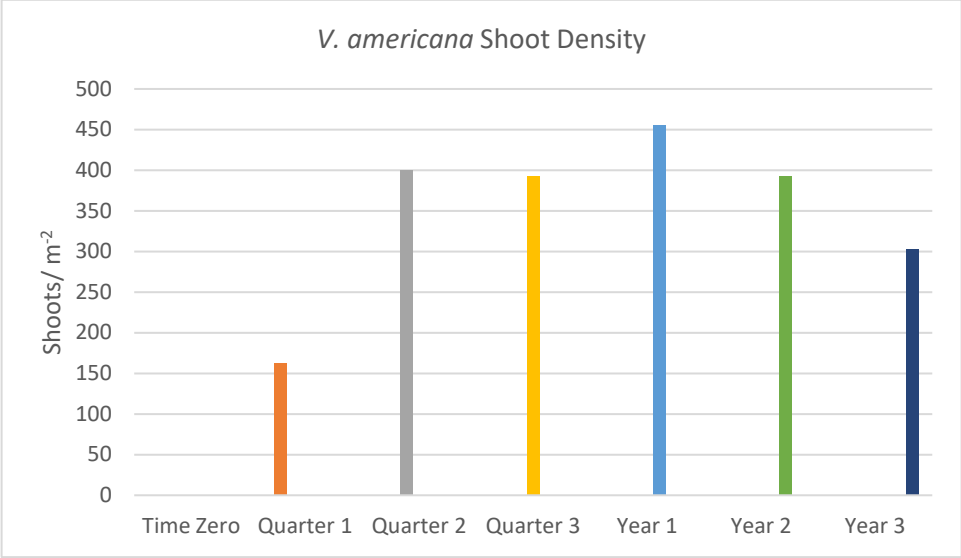
1. *Survival of V. americana planting units*

V. americana was present in 67 percent of samples that were planted in December 2017 and protected by GrowSAV Herbivory Exclusion Devices until December 2018 (10/15 monitored sites).



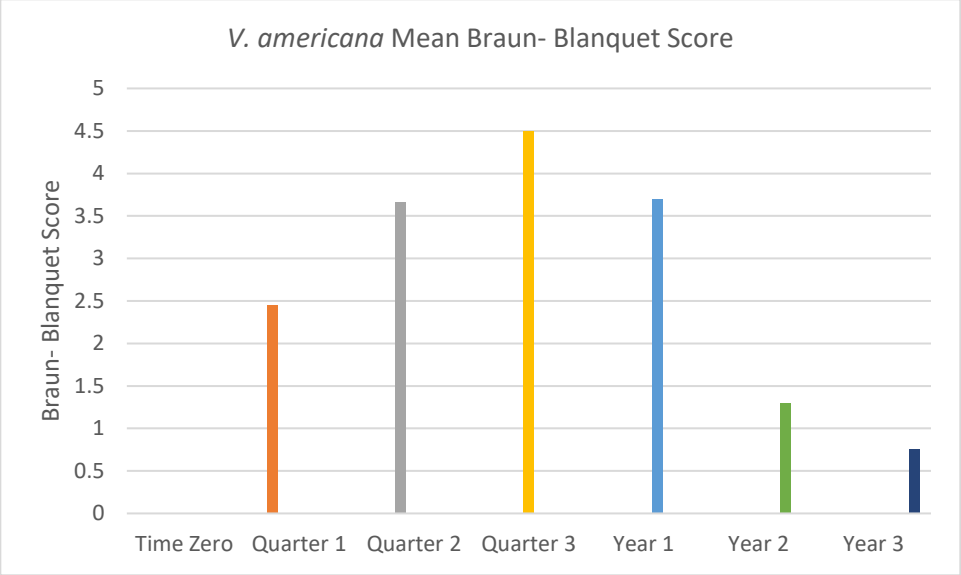
2. *V. americana shoot density*

Mean *V. americana* shoot density was found to be 303 shoots/m^2 at the monitoring sites.



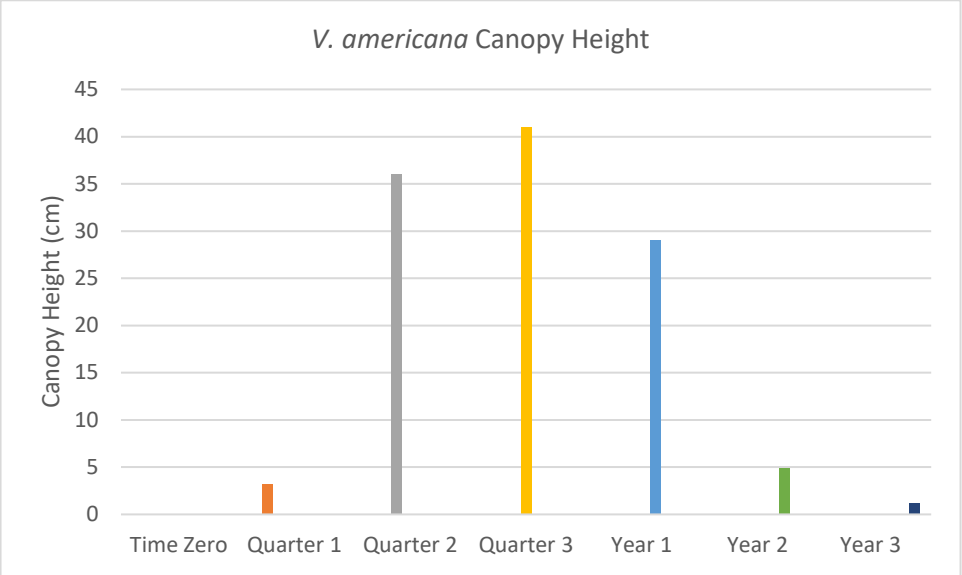
3. *Braun-Blanquet Frequency, Abundance and Density assessment*

The Braun–Blanquet coverage estimate for *V. americana* was 0.76. Frequency of *V. americana* was 0.66, occupying 10/15 samples. *V. americana* was observed at an abundance of 0.76 and a density of 0.43.



4. *Canopy Height*

Mean SAV canopy height in monitored samples was determined to be 1.25 cm.



