Appendix I3

Compilation of Public and Stakeholder Comments From July Through November 2023

From:	Doug Leeper
To:	Angel Martin; Kym Holzwart
Subject:	RE: Little Manatee River MFLs Public Workshop
Date:	Thursday, September 28, 2023 7:36:38 AM

Thanks, Angel.

Doug Leeper
MFLs Program Lead
Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604
1-352-269-5863 or 352-796-7211
doug.leeper@watermatters.org or doug.leeper@swfwmd.state.fl.us

From: Angel Martin <amartin217@tampabay.rr.com>
Sent: Thursday, September 28, 2023 12:59 AM
To: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; kym.holtzwart@watermatters.org
Subject: Little Manatee River MFLs Public Workshop

[EXTERNAL SENDER] Use caution before opening.
Concerning the workshop, below is a brief summary of my comments and conclusions.

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1. Suggested that it may be possible to increase the number of blocks to define the flow regime, especially Block 2 representing medium flows. It was discussed that the number of blocks used in the analysis was sufficient for determining MFLs for the Little Manatee River based on ecosystem parameters. This explanation is satisfactory.
2. Besides stating that sea-level rise may be a reason for possible future analysis for possibly adjusting the proposed MFLs, Martin and others suggested that a prolonged drought period or a better technology for determining the MFLs may be other reasons for possible future analyses.
3. Martin asked to confirm that there is little to no groundwater/surface-water interaction for the river. Be careful in using the terms baseline flow conditions and baseflow conditions as they may be confusing to some readers of the information provided.
4. Martin and Leeper described how the USGS collected and served the data to users. Martin emphasized that the USGS would provide information on any major issues on how streamflow data were collected on the bridge at Highway 301.

Please contact me if you any additional information or clarification. Thank you for the opportunity to comment on the subject public workshop.

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Angel Martin
813-767-6944

Ed Sherwood’s (TBEP Comment During Public I have a meeting conflict at 3pm, and unfortunately, I have to jump off the call. I appreciate the DISTRICT and Peer Review Panels' attention to the development of a protective MFL for the Little Manatee River. As I continue to digest the new content provided in the June 28 draft (as the Peer Review panel continues to do), I am confident that the DISTRICT will consider all comments received to create a robust final MFL document that will continue to protect the ecological health of the LMR. Thanks for everyone's time and attention to this important MFL.

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Randy Smith; Chris Zajac; Doug Leeper
Subject:	My slides for today"s meeting
Date:	Wednesday, July 5, 2023 9:37:55 AM
Attachments:	July 5th slides for Sid Flannery.pptx July 5th slides for Sid Flannery.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym,

Attached are a powerpoint and pdf file of six slides I would like to use during my comments at today's Little Manatee River minimum flows review meeting. During the meeting, could someone at the District call them up and advance them when I say "next slide" rather than me trying to share my screen.

Thanks again to you, Randy, and Chris for your time on Friday. It was a very helpful meeting and I appreciate the informative table you created that summarized the District's responses to my many questions. Doug - sorry you had to miss the gathering.

Please let me know that you received these files.
See you virtually this afternoon.

Thanks again,
Sid

From:	Stevens, Philip
To:	Kym Holzwart
Subject:	RE: Little Manatee River draft MFL report
Date:	Monday, July 17, 2023 12:18:48 PM

[EXTERNAL SENDER] Use caution before opening.

Kym, I'm back from a family vacation, but will leave again on Wednesday. Do you have time today or tomorrow to discuss the LMR MFL? Again, it is much improved and we really appreciate that a lot of the major comments were resolved. At this point, I have a couple questions along the same lines as mentioned already below related to text and inclusion of figures. Mainly that the report walks the reader through what is known about the river and how the fauna respond to different flows. A lot of interesting work was done and it would be nice for the reader to get to see it.

Philip Stevens, PhD
Research Scientist – Fish Biology
FWC – Fish and Wildlife Research Institute
100 8th Ave Southeast
St Petersburg, FL 33701
Phone: 727-896-8626

From: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Sent: Wednesday, July 5, 2023 12:46 PM
To: Stevens, Philip <Philip.Stevens@MyFWC.com>
Subject: RE: Little Manatee River draft MFL report

Hey Phil,

I hope all is well and that you had a great 4th of July holiday! Adding this paragraph to Chapter 4 and the recent references is a good idea and can be easily done. Feel free to review the lower river fish section included in Chapter 4 (we wrote it), and let me know if anything else should be added (a few paragraphs and more references is no problem). I still think a literature review/summary of all the Little Manatee River work that the FWC/FWRI has conducted would be a useful appendix.
Thanks for looking at the report,
Kym

From: Stevens, Philip <Philip.Stevens@MyFWC.com>
Sent: Wednesday, July 5, 2023 12:40 PM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Subject: Little Manatee River draft MFL report

[EXTERNAL SENDER] Use caution before opening.

Kym, I took a look at the revised draft MFL report for Little Manatee River. I still think it would be helpful to capture more of the historical knowledge available for river. I think it can be done without adding substantial length. I worry a lot about the rate of staff turnover in state agencies and the likelihood that studies conducted for the sake of MFLs and/or habitat conservation will be lost. The next person picking up the MFL reports during the revision process should have access to the available knowledge without conducting another literature and peer review. If the information cannot be included directly in the MFL report, perhaps we can revisit the idea of having a supplemental summary on the ecology of the river. However, I'm optimistic that the information can be directly included in the report if summarized succinctly and well. Below is some text that summarizes some recent work by the FWRI fish biology group that I supervise. It seems that Janicki did a pretty good job of summarizing FWRI FIM data in their report if I remember it correctly. I'm willing to help if needed.

Little Manatee River fish summary paragraph

Two studies focused on common snook in the Little Manatee River, a species dependent on coastal wetlands as their juvenile habitat. Common snook serve as flagship, umbrella species for habitat conservation (Wilson et al. 2022). Flagship species are used to promote public awareness of conservation needs, and umbrella species are those whose ecological needs are known and encompass the needs of many other species, thus serving as a focal point for conservation. In the Little Manatee River, Ley and Rolls 2018 found that three tributaries associated with pristine, low salinity (0.5-1.5 psu) marshes (*Acrostichum* spp. and *Juncus roemarianus*) contributed the most juveniles to the 1-year-old population of snook. Trotter et al. 2021 found that the smallest snook (<250 mm total length) strongly selected for backwater habitats (e.g., embayments, small tributaries) while the largest (> 850 mm total length) selected deep river bends. In the Little Manatee River, braided channels and associated backwater habitats overlap with low salinity, apparently providing the most favorable habitat for juvenile snook (i.e., combination of adequate food and refuge). Conservation of environmental conditions and geomorphological features used by juvenile snook should also benefit species that use areas just downstream if salinity gradients within the river can be conserved.

Ley, J.A. and H.J. Rolls. 2018. Using otolith microchemistry to assess nursery habitat contribution and function at a fine spatial scale. Marine Ecology Progress Series 606: 151-173.

Trotter, A.A., J.L. Ritch, E.J. Nagid, J.A. Whittington, J. Dutka-Gianelli, and P.W. Stevens. 2021. Using geomorphology to better describe habitat associations of a large-bodied fish, Common Snook *Centropomus undecimalis*, in coastal rivers of Florida. Estuaries and Coasts 44: 627-642.

Wilson, J.K., P.W. Stevens, D.A. Blewett, R. Boucek, A.J. Adams. 2022. A new approach to define an economically important fish as an umbrella flagship species to enhance collaborative stakeholder-management agency habitat conservation. Environmental Biology of Fishes 106: 237-254.

Files provided by Sid Flannery to the Southwest Florida Water Management District regarding review of the draft Minimum Flows Report for the Little Manatee River (SWFWMD, 2021)

Content and Organization

This document includes text, tables and graphics provided to the Southwest Florida Water Management District (the District) as part of a review of the draft minimum flows report for the Little Manatee River that was published in September 2021. These files were submitted to the District between Oct 2021 and September 2022. A revised minimum flows report for the Little Manatee River that will address many of these topics will be published by the District in July 2023.

Other information

This file does not contain email correspondence with the District and miscellaneous files associated with that correspondence. Most notably, it also does not include analyses, results and discussion presented in an interpretive document provided to the District in January 2022 titled *Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows for the Little Manatee River* (Flannery 2022), which can be provided separately upon request. Several technical points raised in that document are also being addressed by the District.

This document does also does not include a letter submitted to the District by the Florida Fish and Wildlife Conservation Commission in April 2022 regarding fish populations in the Little Manatee River and a review of the minimum flows report, with many of their points to be addressed in the upcoming revised minimum flows report.

Sid Flannery, retired, formerly Chief Environmental Scientist with the Southwest Florida Water Management District

June 28, 2023

Public comments by Sid Flannery at the Little Manatee River minimum flows peer review meeting on 10/5/21 (not completed at the meeting due to time constraints)

Below is a transcript of the complete comments I had hoped to give at the peer review panel meeting on October 5, 2021, but ran short on time. I have added two paragraphs about the work by Dr. Gabriel Vargo and have supplied one additional slide I would like sent to the peer review panel with this document. The other two slides that were shown at the meeting are also submitted and all three slides are shown at the end of this document.

I encourage readers to review the information about Dr. Vargo's work and the important topic of separate flow thresholds for freshwater and estuarine sections of the river that starts on page 3, which I did not have time to cover in my public comments at the meeting.

My name is Sid Flannery, and as I introduced myself earlier, I am a retired Chief Environmental Scientist with the District's minimum flows program, where I worked many years on the hydrobiological flow relationships of the Little Manatee River. I managed nine different consultant research or analysis projects for the river and have probably spent 50 plus field days on the lower portions of the Little Manatee.

I want to first acknowledge how hard and conscientiously District staff works on the minimum flows reports, for they are under a very challenging schedule for the adoption of the minimum flow rules.

I quickly read through the minimum flows report for the Little Manatee, and based on further review, I will submit a series of questions and comments to the District. I will request that these questions and comments be provided to the peer review panel via the minimum flows web-board.

Today, I want to briefly discuss two aspects of the minimum flows report, the first of which I think is pretty easy to address, and the second which may require some new analyses.