Discussion

At the conclusion of Year 3 monitoring *V. americana* was present in 66 percent of monitoring samples. At the time of Year 1 monitoring, *V. americana* was present in 87 percent of monitoring samples, and 80 percent at Year 2. This decrease is again suspected to be due to the removal of the GrowSAV Herbivory Exclusion Devices which help protect planting units until they are mature enough to withstand grazing pressure from herbivores such as manatees, turtles, and waterfowl. 66 percent is less than previous years but the grass that was present showed good coloration, strong although short blades, and good root/ rhizome structure. *V. americana* was noted to be present at 53 percent of reference sites when it was absent at all reference sites during the Year 1 monitoring event and was present in 47 percent of reference samples during Year 2 monitoring. This shows that once-protected planting units are spreading beyond the original footprint of their GrowSAV Herbivory Exclusion Devices to recruit in areas that were not originally planted, and that unprotected planting units that were not originally planted under a protective device are surviving and coalescing to form a continuous eel grass bed.

V. americana remained the most frequent, abundant, and dense SAV throughout the project site. At the time of Year 3 monitoring, frequency of *V. americana* was 0.66, with grass occupying 10/15 samples, it was observed at an abundance of 0.76 and a density of 0.43. Values obtained at Year 3 monitoring are less than those of both Years 1 (0.87, 4.31, and 3.73) and 2 (0.8, 1.62, and 1.3). The mean Braun- Blanquet score for Year 3 monitoring was 0.76 which was less than that of Years 1 (3.7) and 2 (1.3). This may also be attributed to the removal of the GrowSAV Herbivory Devices, allowing the grass to be further grazed down. Canopy height can also affect the Braun- Blanquet score. *V. americana's* mean canopy height was 1.25 cm, which again is less than that of Years 1 (29 cm) and 2 (4.92 cm). A better comparison between all years is the measure of shoot count. At the time of Year 1 monitoring, shoot count was 455 shoots/m^2, Year 2 measured 393 shoots/m^2, and this event for Year 3 measured an average of 303 shoots/m^2. Interestingly, shoot density was slightly higher at reference sites versus monitored sites for Year 3 at 350 shoots/m^2. While slightly decreased, the Year 3 shoot count is still comparable to previous years and with values obtained in similar, existing *V. americana* communities.

In summation, the Year 3 monitoring event showed that *V. americana* remained the most frequent, abundant, and dense SAV within the project footprint in the Little Manatee River. Although many values were decreased from Years 1 and 2 to present, the grass observed at the time of Year 3 monitoring, although short, was healthy, strong, and very importantly, dense. Shoot density across all three annual monitoring events remained fairly consistent, showing that despite being heavily grazed, *V. americana* manages to spread laterally, sending out rhizomes and new shoots to maintain a healthy shoot count. Interestingly, *V. americana* was present at 53 percent of reference sites at the time of Year 3 monitoring, which is more than both Year 1 (0 percent) and Year 2 (47 percent). This shows that grass that was originally planted under protective GrowSAV Herbivory Exclusion Devices, although facing heavy grazing pressure, is able to spread beyond the footprint of the protective devices to contribute to a continuous eelgrass bed that would not otherwise be present. Formal monitoring was concluded with this event, but the warning signs that were installed to inform boaters and swimmers of the GrowSAV Herbivory Device locations were left in place to further warn recreational boaters of the restoration efforts.

Figures

Figure 1 – Provides Braun-Blanquet score values to corresponding SAV coverage

Braun – Blanquet Score	Coverage Value
0	Not Present (0%)
0.1	Solitary
0.5	Very Sparse
1	Sparse (<5%)
2	5% - 25%
3	25% - 50%
4	50% - 75%
5	75% - 100%

Figure 2 – Provides the GPS location of each selected monitoring site

GrowSAV Device	x coordinate	y coordinate
1	82°24'24.272"W	27°40'31.721"N
2	82°24'25.125"W	27°40'30.190"N
3	82°24'26.159"W	27°40'29.251"N
4	82°24'26.688"W	27°40'28.663"N
5	82°24'27.751"W	27°40'27.963"N
6	82°24'28.550"W	27°40'27.405"N
7	82°24'28.930"W	27°40'27.202"N
8	82°24'29.606"W	27°40'26.723"N
9	82°24'30.094"W	27°40'26.035"N
10	82°24'30.426"W	27°40'25.523"N
11	82°23'52.304"W	27°40'00.683"N
12	82°23'48.838"W	27°39'59.316"N
13	82°23'48.193"W	27°39'58.139"N
14	82°23'47.801"W	27°39'57.033"N
15	82°23'48.119"W	27°39'56.187"N

Figure 3 – Formulas

Formula	
Braun- Blanquet Frequency	Number of quadrats a species occupies / total number of quadrats
Braun- Blanquet Abundance	Sum of a species Braun Blanquet Score / Number of quadrats that species occupies
Braun- Blanquet Density	Sum of a species Braun-Blanquet Score / total number of quadrats

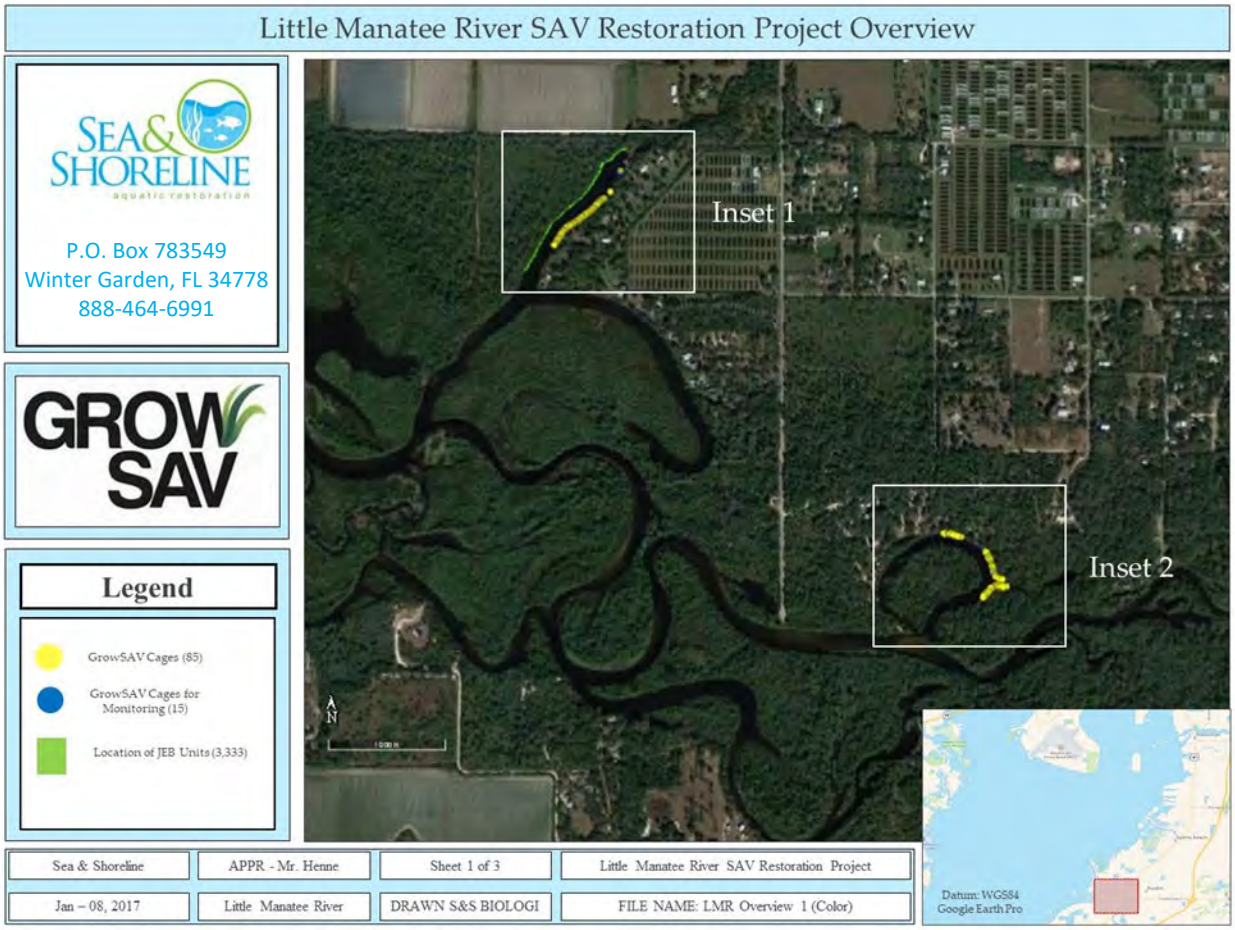
Field Data

Observed by: R. Brushwood **Recorded by:** K. Kramer & B. Rodgers **Observed on:** 10/14/19

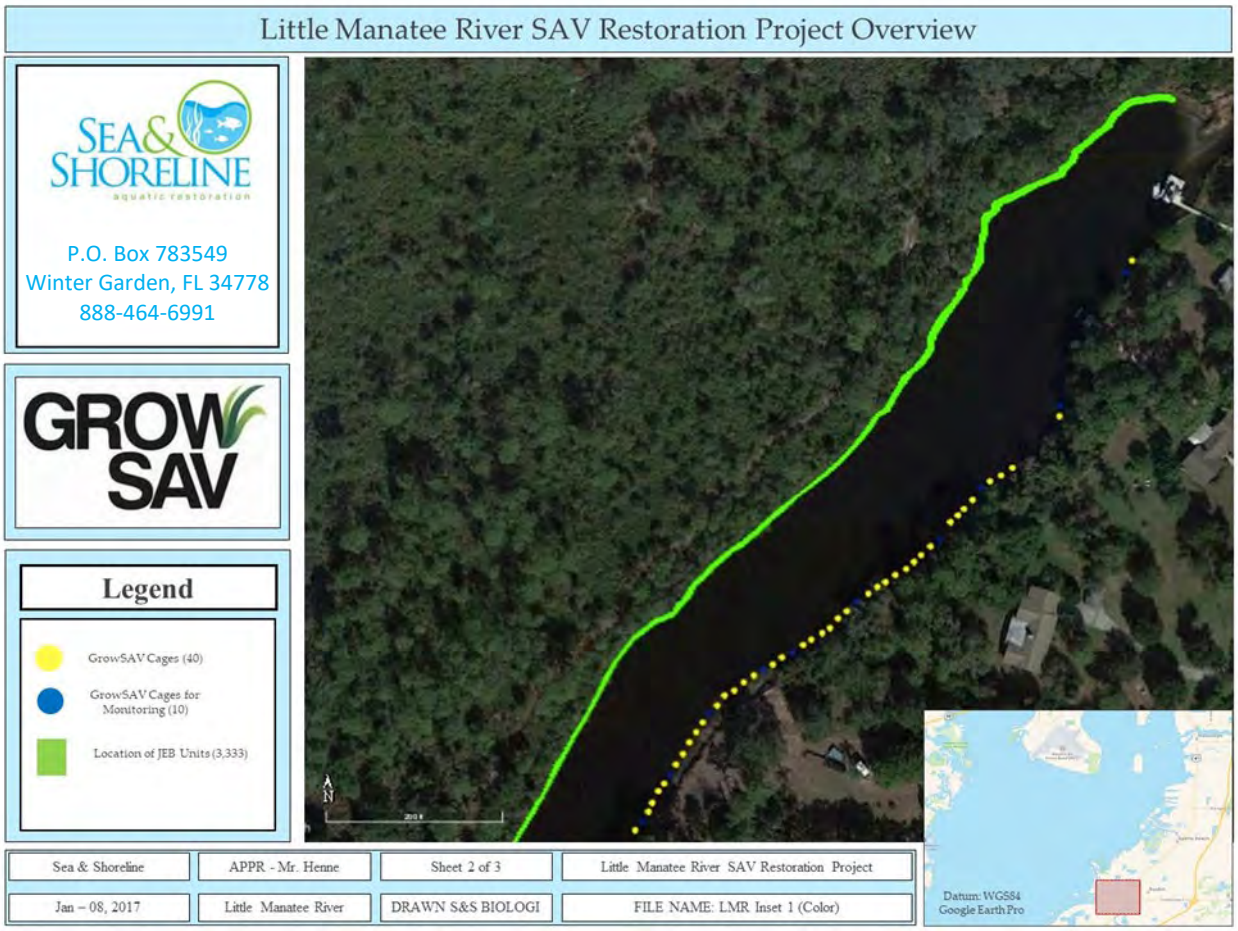
Phase	Area	Site Id	Epiphytes	BB SAV	BB MAC	Shoot count	Blade height (cm)	BB Va	BB Hv	BB Lw	BB Ms	BB Ng	BB Other MAC	Other MAC	BB Other SAV	Other SAV	Pic ID
LMR	1	1	0	0	0	0	0	0	0	0	0	0	0		0		8363
LMR	1	1R	0	0	0	0	0	0	0	0	0	0	0		0		8364
LMR	1	2	0	0	0	0	0	0	0	0	0	0	0		0		8365
LMR	1	2R	0	0	0	0	0	0	0	0	0	0	0		0		8366
LMR	1	3	0	0.5	0	3	2	0.5	0	0	0	0	0		0		8,367
LMR	1	3R	0	0	0	0	0	0	0	0	0	0	0		0		8369
LMR	1	4	0	0	0	0	0	0	0	0	0	0	0		0		8370
LMR	1	4R	0	0	0	0	0	0	0	0	0	0	0		0		8371
LMR	1	5	0	1	0	7	1	1	0	0	0	0	0		0		8372-74
LMR	1	5R	0	0	0			0	0	0	0	0	0		0		8375-78
LMR	1	6	0	0.5	0	3	2	0.5	0	0	0	0	0		0		8379-81
LMR	1	6R	0	0.5	0	3	3	0.5	0	0	0	0	0		0		8383-85