The first topic is the report does not cite nor describe some important earlier technical reports that were prepared for the District about the Little Manatee River which provide very useful information regarding its ecological relationships with freshwater flows. I think these reports need to be cited and briefly summarized in the District report. Importantly, I don't think that concise summaries of these reports will change the recommended minimum flows and it should be fairly easy to incorporate them in the format of the District report. Inclusion of this material will improve the public and the technical community's understanding of the freshwater flow relationships of the Little Manatee River, and therefore better support the recommended minimum flows.

I have got two slides I want to show you in this regard *(a third slide has been added since I spoke).*

On page 70, the District report shows a land cover map for the lower, tidal reach of the Little Manatee River using the Florida Land Use, Cover, and Forms Classification System, also known

as FLUCCS. However, there is much better information available for the river, for in the 1990's the District contracted the State of Florida Marine Research Institute to do detailed mapping of vegetation communities in five tidal rivers, including the Little Manatee.

This slide (at end of this document) shows the vegetation communities that were mapped as part of that project. Note that compared to the FLUCCS codes shown in the District report, the low salinity plant communities are identified with much greater resolution, including *Typha*, *Cladium*, *Acrostichum*, freshwater marshes and other communities. It is worth noting that on the Little Manatee and other tidal rivers, the District has rightly emphasized the protection of low salinity zones, such a < 2 psu salinity. This is particularly relevant on the Little Manatee for it has a highly braided zone above kilometer 12, which has a very high degree of shoreline length per river kilometer. This zone of the river is one of the real unique areas in southwest Florida and its health is closely linked to the minimum flows. This is the map that needs to be used in the District report and work that produced it needs to be cited.

Also, in 1988 and 1989, the District received grants from the Florida Department of Environmental Protection to examine the linkages between the Little Manatee River watershed and its receiving estuary. That project included a two-year study of ichthyoplankton communities in the tidal reach of the river, which involved the early life stages of estuarine fishes. This was conducted by Dr. Ernst Peebles of the University of South Florida College of Marine Science and it is briefly described on page 99 in the District report, followed by a table of the 30 most abundant fish life stages captured during the study. It should be noted this study also quantified the abundance of many invertebrates caught in the plankton net that are important fish food organisms.

There are other valuable findings from this project that could also be briefly summarized in the District report. The next slide is from that project. I think If there is one slide that best supports the District's minimum flows program for tidal rivers, this is it. It shows mean salinity at capture for the immature life stages for five species of fish in the Little Manatee, with age increasing toward the right. The first three are larval stages, as many important estuarine dependent species spawn in the bay or gulf or near the mouths of rivers.

As these fishes grow to juveniles and develop stronger swimming ability, they move into low salinity waters. This, about as effectively as anything, justifies the use of the low salinity habitats as a parameter for establishing minimum flows. There are some other aspects of the ichthyoplankton report for the Little Manatee that are valuable, but at a minimum this graphic needs to go into the District report.

There are four other papers or reports (one a group of three related reports) that need to be cited and summarized in the District report. Of particular significance is important primary production work done by Dr. Gabriel Vargo of the University of South Florida College of Marine Science.

On page 56, the District report shows yearly mean chlorophyll *a* concentrations at five stations in the Little Manatee monitored by the Environmental Protection Commission of Hillsborough

County, including four in the estuarine reach of the river. The report states the spatial pattern shown between these stations is typical of tidal rivers. Well not exactly, the Little Manatee is unusual in that regard and there are reasons for it. The table below, which is also submitted as a slide, is adapted from a report that Dr. Vargo prepared for the District that compares chlorophyll and phytoplankton relationships in the Little Manatee, Alafia, and Peace Rivers.

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.

		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

The Alafia and Peace have the more typical pattern of high chlorophyll *a* concentrations at the 6 and 12 psu zones, while the Little Manatee frequently has its highest values near the freshwater/brackish water interface. This is likely due to comparatively longer residence times in the braided reach of the river which allows phytoplankton blooms to develop. The effects of changes on freshwater inflows on excessive phytoplankton blooms can be an important factor to consider in minimum flows analyses, as was done for the Lower Alafia. I think we are okay on the Little Manatee in that regard, but the three reports that Dr. Vargo prepared for the District need to be cited and briefly summarized in the minimum flows report.*

The citation and summaries of these and a few other reports can be very brief, one or two paragraphs with a figure or table. These concise and informative summaries will improve the public and technical community's understanding of the freshwater inflow relationships of the Little Manatee River and better support the technical justification of the minimum flows.

Assessment of separate thresholds for flow-based blocks for the freshwater and estuarine sections of the Little Manatee River

I want to change topics now and discuss the use of flow-based blocks in the District report. I strongly support the use of flow-based blocks, but they probably should be identified separately for the freshwater and estuarine reaches of the river. For most rivers, the District has previously produced separate reports for the freshwater and estuarine reaches of each river using different analytical methods, such as for the Alafia, Peace and Myakka Rivers. For many

* **The District report cites a paper by Vargo et al. (1991) in the Proceedings of the BASIS 2 Symposium, but the reports for the District provide other valuable findings with the third report completed after BASIS 2.**

years the District used a seasonal block approach for the freshwater rivers, with three seasonal blocks corresponding to low, medium, and high flows. For example, if it was February, you assumed flows were in the medium range and you applied the minimum flow percentages for that time of year.

On page 103 the District report makes a good case that this method has serious limitations, for flows in any season can be above or below the expected seasonal flow range for prolonged periods of time. A much simpler and more direct way to avoid this is to use flow-based blocks, in which minimum flow percentages are defined for different flow ranges, an approach which the District has recommended for the Little Manatee, which I strongly support.

Flow based minimum flows have previously been determined by the District for estuarine rivers, such as the Lower Pithlachascotee and the Lower Peace. In these rivers, the relationships of variables to freshwater inflow within the estuary were examined to determine ranges of flows where different percent withdrawal limits should be applied. Combined with a low flow cutoff, this is a very effective way to largely preserve natural flow characteristics, protect the estuary from significant harm, and make water proportionately more available as flows increase.

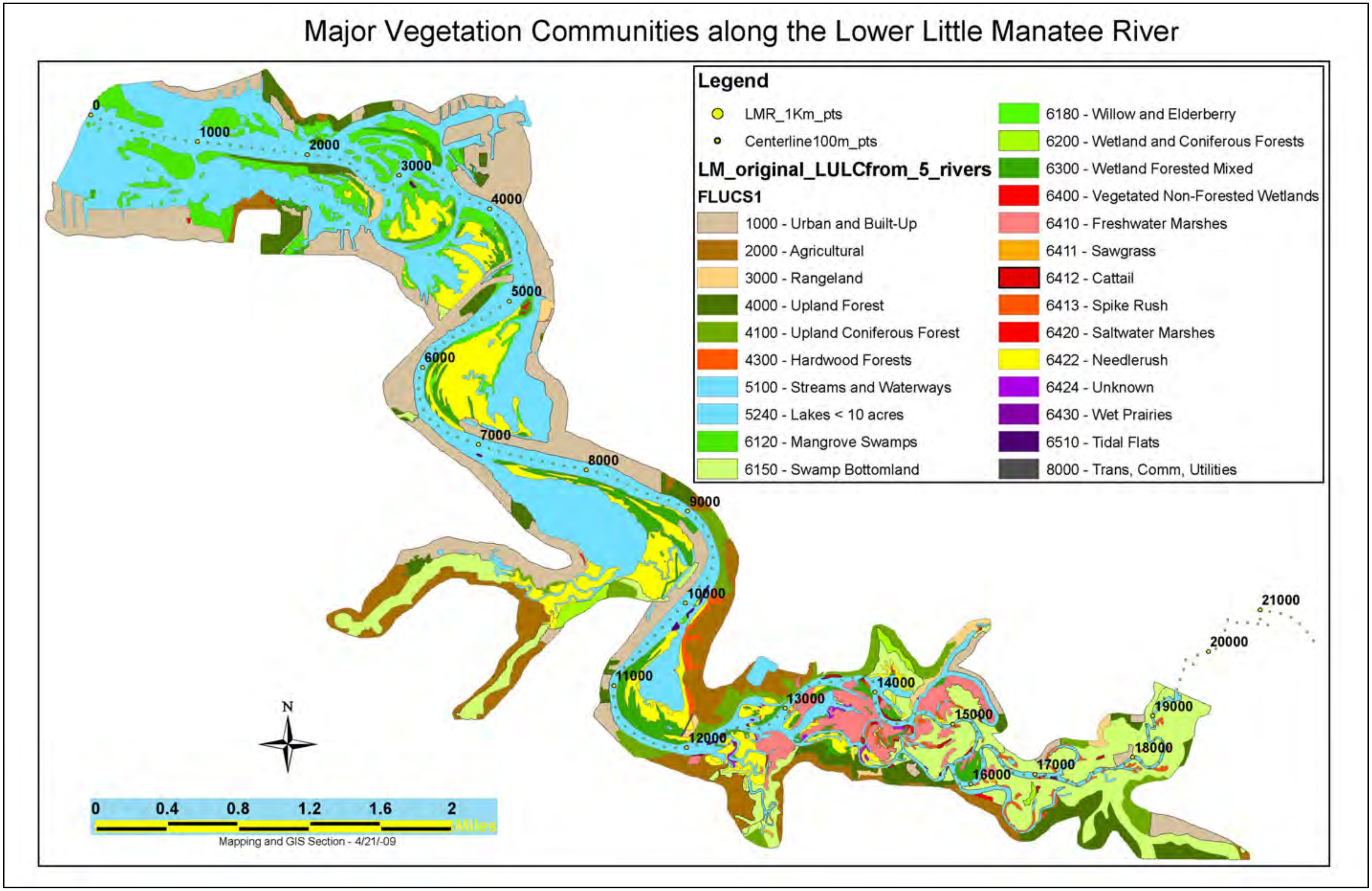
The problem with the Little Manatee River report is that flow thresholds of 35 and 72 cfs were based solely on environmental analyses of the freshwater reach of the river. These flow thresholds are then applied to the estuarine reach of lower river as well. This is a first, as the District has never done this before, and it is probably not the best approach.

As was done for the Lower Pithlachascotee and Lower Peace Rivers, the response of key variables in the estuary to freshwater inflows should be examined separately for a series of flow ranges. Flow thresholds can then be identified to switch percent allowable flow reductions. Practical and ecologically effective flow thresholds for the estuarine portion of the Little Manatee might be similar to the flow thresholds identified for the freshwater reach, but you don't know until you analyze the data in that manner.

If necessary, the application of separate thresholds for flow-based blocks for the freshwater and estuarine reaches of a rivers is very feasible from a management perspective and can easily be applied, especially on a small river like the Little Manatee.

I recommend the District conduct further analyses to examine the response of low salinity zones and the environmental favorability functions for fishes in the lower river to freshwater inflow, and determine if separate thresholds for flow-based blocks in the estuarine section of the Little Manatee River are needed. The Lower Little Manatee River is an Outstanding Florida Water, an Aquatic Preserve, and is the jewel of tidal rivers flowing to Tampa Bay. It warrants a high degree of protection and the best analyses possible.

Three slides begin on the following page


Major Vegetation Communities along the Lower Little Manatee River
Legend
LMR_1Km_pts
Centerline100m_pts
LM_original_LULCfrom_5_rivers
FLUCS1
1000 - Urban and Built-Up
2000 - Agricultural
3000 - Rangeland
4000 - Upland Forest
4100 - Upland Coniferous Forest
4300 - Hardwood Forests
5100 - Streams and Waterways
5240 - Lakes < 10 acres
6120 - Mangrove Swamps
6150 - Swamp Bottomland
6180 - Willow and Elderberry
6200 - Wetland and Coniferous Forests
6300 - Wetland Forested Mixed
6400 - Vegetated Non-Forested Wetlands
6410 - Freshwater Marshes
6411 - Sawgrass
6412 - Cattail
6413 - Spike Rush
6420 - Saltwater Marshes
6422 - Needlerush
6424 - Unknown
6430 - Wet Prairies
6510 - Tidal Flats
8000 - Trans, Comm, Utilities
0
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2000
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Mapping and GIS Section - 4/21/-09

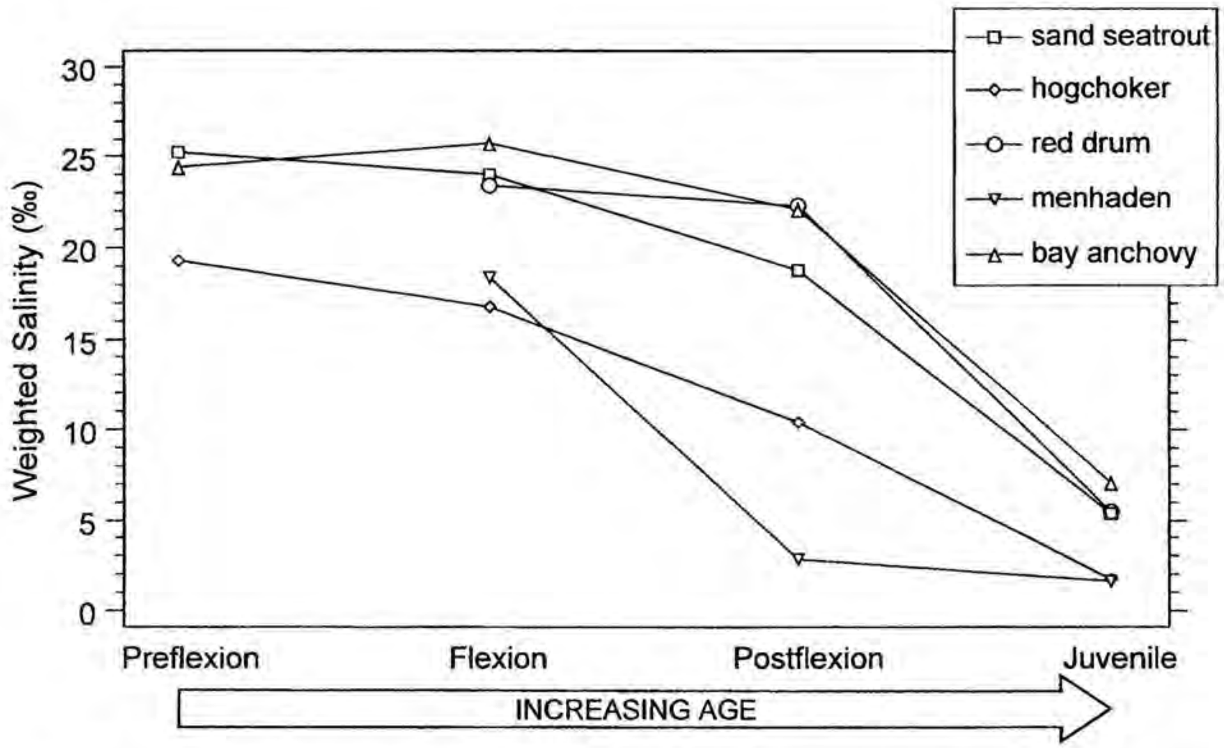

Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

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.					
		Salinity-based stations			
	N	0.5 psu	6 psu	12 psu	18 psu or 20 psu (Peace only)
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Alafia (01/99 - 12/01)	36	15.3	63.4	95.7	43.7

Technical review of the description and analysis of the freshwater flow regime of the Little Manatee River presented in the 2021 SWFWMD minimum flows report

Submitted by Sid Flannery, October 14, 2021

The comments contained in this document pertain to the characterization of the freshwater flow regime of the Little Manatee River presented in the current draft minimum flows report for the river. Some of the comments pertain to the discussion of factors that can affect those flows such as land and water use, climate, and permitted surface water withdrawals and discharges. In a week or two, I will submit additional comments related to the response of various biological and water quality variables in the estuarine portion of the river to freshwater inflow.

In the meantime, the comments below are intended to clarify and enhance the material presented in the District's draft minimum flows report so that readers have a better understanding of the flow regime of the Little Manatee River and how it is related to the ecological characteristics of the river and the potential effects of the proposed minimum flows.

The primary consultant, Janicki Environmental Inc. (JEI), has a done a very good job in justifying the use of flow-based blocks, which I strongly support. Also, the method they developed to adjust the gaged flows to develop a baseline flow record is very good and better than the method presented in the first minimum flow report (Hood et al. 2011).

I realize the District wants to produce minimum flows reports that are concise, but for some topics (e.g., the Florida Power and Light withdrawals), I think the hydrologic characterizations presented in the first minimum flows report are more informative than the material presented in the current report. I suggest the review panel read pages 4-1 and 4-6 to 4-32 to in the first minimum flows report. That report is provided as Appendix A with the current minimum flow report, and possibly in some cases the current report could say something like "See Appendix A for further details on …..". In that regard, I preface some my suggested edits with "At a minimum" and suggest the current report make reference to material presented in the first report. I don't think that is the best solution, but the District could go that route on some items to direct readers to the first minimum flows report for more information on a certain topic.

Organization

In several other minimum flows reports including the Lower Alafia, the Pithlachascotee and the Lower Myakka, the section on the baseline flow adjustment was in the same chapter as the hydrologic characterization, which flowed nicely as the baseline adjustment was described after the presentation of historic trends in rainfall, flows, and anthropogenic factors.

On the other hand, in the current report rainfall and flows are discussed in Chapter 2, while the flow blocks and generation of the baseline flow record are in Chapter 5, as was done for the Lower Peace River minimum flows report. I found this a bit hard to follow, but it is workable and suitable the District did it that way. However, for understanding the potential ecological changes that can result from applying the percent-of-flow method, it is helpful to see some other basic

hydrologic data reductions such as a bar graph of average monthly flows and a flow duration curve of baseline and observed flows. Some suggestions in that regard are presented below, along with other edits to the parts of the report that deal the freshwater flow regime of the river. Another day I will submit comments pertaining to the estuarine results presented in the report.

Suggested edits

Page (P) 18, Lines (L) 4 to 5. This sentence could shortened and slightly revised to read "Compared to other rivers in the region, flow in the Little Manatee watershed has a relatively high mean runoff rate normalized by contributing area. See page 4-10 in the previous minimum flows report (Apppendix A), where average areal based runoff rates for the Little Manatee are listed along with values for five other rivers."

Regarding the second half of this same sentence on page 18, I don't think the Little Manatee has a moderate to high baseflow fraction compared to other rivers such as the Hillsborough, Alafia and Withlacoochee, which all receive some springflow and other flow from the upper Floridan aquifer.

For example, from the minimum flows report for the Lower Alafia River, which is located about 14 miles north of the Little Manatee, the 10th percentile flow of the Alafia is 16.2% of its mean flow. If flows from Lithia and Buckhorn Springs are added to the gaged flows, the 10th percentile flow for the Alafia is 21.9% of its mean flow. In contrast, the 10th percentile flow for gaged flows on Little Manatee for 1996 to 2019 period (24 cfs) listed on page 144 in the current report is 14.4% of the mean flow (167 cfs) for that period.

Keep in mind the baseflow in the gaged record of the Little Manatee has been supplemented by excess agriculture irrigation water and the mean flow I just cited was not corrected for withdrawals from Florida Power and Light. So, the baseflow fraction for natural flows corrected for agricultural flows and FP&L withdrawals would be even lower. Therefore, I would not characterize the Little Manatee has having a moderate to high baseflow fraction. Simply drop that part of the sentence, which will agree better with the statement two sentences later about flows in the river having spiky behavior and low relatively low surface storage, which is accurate.

P28 – 30. I have reservations about over postulating about the effects of the Atlantic Multidecadal Oscillation (AMO). In the more recent warm AMO period (Figure 2-12), which is supposed to result in more rainfall, some of the worst multi-year droughts in the region occurred, including the year 2000 and early 2001 and an eight-year period from 2006 to 2013 when yearly rainfall was below normal for seven years (Figure 2-14). The report says there is not a lot of surface or surficial aquifer storage in the Little Manatee River basin and it responds quickly to rainfall events. In that regard, the time series graph of moving 20 -year average rainfall does not have as much to do with variations in flows the Little Manatee River as it might with rivers with more surface and groundwater storage like Pithlachascotee or the Withlacoochee. A moving average yearly rainfall hydrograph of shorter length would be more appropriate for comparison to flow trends in the Little Manatee. The previous minimum flows report used a moving three-year average rainfall hydrograph (Figure 4-4 on page 4-6).