LMR	1	7	0	0.5	0	4	2	0.5	0	0	0	0	0		0		8386-88
LMR	1	7R	0	0.5	0	3	2	0.5	0	0	0	0	0		0		8389-91
LMR	1	8	0	0.5	0	10	1.5	0.5	0	0	0	0	0		0		8392-94
LMR	1	8R	0	0.5	0	2	2	0.5	0	0	0	0	0		0		8395-97
LMR	1	9	0	2	0	11	2	2	0	0	0	0	0		0		8398-8400
LMR	1	9R	0	0.5	0	3	2	0.5	0	0	0	0	0		0.5	Eleocharia spp.	8401-403
LMR	1	10	0	0.5	0	10	2	0.5	0	0	0	0	0		0.5	Eleocharia spp.	8404-406
LMR	1	10R	0	0.5	0	3	1	0.5	0	0	0	0	0		0		8453-55
LMR	1B	11	0	1	0	7	2	1	0	0	0	0	0		0		8456-58
LMR	1B	11R	0	0.5	0	1	1	0.5	0	0	0	0	0		0		8459-461
LMR	1B	12	0	0.5	0	2	4	0.5	0	0	0	0	0		0		8463-8465
LMR	1B	12R	0	0	0	0	4	0	0	0	0	0	0		0		8466-8468
LMR	1B	13	0	1	0	6	2	1	0	0	0	0	0		0		8469
LMR	1B	13R	0	2	0	13	2	2	0	0	0	0	0		0		8470
LMR	1B	14	0	0	0	0	0	0	0	0	0	0	0		0		8471
LMR	1B	14R	0	0.5	0	0	0	0	0	0	0	0	0		0.5	Eleocharia spp.	8472
LMR	1A	15	0	0	0	0	0	0	0	0	0	0	0		0		8473
LMR	1A	15R	0	0	0	0	0	0	0	0	0	0	0		0		874