<u>P38 Section 2.5 (Little Manatee River Flow History)</u> This section of the current report starts off describing the effect of agriculture on past flows, then follows with two short paragraphs and four hydrographs about the gaged flow record, then turns to a discussion of groundwater flow modeling. I suggest it would be better to start of with a description of the flow record and present the hydrographs and discuss the temporal patterns shown in them, then switch to possible causative factors including the groundwater modeling discussion.

P39. Figure 2-24. This figure plots average yearly flows on a semi-log scale with a fitted polynomial trend line. The range of yearly flows appears to be from about 40 to 400 cfs, which should plot fine on an arithmetic scale and would give the readers a better sense of the natural variation in yearly flows. If the polynomial trend was fitted to log transformed data, the current hydrograph could also be shown, but I think would be helpful to also show the flows on an arithmetic scale (see page 4-1 in the previous minimum flow report).

Monthly flows are plotted on a semi-log scale in Figure 2-25, which is helpful as there is much greater range in values. The report says there appears to be no significant long-term trend in monthly flows, but the occurrence of low monthly flows prior to the mid-1970s seems apparent, which is supported by other findings presented in the report. The report does suggest there appears to be a slight increasing trend in dry season flows (October to May), but not wet season flows. As with Figure 2-24, the time series plots of yearly average dry and set season flows on an arithmetic scale would be valuable.

Though the data end in the year 2010, there are very informative hydrographs and trend tests presented in previous minimum flows report by Hood et al. 2011. Having worked in estuarine ecology, I think the eight-month October to May dry season discussed in the current report is too broad for some ecological applications, and examining trends in other flow parameters can be meaningful from a resource management perspective. On pages 4-22 to 4-29, the previous minimum flows report showed some interesting results for trend tests and hydrographs for various yearly percentile flows, which clearly show a rise in values for the yearly 10^{th}, 25^{th}, and 50^{th} percentile flows starting in the mid-1970s. As concluded in the current report, the previous report found no significant change in the higher flows. However, trend tests on monthly flows showed an increase for the dry season months of November, December, April and May. The previous report also showed hydrographs and trend results for moving average flows for various durations from 3 to 120 days, which clearly showed significant increases in their yearly minimum values (e.g, the lowest 60-day moving average flow within each year).

Frankly, I think it would be valuable to repeat such graphical and trend analyses for key flow parameters in the current report and see what the updated results look like, but will defer to the District. However, at a minimum, the current report should at least refer to some of the findings in the previous report, acknowledging the flow data end in 2010.

In the discussion of the effects of agriculture on flows in the river, the current District report should cite and briefly mention the paper by Flannery et al. (1991). I am not saying this to see my name in lights, but rather this was a very large effort that was funded by grants the District received from the Florida Department of Environmental Protection that involved the District, the University of South Florida, the USGS, and land use mapping specialists from the Florida Marine Research Institute. The USGS installed three new streamflow gages in the watershed and baseflow and runoff rates were compared from six sub-basins. Extensive water quality monitoring was conducted and nutrient loading rates were compared from these sub-basins. Water quality sampling of 21 sites was also conducted in May 1988 and May 1990, which showed where mineralized water of groundwater origin was entering the river.

The current report can qualify that these data were collected when the quantities of excess agricultural water entering the river was near maximum. On page 4-31, the previous District report has a very short paragraph about this study, and in a previous section described that since that report was produced there have been improvements in agricultural water use practices and a reduction in excess irrigation water entering the streams. The current District report provides a good summary of changes in land use and water use efficiency and the plot of residuals from the baseline flow analysis (Figure 5-2 on page 105) is very effective. Overall, the findings of the watershed assessment in the late 1980s supports the District's findings and that paper (Flannery et al. 1991) should be cited and quickly summarized in a short paragraph in the current report. A pdf of that paper is submitted along with this review.

Florida Power and Light

Because they utilize an off-stream reservoir and have long used withdrawal schedules linked flow rates, the FP&L facility has been an example of progressive water resource management. Along with the Peace and Alafia Rivers, ecological results and management applications from the Little Manatee River are featured in the 2002 journal article about the percent-of-flow method (Flannery et al, 2002), which is also submitted with this review.

Having said that, the withdrawal schedule that FP&L now uses will have to be revised to comply with the proposed minimum flows, and the description of their withdrawal schedule in the previous minimum flows report is much more informative than the discussion in the current report. In particular, the frequency that the emergency withdrawal schedule has been used and the quantities that were withdrawn from the river is well described in the previous minimum flows report. Again, the District could update and enhance the discussion of the FP&L withdrawals in the current report, or at a minimum, refer to the previous report (Appendix A) which provides a history of the changes in the diversion schedule and the frequency of use for the emergency schedule, acknowledging those data end in 2009.

At a minimum, the District needs to support their statement on page 44 that FP&L withdrawals have been less in recent years. The previous report listed an average water withdrawal by FP&L of 9.1 cfs for the 1976-2009 period, pointing out that includes the initial filling of the

reservoir. The previous report also mentioned this average withdrawal rate was largely driven by the diversion of high flows, as no withdrawals occurred on 71 percent of the days during that period. The District could easily characterize diversions by FPL during recent years, and at an absolute minimum, report an average diversion value for 2010 to 2020.

I was very involved in the re-evaluation and the revision of the FP&L withdrawal schedule, and toward the end of this peer review process, will offer some thoughts on further revision of their schedule to comply with the minimum flows. As a sneak preview, I think it would ecologically counter-productive to restrict FP&L to the 13% and 11% allowable freshwater flow reductions at flows in block 3. Reasons will be presented later, but if the final percent allowable reduction for estuarine minimum flows is greater at high flows, that is what FP&L should be regulated on. Tentative for now, but should be the way to go.

Mosaic land use and diversions

On page 44, the current report has a short paragraph about the permitted discharge by Mosaic Company for their phosphate mining operations and cites a report from 2012 (FDEP, 2012) to support the statement that the discharge has been limited for several years. Clearly, any characterization of discharges from the D-001 outfall needs to be updated.

As with FP&L, a good description of Mosaic's land use and hydrographs and characterization of the discharges for 1996 to 2009 is provided in the previous District report (pages 4-18 to 4-22). That report described why it would be difficult to create a baseline flow record adjusted for these discharges, so that was not done as part of that study. On page 4-20, the previous report shows an excellent map that showed the status of various categories of the Mosaic Company's lands (e.g., mined, reclaimed, preserved) and described the status of these land use categories and the percentages of the river watershed they represented.

In Section 2.2, the current District report generally characterizes extractive land covers, but provides no information on the status of those lands, such as what is currently and previously mined, reclaimed, preserved, or other. The land use maps that are shown have Extractive land use included as part of Urban and Built-Up, but Table 2-1 has the acreages of Extractive separately quantified over time. The previous District report states that Mosaic owns 26% of the Little Manatee River watershed. Given that a quarter of the watershed is owned by a phosphate mining company, it would improve the current District report to provide a more comprehensive update on the status of Mosaic's land holdings and the projections for future mining.

The District could cite the section on phosphate mining in the previous minimum flows report, but qualify that those results and projections are out of date and may no longer apply. At a minimum, the District needs to access the discharge records for the D-001 outfall and present an updated hydrograph and statistics for those discharges.

Nitrogen trends

In Section 3.3.2 (pages 54-56) the current report presents information on concentrations and trends for various forms of nitrogen measured by the Environmental Protection Commission of Hillsborough County (EPCHC). With the exception of organic nitrogen at freshwater station 113 at the Highway 301 bridge, concentrations were either decreasing or showed no trend. These results are encouraging, and it is good that the tidal section of the Little Manatee River has very little hypoxia (low dissolved oxygen concentrations). With regard to chlorophyll *a*, concentrations generally do not indicate impairment, but as will be discussed in the next review I submit, there are periodically very high chlorophyll *a* concentrations in the upper reaches of the tidal river and the potential effects of flow reductions need to be examined further. But that is for another day.

For now, I think it would be useful for the minimum flows to very briefly point out while that nitrogen concentrations have generally been either decreasing or non-trending in recent years, water in the Little Manatee River is nitrogen enriched compared to decades prior to the 1970s. Historical data presented as part of the late 1980s watershed assessment (Flannery et al. 1991) found that nitrate-nitrite concentrations have increased greatly since the mid-1970s, which corresponds to the increase in agricultural land use. The previous minimum flows report also reported an increase in nitrate-nitrite concentrations measured by the USGS, but the data ended in 1999 (pages 5-4 and 5-5). Increases in specific conductance, which are shown in Figure 12 in Flannery et al. (1991) and Figure 4-23 in the previous minimum flows report, show this same temporal trend, indicating the effect of agricultural land and water use on the river.

Also, during the 1988-1989 study period, the phosphate mining operations were largely inactive and the Ft. Lonesome station in the river upper river sub-basin served somewhat as a control site. Nitrogen concentrations and loading rates from that sub-basin were much less than from downstream sub-basins where there was much more agriculture. The point of this is the current minimum flows report could have one or two sentences that say that although nitrogen has been non-trending or decreasing in recent years, historical data indicate the the river is nitrogen enriched compared to before the 1970s (Flannery et al. 1991, Hood et al. 2011)

P 103 – **Excess flows and adjustment of the baseline flow record**.

The consultant (JEI) did a very nice job on the method for adjusting the gaged flows to develop a baseline flow record, which was an improvement over the method used in the previous District report. However, it is interesting the previous peer review panel did not criticize the method for adjusting the baseline record in the first minimum flows report, but they waxed at length about the use of benchmark flow periods. Regardless, the current method for adjusting the gaged flow to come up with baseline flows is very useful and the plot of residuals and the LOESS curve plotted in Figure 5-2 (page 105) is very informative. Also, with regard to benchmark flows issue, that is handled well in Section 6.5 in the current report in which the estuarine fish habitat analyses were conducted over four different multi-year periods.

Figure 5-3 on page 106 in the current District report is interesting in that there are large increases in excess flows during July to September, when irrigation rates are small or not occurring. This likely occurs because the excess irrigation raises water levels in the surficial aquifer, which can persist into the wet season and increase runoff potential. Also, the change from more natural land covers to agriculture can result in greater runoff from rainfall events.

In Figure 5-3 (page 106) the current District report cites the Lower Myakka River minimum flows report (Flannery et al. 2007). However, all the work on the excess flows was done by Interflow Engineering, which was presented and cited in the District's Lower Myakka River report. The current Little Manatee report should cite their work, such as Interflow Engineering LLC (2008 or 2009). Panel member Dr. Loper who conducted that work, can review the District's Lower Myakka minimum flows report and conclude which of the three references for Interflow Engineering cited therein should be used.

Also, the caption for the figure should say agricultural excess flows in the Myakka River, because Interflow also simulated total excess flows from all land use changes. In that regard, since it was based on overall rainfall runoff relationships, the baseline corrections done by Janicki Environmental are for total excess flows, though I suspect the predominant source of the excess flows results from agricultural land and water use.

A few basic graphics of a table to describe the flow regime of the Little Manatee River

The current report could benefit from presenting a few simple graphics and a table to describe the basic streamflow characteristics of the Little Manatee River. Such hydrologic information is important for not only understanding the seasonal and flow duration characteristics of the river, but also for understanding how application of the minimum flows will affect the ecology the river.

A plot of average monthly flows needs to be included to characterize the seasonal flow characteristics of the river. Two figures from page 4-12 in the previous minimum flows report are presented on the following page. This should be updated for the current report. Obviously, the yellow line in the second figure mimics the average monthly flows in the top graphic, but it is helpful to demonstrate how flows are lagged with regard to seasonal rainfall during some months of the year.

Also, as previously described, the Little Manatee River has a relatively high rate of basin runoff, a spikey response to rainfall events, and a relatively low rate of baseflow. These flow characteristics are manifested in the graphs on the following page where the difference in average monthly flows between the spring dry season and late summer flows is among the highest in the region. As will be described later in this review, the springtime dry season is especially important to the ecology of the freshwater river and the estuary and flow reductions must be managed very carefully during that time of year.

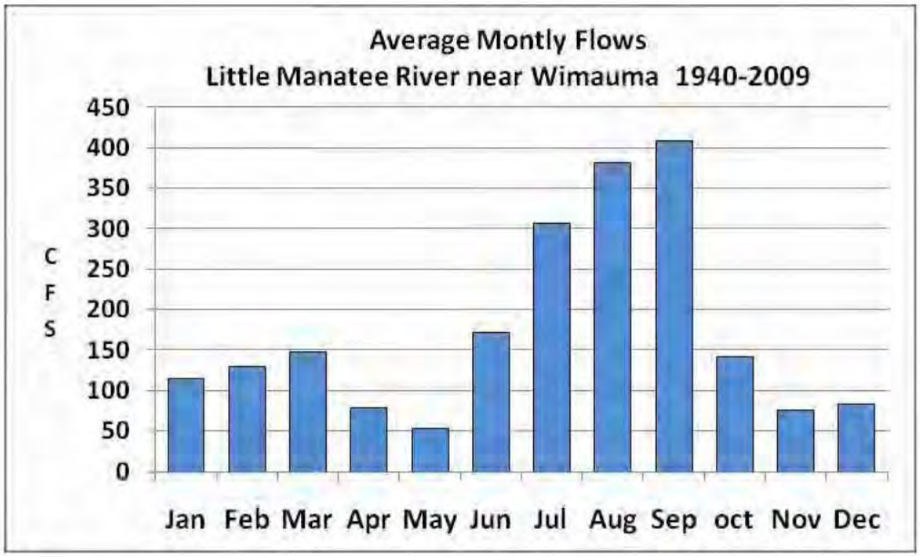


Figure 4-9. Average monthly rates of flow for the Little Manatee River near Wimauma for the years 1940-2009.

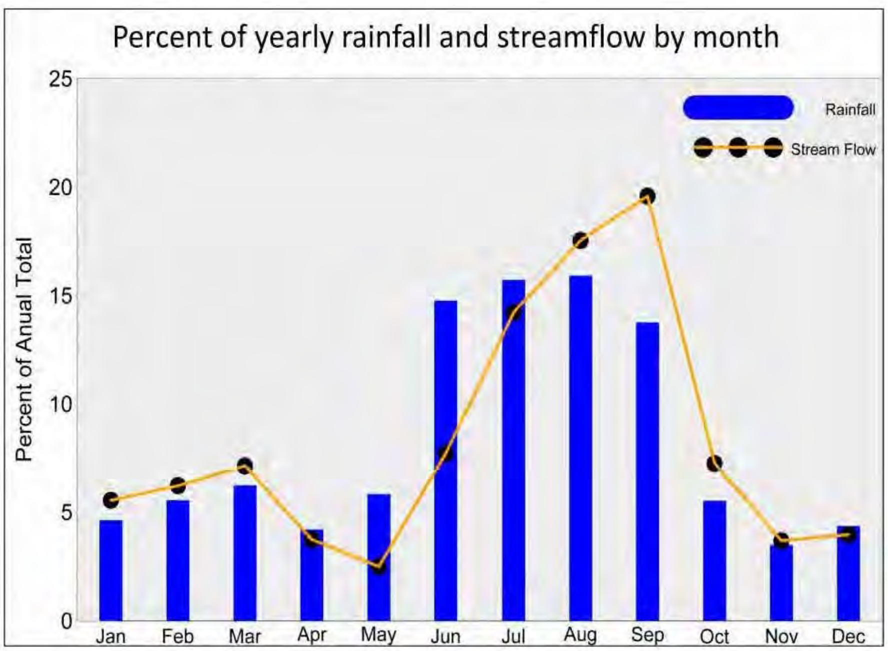


Figure 4-10. The percentage of yearly rainfall and streamflow by month for the Little Manatee River watershed and the LMR Wimauma gage.

4-12

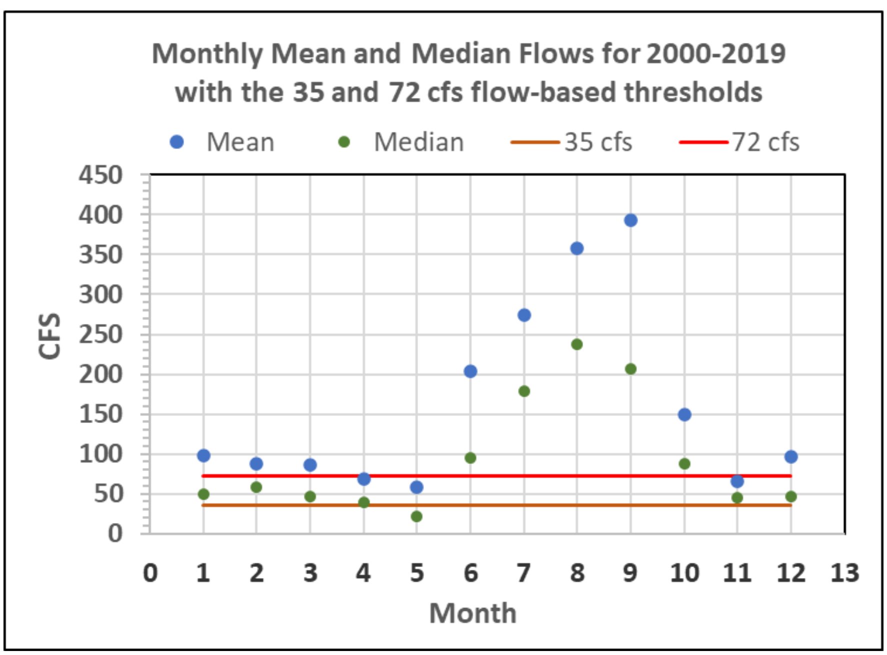
Figures 4-9 and 4-10 from the previous minimum flows report (Hood et al., 2011)

Also, in application of the percent-of-flow method it is very important to understand the seasonal flow duration characteristics of the river, particularly how often the different flow-based blocks will be in effect. In the second paragraph on page 103 the current report states "For reference, 35 cfs is the 34th non-exceedance percentile and 72 cfs is the 60th non-exceedance percentile." This is one of the most important findings in the report, and in general, the amounts of time that flows will be within the various flow-based blocks needs more description and emphasis in the report.

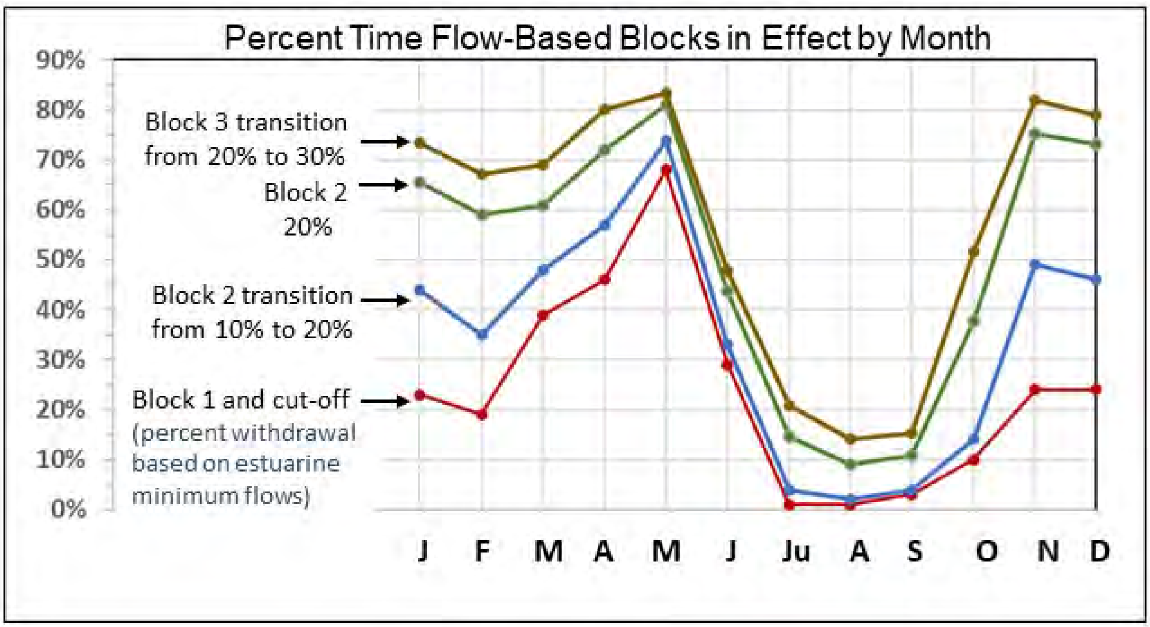
As part of such a description, it would be also helpful to see present a flow duration curve (cumulative distribution function) for the baseline and uncorrected flows for the 1976 to recent period. Both data sets should include corrections for FP&L withdrawals from the river. Also, various percentiles from these two flow records could listed in in a table, as in Table 2 in the first peer review report (Appendix B) or Table 4-2 (page 4-11) in the previous minimum flows report. The current report does show a flow duration curve and some percentile flows for the unadjusted flows at the USGS streamflow gage for four different time periods, but a similar table for baseline and observed flows together would be helpful.