Maps

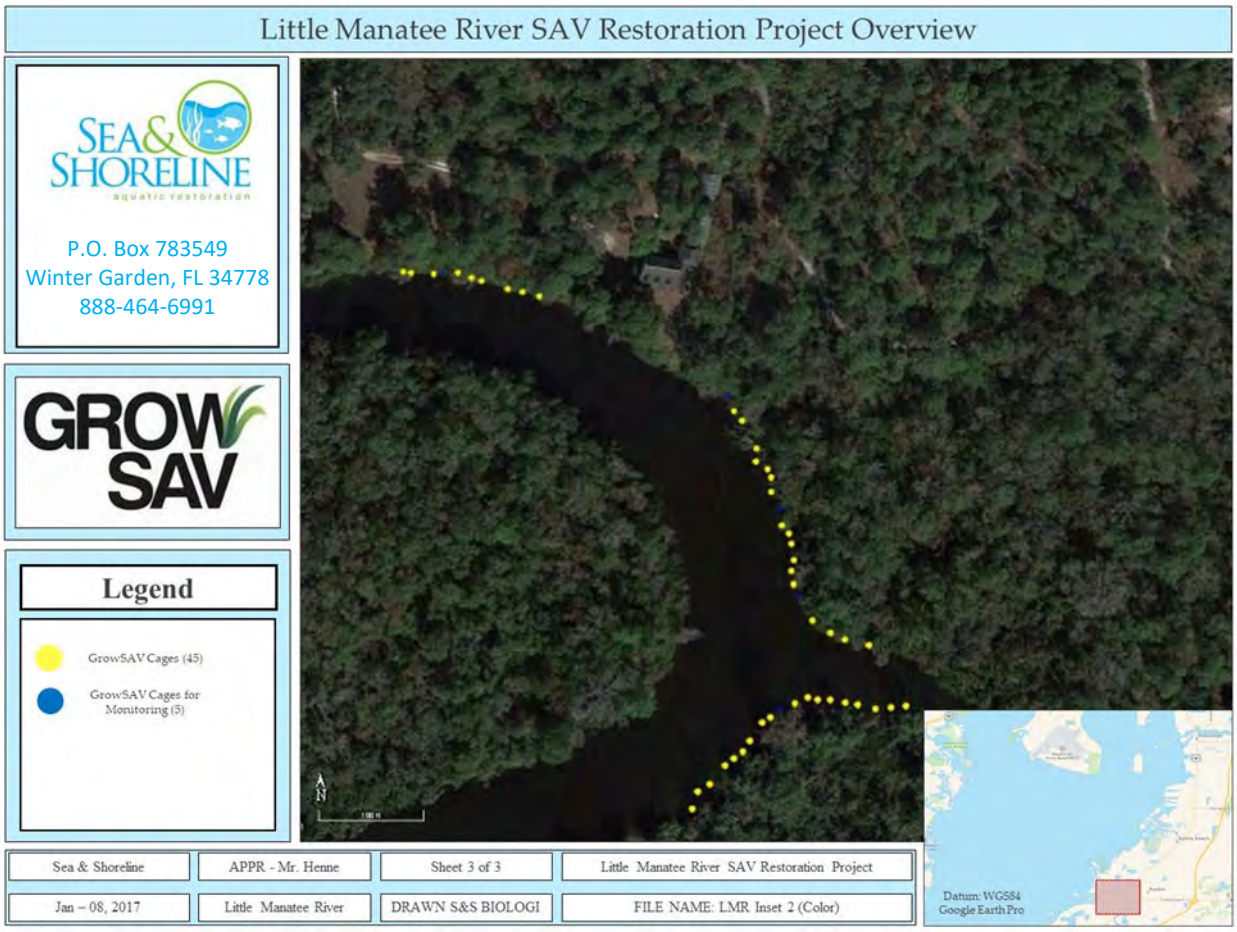
Map 1 – Overview of Project Sites



Map 2 – Overview of Inset 1

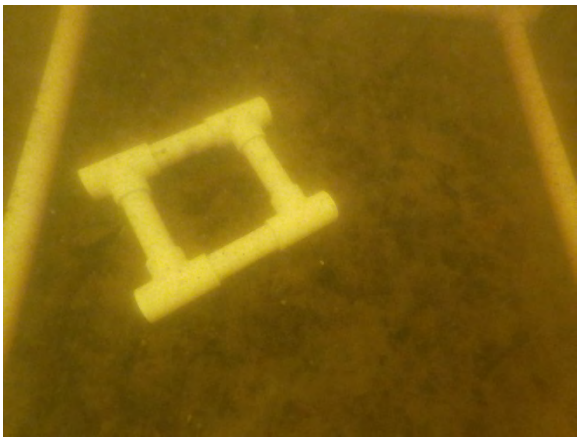


Map 3 – Overview of Inset 2

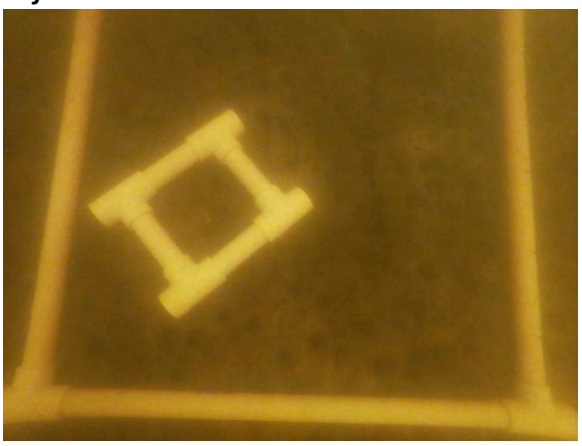


Monitoring/ Reference Site Photos

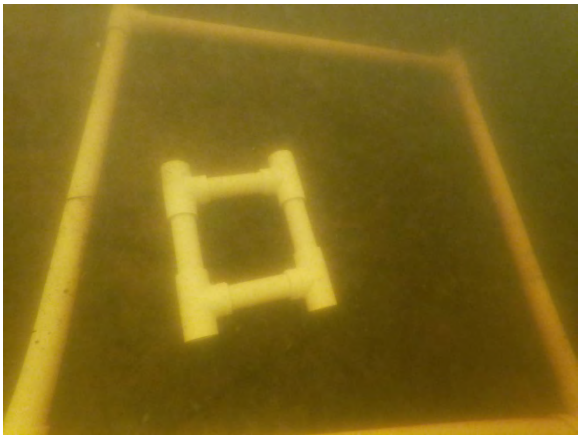
Site 1



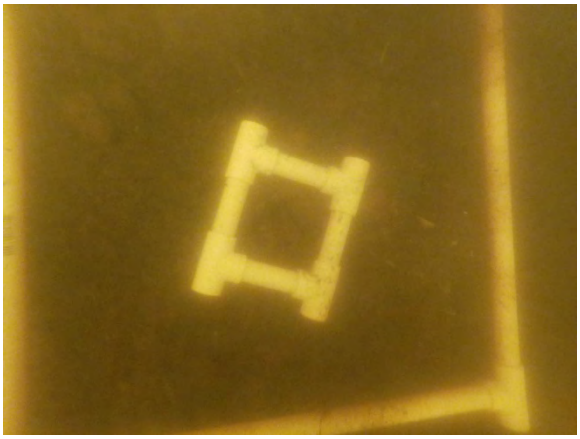
Reference 1



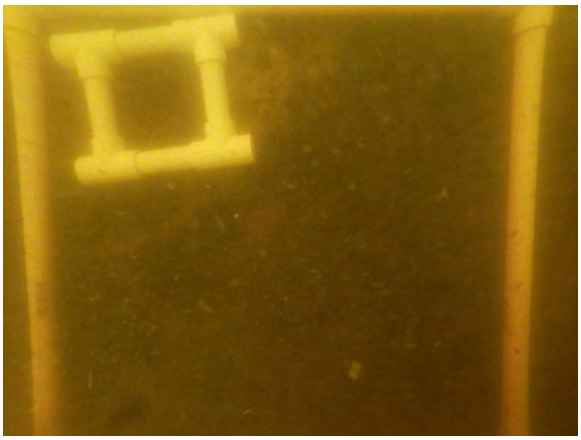
Site 2



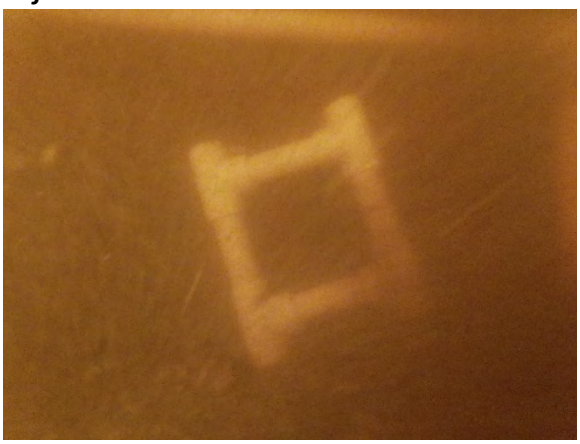
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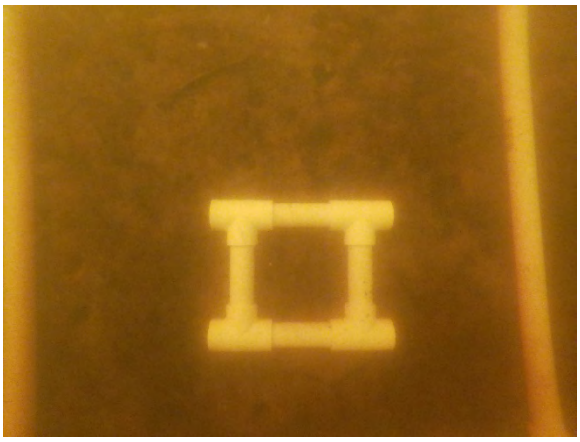
Site 3