Also, this critical hydrologic information is included in the Sections 5 and 6 of the report. It is probably too late now, but reorganization of the report to put the hydrologic characterization, including the adjustment for baseline flows, in Chapter 2 would be helpful, from where it could be referred to as needed later in the report.

Although flow durations for the entire period of analysis are important, it also useful to see how the flow-based blocks correspond to different seasons in the year. The 35 cfs threshold between blocks 1 and 2 and the 72 cfs threshold between blocks 2 and 3 are show in the figure below along with the average and median flows for each month for a recent 20-year period. It is apparent there are very large differences between months in how frequently flows in the river will be within the different flow-based flows, which has important implications for the ecological effects of the minimum flows.



The figure below shows how often the flow-based blocks would be in effect on a monthly basis. Note that lines are included for the transition between blocks 1 and 2 and between blocks 2 and 3. This is because the full percentage flow reduction for a given block cannot be achieved until flows get to a certain flow rate. For example, using the proposed minimum flows for the estuarine lower river, a 30% flow reduction at 77 cfs in block 3 would result in less flow than a 20% flow reduction at 70 cfs in block 2. Therefore, minimum flows rules typically provide for a transition range between blocks. This operations plan is feasible and is how water user permits for withdrawals from rivers using the percent-of-flow method are currently managed, as the utilities know for each rate of daily flow the amount they can withdraw.



The region below each line is the percent of time that flow reduction, or a lesser flow reduction, will be in effect. For example, in January flows are less than the block 1 cutoff 35 cfs threshold 23 percent of the time. Flows are in the block 2 transition 21 percent of the time, which is the difference between the blue and red lines (44% and 23%, respectively). Full block 2 flow reductions for January will be in effect of 22 percent of the time (66% minus 44%). Flows are fully in block three above the brown line, or 100 percent minus the value of the brown line, which would be 27% of the time (100% – 73%) for January.

Given the large differences in seasonal flows, it is striking how often the different flow blocks will be in effect in the various months. On average, flows are below the 35 cfs low flow cutoff 68% of the time in May, but only 3% of the time in September. Conversely, flows are in block 3 for 85% of the time in September. However, it is emphasized that these are average conditions over 20 years, and flows can be above or below a given threshold for longer periods of time in a specific year.

Seasons are still relevant

As previously described in this review and the document I submitted on October 6th, the District has gone to flow-based blocks for both the freshwater and estuarine reaches of the river. This is a first, for the District has previously used seasonal blocks for freshwater systems.

I support this approach, but emphasize the District continue to consider seasonal factors in their minimum flows analyses. I was not involved in the earlier PHABSIM evaluations of for freshwater systems, but apparently some freshwater fish species have a strong seasonal component to their reproductive cycles and habitat use patterns.

There are also strong seasonal factors in estuaries, with two figures shown below as examples. It has been repeatedly shown in tidal rivers, with and example shown for the Lower Alafia, that the number of larval fish taxa increases rapidly in the spring due to seasonal fish spawning. Based on estuarine considerations, the journal article by Flannery et al. (2002) suggested that flow reductions should be most restrictive in the spring (article submitted with this review). On the other hand, as shown below, the migration of red drum juveniles into the Little Manatee River occurs in the fall and winter (from MacDonald et al. 2007 cited in the current minimum flows report).

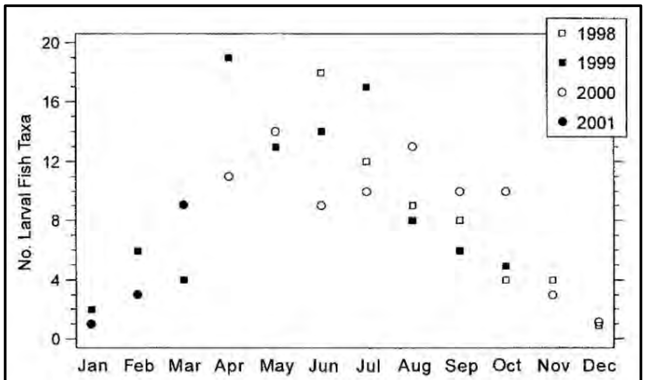
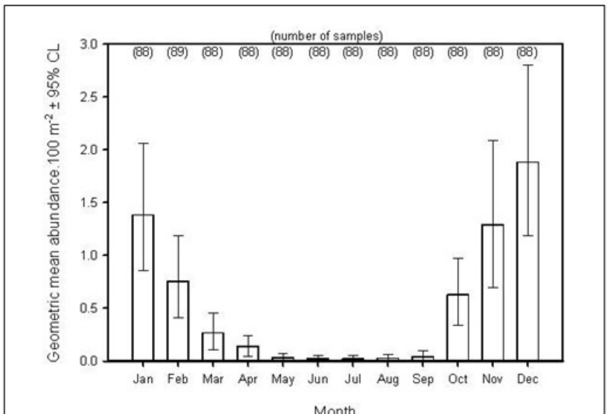


Fig. 9. The seasonal distribution of approximate larval richness in the tidal Alafia River (data from Peebles 2002a).



Red drum, all size classes (primarily juveniles)

Seasonal factors are also important for water quality in estuaries, as hypoxia is often most frequent in the summer during times of high water temperatures. Similarly, low flows and increasing water temperatures often contribute to large phytoplankton blooms in the spring.

All things considered, I think the flow-based approach proposed for the Little Manatee River is appropriate for the tidal portion of the river, in part because using the percent-of-flow method withdrawals in the springtime will be very low. However, as I recommended in the review submitted on October 6th, I strongly recommend that flow-based blocks be evaluated separately for the freshwater and estuarine sections of the river.

I also think the flow-based approach has important advantages for the freshwater section of the river, but I have not worked on the freshwater biological communities in the river and I defer to the District and the review panel. However, for both freshwater and estuarine systems, I suggest the District continue to evaluate seasonal factors and incorporate them in the minimum flows as needed.

Summary Points

- For some topics, the previous minimum flows report is very informative and the current report should refer to it, although it would be better to repeat those analyses or presentations
- It is probably too late, but the report could be reorganized to put the method for baseline flow creation and flow duration characteristics in Chapter 2 with the other hydrologic information
- The differences between seasonal low and high flows in the Little Manatee are among the highest in the region, so it should not be characterized as having moderate to high baseflow
- The discussion of the AMO has less relevance to the Little Manatee than some other rivers
- Chapter 2 should be slightly reorganized to present the flow hydrographs first, then discuss possible causative factors
- Some time series plots of flows on semi-log scale should be changed to an arithmetic scale
- Some of the trend analyses for flow parameters presented in the first minimum flows report should be repeated or as least referred to
- The report should reference the watershed assessment done by the District in the late 1980s as it was a very large effort that supports the District's current findings regarding flows in the river
- The description of Florida Power and Light's withdrawals from the river should be expanded, or at least refer to the previous District report and list an average withdrawal rate since 2010
- The description of the current status of Mosaic Company's land holdings and rates of outfall discharge should be expanded, or least refer to the previous District report and update the discharge records at the outfall
- The report should acknowledge that while water quality trends in recent years are encouraging, the Little Manatee River is nitrogen enriched compared to decades prior to the 1970s
- The report should cite Interflow Engineering regarding excess flows in the Myakka River
- The report should include some graphs of the basic hydrologic characteristics of the Little Manatee and a flow duration curve and table of percentiles for observed and baseline flows.
- The report should describe how often flows will be within the various flow blocks by month or season
- Seasons are important for biological use of both the freshwater and estuarine sections of rivers. The District should continue to evaluate seasonal relationships in their minimum flows analyses and incorporate seasonal factors in proposed minimum flow rules as necessary
- The flow-based blocks seem to work well for the Little Manatee River, in part because the resulting maximum allowable flow reductions will be small in the springtime.
- The District should establish flow-based blocks separately for the freshwater and estuarine sections of the Little Manatee River

Public comments given at second Little Manatee River minimum flows peer review meeting by Sid Flannery, Oct. 20, 2021

As I mentioned at the kickoff meeting two weeks ago, I am a retired Chief Environmental Scientist with the District's minimum flows program where I worked extensively on the Little Manatee River. I have submitted three sets of comments to the District regarding the minimum flows report. The first set of comments were posted 12 days ago, the second two days ago, and the third set today.

Regarding my second set of comments, I think the District could easily improve parts of the report that describe the streamflow characteristics of the Little Manatee to make it more understandable and comparable to the ecological characteristics of the river. For example, for understanding the ecology of the lower river estuary, a useful piece of information is a simple bar graph of average monthly flows, but one does not appear in the report

Also, for assessing both the ecological and water management aspects of minimum flows that are based on the percent-of-flow method, it is very informative to view the flow duration characteristics of a river on a seasonal and monthly basis, and how often the different flow-based blocks would be applied. I have included a couple of graphics of such values in my comments that I think you will find interesting.

My review also points out that the withdrawals by Florida Power and Light and the phosphate mining operations by the Mosaic Company, which are still ongoing, were described in much better detail in the previous minimum flows report. The District should expand the description of phosphate mining in the current minimum flows report and update the discharge records for Mosaic's point source outfall.

I also recommend the District cite, and with one short paragraph, summarize a paper that resulted from a FDEP funded watershed assessment that the District and other agencies performed in the late 1980s, as it provides valuable information that supports the hydrologic results presented in the minimum flows report.

The comments that were uploaded today discuss published biological studies I think the District should cite and briefly describe in the minimum flows report. Even though estuarine minimum flows are sometimes based on the modeling of just a few parameters, it benefits and improves minimum flows reports to describe the other ecological characteristics of a tidal river estuary that are related to freshwater inflow and minimum flows.