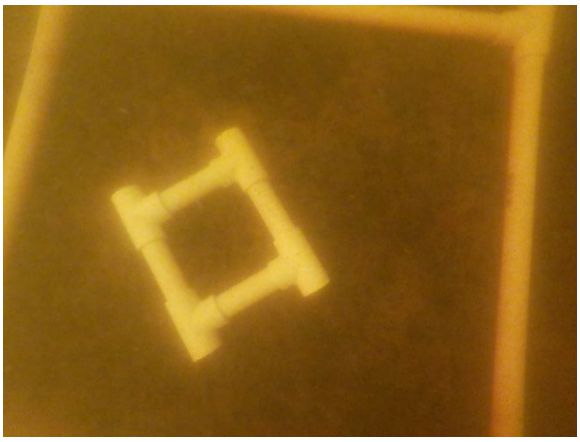
Reference 3



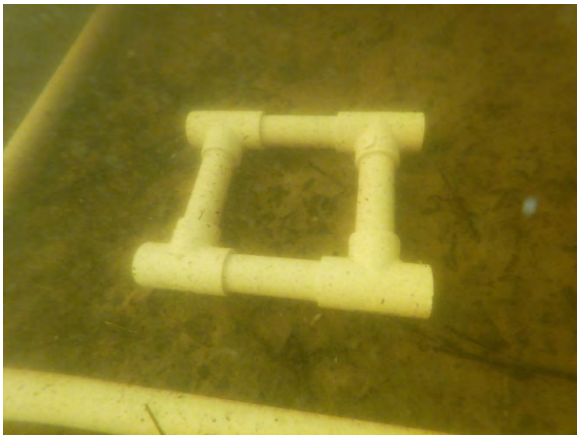
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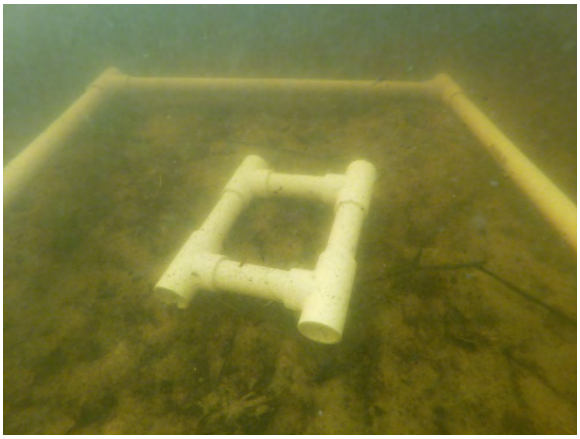
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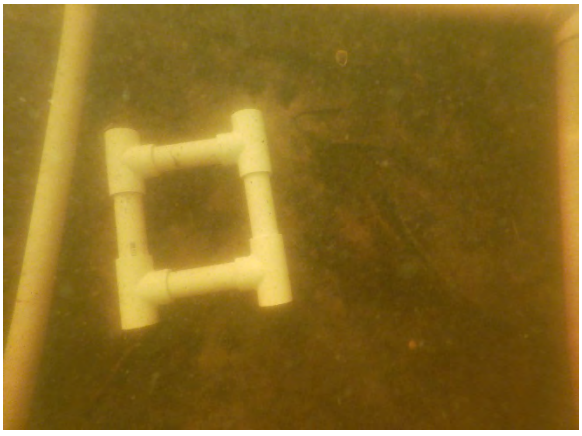
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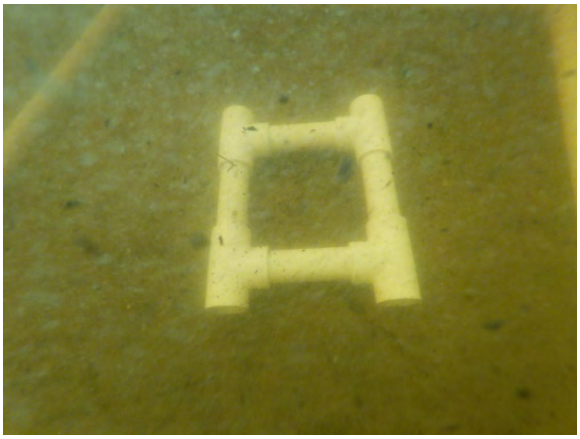
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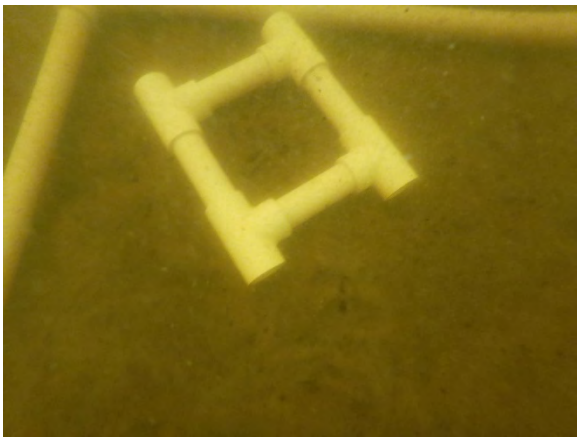
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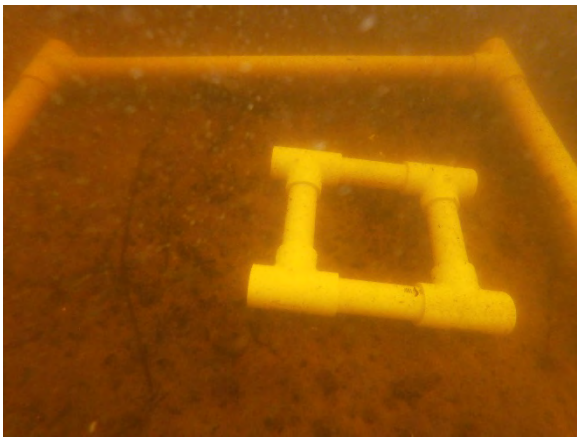
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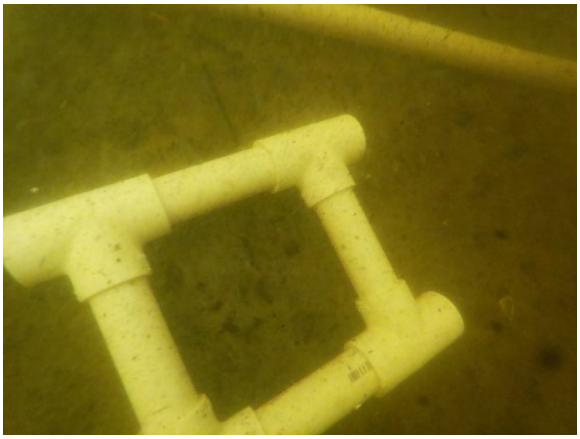
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Reference 7



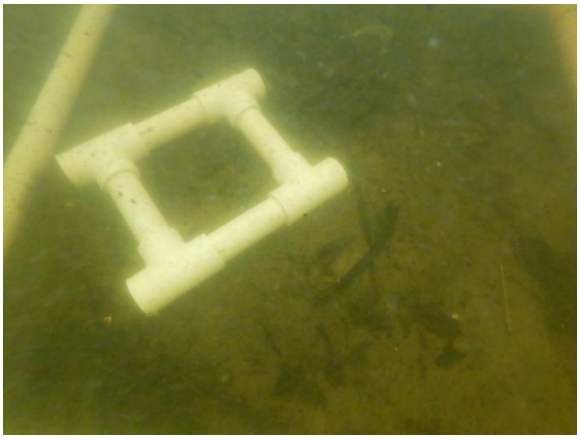
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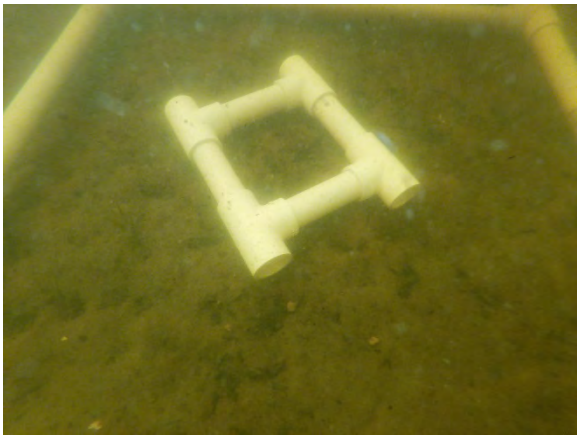
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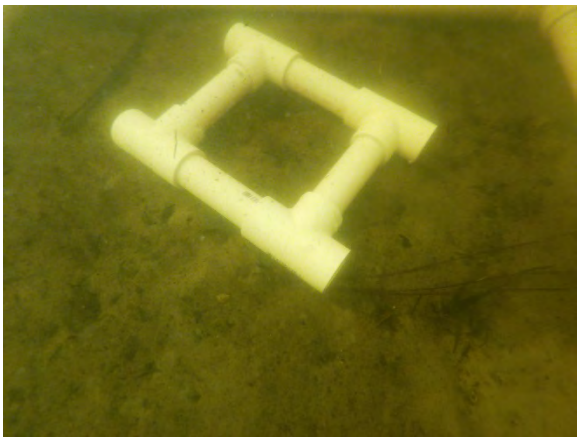
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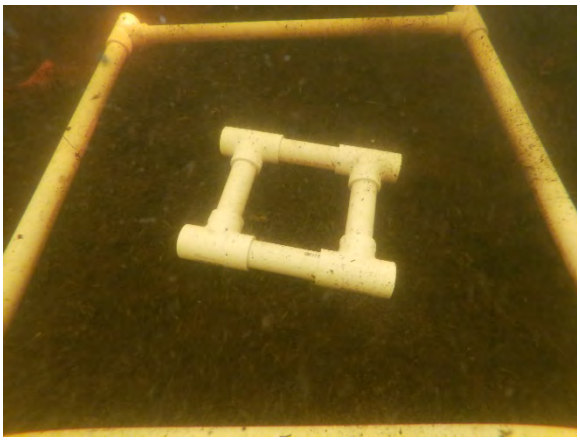
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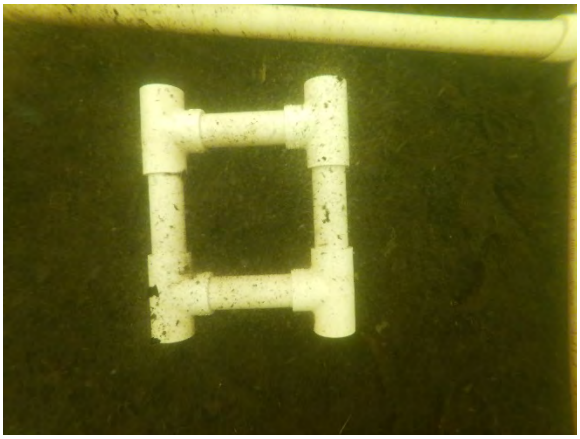
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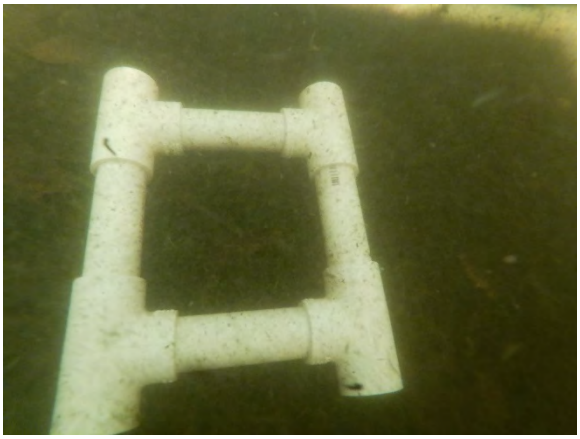
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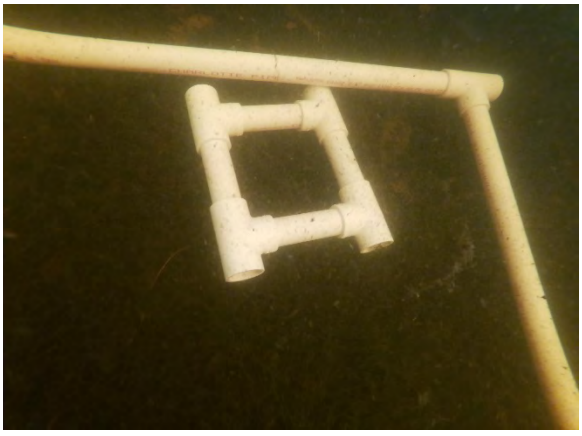
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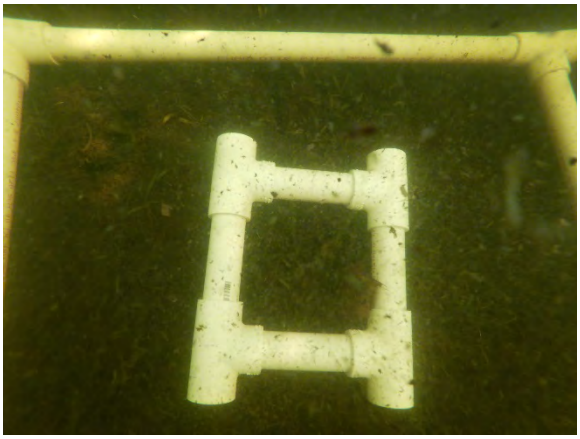
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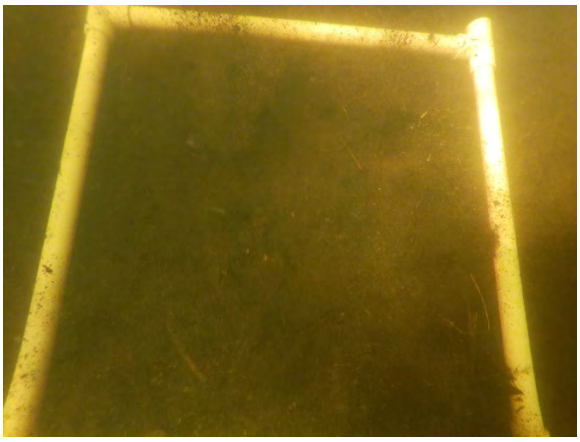
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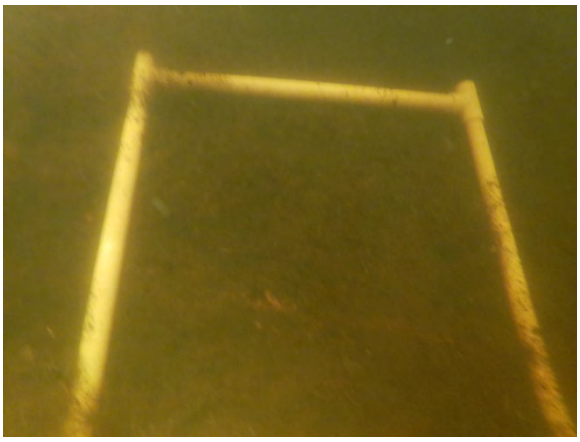
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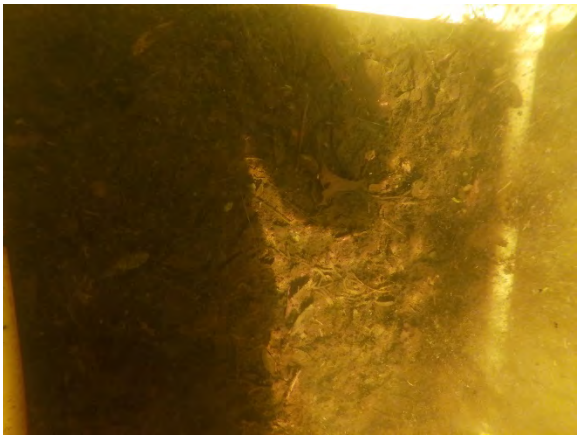
Site 13