There are five informative reports that need to be cited the minimum flows report. For example, a zooplankton study of the lower river was conducted by the University of South Florida. Zooplankton are an important food source for young fish, and they play a critical role in the nursery function that estuaries provide for sport and commercial fisheries. Among other findings, the USF report shows plots of zooplankton density vs. salinity and the rate freshwater inflow, which are obviously relevant to minimum flows.

There are four reports that are cited in minimum flows report that could benefit from a bit more description. For example, on page 78 the report has a single sentence that says a survey of mollusks in river was performed, but does not mention any findings. In the document that was posted today, I've included a graphic from the mollusk report that clearly shows strong spatial partitioning of species along the river's salinity gradient. Also, the mollusk report describes the distribution of oyster reefs in the lower river, which comprise a key biological community whose health is related to the quantity of freshwater inflow.

So, in the document that was uploaded today, I have provided an overview of these reports and provided text, sometimes with a figure or table, the District could include in the minimum flows report to better describe the biological characteristics of the lower river that are related to salinity and freshwater inflows. These findings do not invalidate, but instead provide important justification for minimum flows. The text I have provided is fairly brief and should be fairly easy to incorporate. I also want to point out the Lower Little Manatee Rive is a State of Florida Aquatic Preserve, and it would be very helpful for the minimum flows report to cite and briefly describe valuable biological information that is available for it.

There is one section of my comments that were uploaded today that do not concern biology. Section 5.1 of those comments concerns residence time simulations that were conducted as part of the development of the EFDC hydrodynamic model of the lower river by Drs. Huang and Liu of Florida State University. That residence time work was described in the final project report by Dr. Huang and needs to be mentioned* in the minimum flows report. Residence time is directly related to rate of freshwater inflow, and as demonstrated by model simulations and analyses that Xinjian and I conducted on the Lower Alafia River, changes in residence time can affect water quality in tidal rivers.

So, that concludes my verbal comments for today. Next week I will speak to the need to develop flow thresholds for switching between low, medium, and high flow blocks separately for the freshwater and estuarine sections of the river. That topic was discussed in my first comments that were uploaded 12 days ago, so please consult that document for an overview of that topic.

* On page 125, residence time is mentioned in a sentence with two other objectives the FSU project addressed with the EFDC model, but a brief discussion of the residence time work is needed

Overview of selected technical reports about the Little Manatee River and suggested text, figures, or tables for the District's minimum flows report

Prepared by Sid Flannery, October 19, 2021

This document provides an overview of technical reports about the Lower Little Manatee River that were prepared for the District by staff from the State University System, the Florida Marine Research Institute, or Mote Marine Laboratory. I have also prepared paragraphs or single pages of text that include a figure or table that can be inserted into the minimum flows report to present findings from these reports that describe important relationships of the lower river to freshwater inflows.

These findings support the technical basis for the recommended minimum flows and provide valuable information on the physical, chemical and biological characteristics of the Little Manatee River. As described in the 2002 paper in the journal *Estuaries*, the Little Manatee was one of the three rivers on which the development of the percent-of-flow approach for minimum flows was initially based (Flannery et al. 2002). Furthermore, the tidal reach of the Little Manatee River is a State of Florida Aquatic Preserve and one of the most valued natural resources in the Tampa Bay region. As such, it would be beneficial for the report to briefly describe its biological characteristics, especially as they relate to freshwater inflows that will be affected by the proposed minimum flow rules.

1.1 Overview of Phytoplankton Reports

Dr. Gabriel Vargo of the USF College of Marine Science published two reports for the District about phytoplankton related parameters in the Little Manatee River based on just over two years of sampling from December 1987 to January 2000 (Vargo, 1989, 1991). In a separate report, he compared these data to phytoplankton related data collected from the Lower Peace and Alafia Rivers that used a similar salinity based sampling design (Vargo et al. 2004). None of these three reports are currently cited in the draft minimum flows report, but it does cite a paper that Dr. Vargo submitted to the proceedings of the BASIS 2 conference (Vargo et al. 1991).

Combined, these three reports are very informative about the relationships of different salinity zones to phytoplankton related parameters in tidal rivers, particularly the unusual characteristic of the Little Manatee in which the highest phytoplankton counts and chlorophyll *a* concentrations typically occur at the interface of fresh and brackish waters (0.5 psu), compared to other rivers where the highest phytoplankton counts and chlorophyll *a* concentrations typically occur in mesohaline waters.

In a week or so, I will present data that indicate that relationships of chlorophyll *a* to the rate of freshwater inflow and residence time in the lower river could be important to determining flow thresholds to switch between low, medium, and high minimum flow blocks for the estuarine section of the Little Manatee.

References for the three phytoplankton reports are below, including brief overviews of that work. This is followed text on page 4 that I suggest be inserted into the minimum flows report regarding the phytoplankton work on the Little Manatee River.

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

> Nutrients, chlorophyll *a*, and primary production were monitored on a bi-weekly basis for one year at four moving salinity based stations in the Little Manatee River and two fixed location stations; one near the mouth of the river in Tampa Bay and one in Ruskin Inlet, an urbanized inlet to the middle reaches of the Little Manatee River estuary. Among the salinity based stations, mean chlorophyll *a* and primary production rates were greatest at the 0.5 psu station and lowest at the 18 psu station. The Little Manatee has very low N:P rations due to high inorganic phosphorus concentrations in the river water.

Vargo, G.A. 1991. Phytoplankton studies in the Little Manatee River and Tampa Bay: Species Composition, Size Fractionated Chlorophyll, Primary Production, and Nitrogen Enrichment Studies. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> During the second year of a two-year study of phytoplankton populations in the Little Manatee River and adjacent waters of Tampa Bay, nutrients, size fractionated values for chlorophyll *a* and primary production rates were monitored monthly at a moving 12 psu salinity station in the river and a fixed location station in Tampa Bay. Phytoplankton populations were found to be nutrient sufficient or borderline nitrogen limited with respect to short-term photosynthesis, but long-term growth and biomass were clearly nitrogen limited based on bioassays of natural populations.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> Phytoplankton populations, nutrients and chlorophyll *a* concentrations were compared from similar, salinity based sampling designs in the Lower Alafia, Peace, and Little Manatee Rivers. Samples were collected on at least a monthly basis at the locations 0.5, 6, 12, and 18 psu surface salinity values in each river, with exception of the location of 20 psu being sampled in the Peace River. Mean phytoplankton counts were highest at the 12 psu station in the Alafia, the 6 psu station in the Peace, and the 0.5 psu station in the Little Manatee (see figure on next page). Phytoplankton counts were frequently an order of magnitude higher in the Alafia compared to the other rivers, presumably due to high nutrient loading from that watershed. In the figure on the next page, note separate axis for the Alafia River, which is an order of magnitude greater.

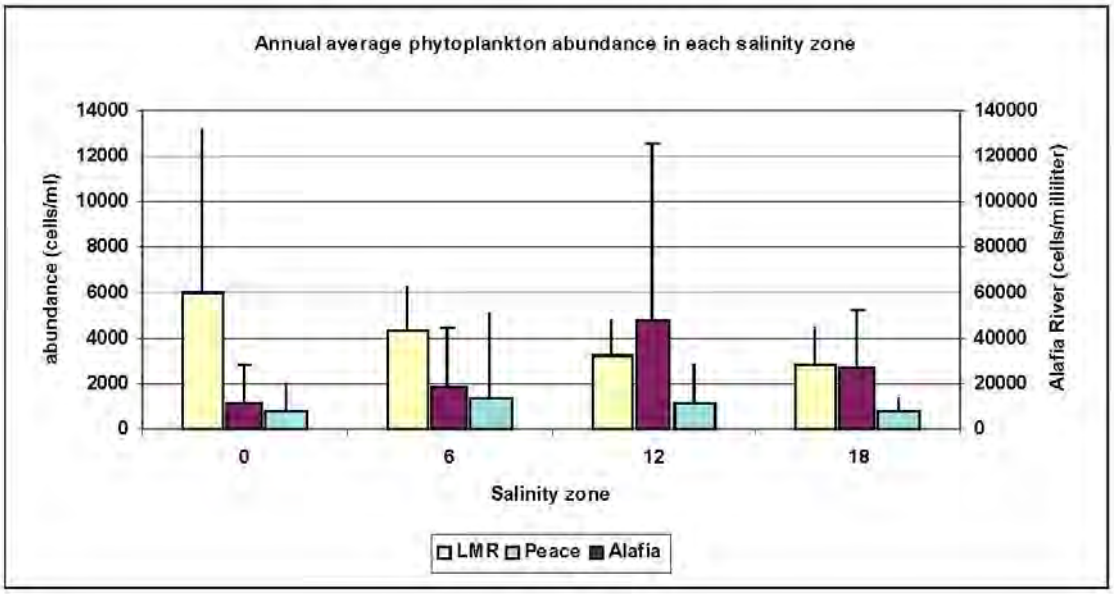


Figure X. Annual average phytoplankton abundance in the Little Manatee, Peace, and Alafia Rivers by salinity zone (20 psu for the Peace grouped with 18 psu). The Alafia is shown on a separate axis since the counts are an order of magnitude greater than the other rivers. From Vargo et al. (2004)

Mean values for chlorophyll *a* concentrations during the phytoplankton sampling periods for these rivers are listed on the following page. The much higher chlorophyll concentrations in the Alafia River are apparent, especially in mesohaline waters. Similar to the phytoplankton count data, the pattern for high chlorophyll *a* in the very low salinity zone (0.5 psu) in the Little Manatee River is again apparent, as are the high concentrations in the mesohaline zones for the Peace and Alafia. Although cell counts are higher in the mesohaline zone in the Little Manatee than in the Peace, chlorophyll *a* concentrations were higher in the Peace due to differences in the species composition of the phytoplankton between the rivers.

Comment - I think that differences in residence time for the Little Manatee contribute to it having its highest phytoplankton abundance and chlorophyll *a* concentrations at the 0.5 psu zone. The upper reaches of the Little Manatee are braided, and given the smaller rates of freshwater inflow, water moves more slowly through the tidal freshwater and oligohaline zones of the Little Manatee compared to the other rivers. All of these rivers (Peace, Alafia and Little Manatee) have residence time values that were generated from hydrodynamic model simulations.