Reference 13



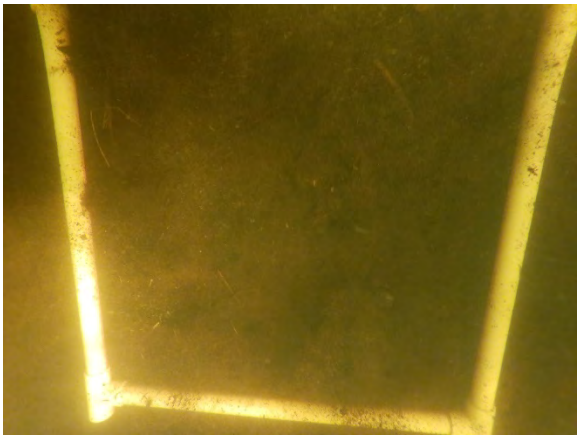
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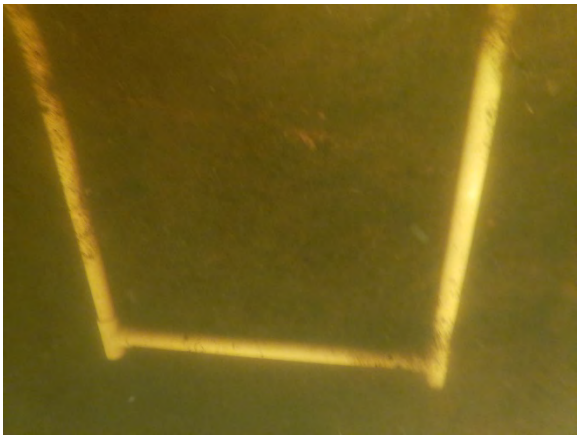
Reference 14



Site 15



Reference 15



Example of Mechanical Planting Units