Suggested page for phytoplankton. I think the Little Manatee minimum flows report could contain one page that ties the findings from these reports together. As an example, I have prepared three paragraphs and a table on the following page.

1.2 Phytoplankton (suggested text)

Based on just over two years of sampling spanning 1988 and 1989, the University of South Florida College of Marine Science produced two reports describing phytoplankton related parameters in the tidal reaches of the Little Manatee River and a nearby station in Tampa Bay (Vargo 1989, 1991). Data for nutrients, light penetration, chlorophyll *a*, phytoplankton species composition and primary production rates were measured at four moving salinity-based stations in the river and a fixed location station near the mouth of the river in Tampa Bay (Vargo 1989). Nutrient concentrations in the Little Manatee were characterized by very low nitrogen/phosphorus ratios (generally less than 2) due to high phosphorus concentrations in the inflowing river water. The second of these reports concluded that increased nitrogen loading could result in increased algal biomass and eutrophication in the tidal river (Vargo 1991).

In a subsequent report, (Vargo et al. 2004) compared data from the Little Manatee to phytoplankton related data collected in the Lower Peace and Alafia Rivers that were collected using a similar moving salinity-based design. The highest phytoplankton counts and chlorophyll *a* concentrations typically occurred at the interface of fresh and brackish waters (0.5 psu salinity) in the Little Manatee, whereas the highest cell counts and chlorophyll *a* concentrations typically occurred in mesohaline waters (6 and 12 psu salinity) in the Peace and Alafia (Table x). Using a separate data set for the Alafia, Vargo et al. (1991) compared chlorophyll *a* concentrations and primary production rates for the Little Manatee, the Alafia, and a nearby station in Tampa Bay.

Table X. 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

The high chlorophyll *a* concentrations at the freshwater/brackish water interface in the Little Manatee may be related to comparatively long residence times there, which were simulated as part of the development of the hydrodynamic EFDC model for the river (Huang and Liu 2007, Huang et al. 2010, 2011). These comparatively long residence times are related to the braided morphology of the river between kilometers 12 and 16, where the water slows compared to the upstream freshwater reach. These findings and data presented in this report indicate chlorophyll *a* concentrations in the upper reaches of the tidal river could be sensitive to the effects of freshwater flow reductions.

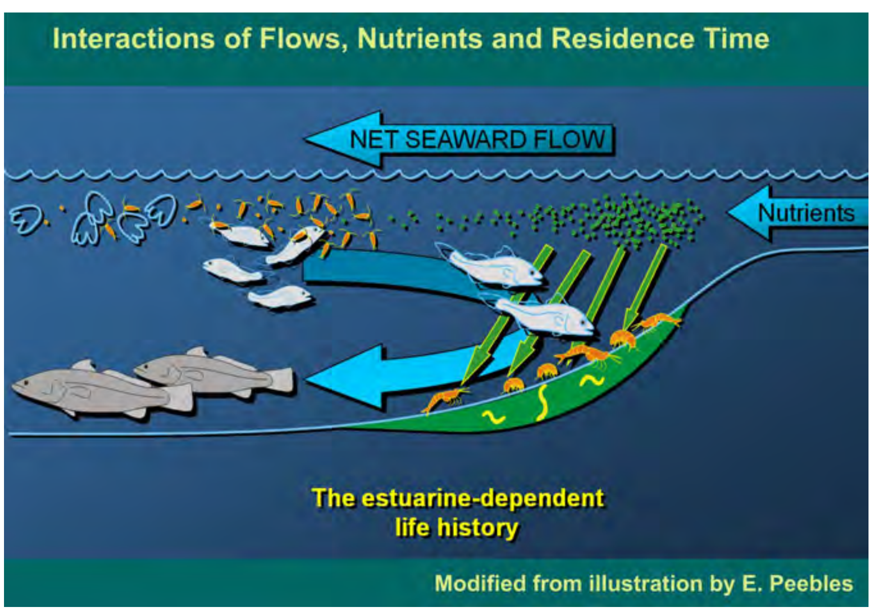
2.1 Overview – Zooplankton Report

Zooplankton were sampled in the estuarine section of the Little Manatee River during 1988 and 1989 concurrently at the same stations as the ichthyoplankton work performed by Dr. Ernst Peebles. Five stations were sampled ranging from the mouth of the river to kilometer 14.2, with another station located at a nearby site in Tampa Bay. The second of these two reports is the more comprehensive of the two and should be briefly described in the District report.

Rast, J.R. and T. L. Hopkins. 1989. The Zooplankton of the Little Manatee River Estuary, Florida. First yearly report. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Rast, J.P., M.E. Flock, T. T. Sutton and T. L. Hopkins. 1991. The Zooplankton of the Little Manatee River Estuary: Species Composition, Distribution, and Relationships with Salinity and Freshwater Discharge. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

In contrast to fish and benthic macroinvertebrate studies, which have been conducted in many rivers, this is the only true zooplankton study in the region's tidal rivers and it is very informative. The second report describes the abundance and distribution of zooplankton, which for many species are more abundant in the lower reaches of the tidal river. Following the tidal river engine concept developed by Peebles (illustration below), this is where the larval stages of many fishes are concentrated early in their life history when they feed on zooplankton. As they grow to juveniles, these fishes migrate to lower salinity waters and feed more on benthic oriented prey. See the illustration below, all evidence I've seen indicates this conceptual model is generally true.



The abundance of zooplankton in higher salinity waters in the lower river probably also results in increased grazing of phytoplankton and contributes to the tendency for chlorophyll *a* concentrations to be lower and more stable near the mouth of the river. Conversely, ungrazed phytoplankton blooms in lower salinity waters probably results in more deposition (see illustration).

The District minimum flows report could briefly summarize the zooplankton study. Along with one table, this would fit on one page and not substantially affect the pagination of the report. Suggested text for a brief discussion of the zooplankton is provided on the following page

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2.2 Zooplankton (Suggested text)

Zooplankton in the Lower Little Manatee River were studied during 1988 and 1989 by the University of South Florida College of Marine Science (Rast et al. 1991). These data were collected concurrently with the ichthyoplankton work in the lower river (Peebles and Flannery, 1992), at the same five locations that ranged from kilometers 0 to 14.2, plus a nearby station in Tampa Bay. This project provides valuable information for the abundance and distribution of major zooplankton groups in the lower river, including; holoplankton (entire life cycle in the water column), meroplankton (in the water column for only a portion of their life cycle), tychoplankton (swept off of the river bottom) and hypoplankton (swim off the bottom for a limited amount of time).

Average values for the abundance and estimated biomass of these zooplankton groups are listed in Table X. Holoplankton and meroplankton had their highest values and biomass near the mouth of the river and Tampa Bay, whereas combined tycho-hypoplankton had highest values in the middle and upper parts of the lower river (year 1 only as two stations were discontinued in year 2).

Table X. Average density (numbers/m3) and biomass (in parentheses as mg dry weight/m3) for total holoplankton, meroplankton and tycho-hypoplankton for 25 trips from 1/29/88 – 1/31/89

	Bay or River Kilometer					
	Tampa Bay	**0.0**	**3.8**	**7.1**	**10.3**	**14.3**
Holoplankton	309,000 (147.7)	235,000 (87.6)	177,000 (44.5)	150,000 (34.4)	84,300 (15.1)	29,700 (5.7)
Meroplankton	40,900 (23.8)	12,000 (6.5)	4,350 (3.9)	3,540 (1.7)	4,220 (3.6)	1,490 (1.0)
Tycho-hypoplankton	1,520 (3.7)	1,290 (3.5)	1,390 (22.6)	5,820 (11.3)	4,590 (12.7)	1,530 (3.1)

Zooplankton are very important prey for the early life stages of many fishes, and their abundance in the river is important to the nursery function provided for many estuarine dependent fish species. Based on 48 total samples, the report by Rast et al. (1991) provided informative plots of zooplankton density versus salinity and the rate of freshwater inflow for eleven dominant species or taxonomic groups (e.g., *Acartia tonsa*, *Oithona colcarva,* copepod nauplii, polychaete larvae).

The numbers and biomass of the major zooplankton groups were were also plotted vs. salinity and freshwater inflow at the five stations in the river and Tampa Bay. The response of the different species or groups to inflow and salinity differed, with the abundance of several taxa or groups associated with the lower part of the river increasing upstream with decreased freshwater inflow. On the other hand, benthic harpacticoid copepods maintained relatively high abundance in the upper river stations except for very high flow events. In general, this project provides very useful information on how zooplankton species and communities respond to changes in salinity and freshwater inflow, which can affect fish nursery use of the lower river and is related to the establishment of minimum flows.

3.1 Overview – Mollusk Report

Dr. Ernest Estevez of Mote Marine Laboratory performed a field intensive survey of the distribution of mollusks in subtidal and intertidal habitats in the Little Manatee River during August 2006. The draft minimum flows report has one sentence on page 78 that cites Estevez (2006) and states this work was performed, but mentions no findings from the study.

The minimum flows report should provide one table and a brief description of the findings of the Mote study for three reasons. First, the mollusk communities show clear gradients with regard to salinity in the river, which supports the District's use of salinity as a parameter for determining the minimum flows. Secondly, the report describes the distribution of oyster bars in the river, which are important for shoreline stability, improving water quality, and creating habitat for reef associated fauna in the tidal river. Lastly, as previously discussed, the Lower Little Manatee River is an aquatic preserve and the District report should describe the biological communities of the lower river, especially as they relate to freshwater inflows and the determination of minimum flows.

Based on mollusk studies conducted within the District, noted invertebrate biologist Dr. Paul Montagna of Texas A&M University was the senior author of the journal article below that assessed the relationship of salinity to the distribution of mollusk species in tidal creeks and rivers in the region. This study can also be cited along with a discussion of the Mote Marine Study.

> Montagna, P. A., E. D. Estevez, T. A. Palmer and M. S. Flannery. 2008. Meta-analysis of the relationship between salinity and molluscs in tidal river estuaries of southwest Florida, U.S.A. *American Malacological Bulletin* 24:101-115.

Two short paragraphs about the Mote study and Montagna et al. findings are provided on the following page, including one figure. I suggest that this text or something similar, including the figure, be included in minimum flows report to enhance the biological information presented for the river and provide additional support of the recommended minimum flows

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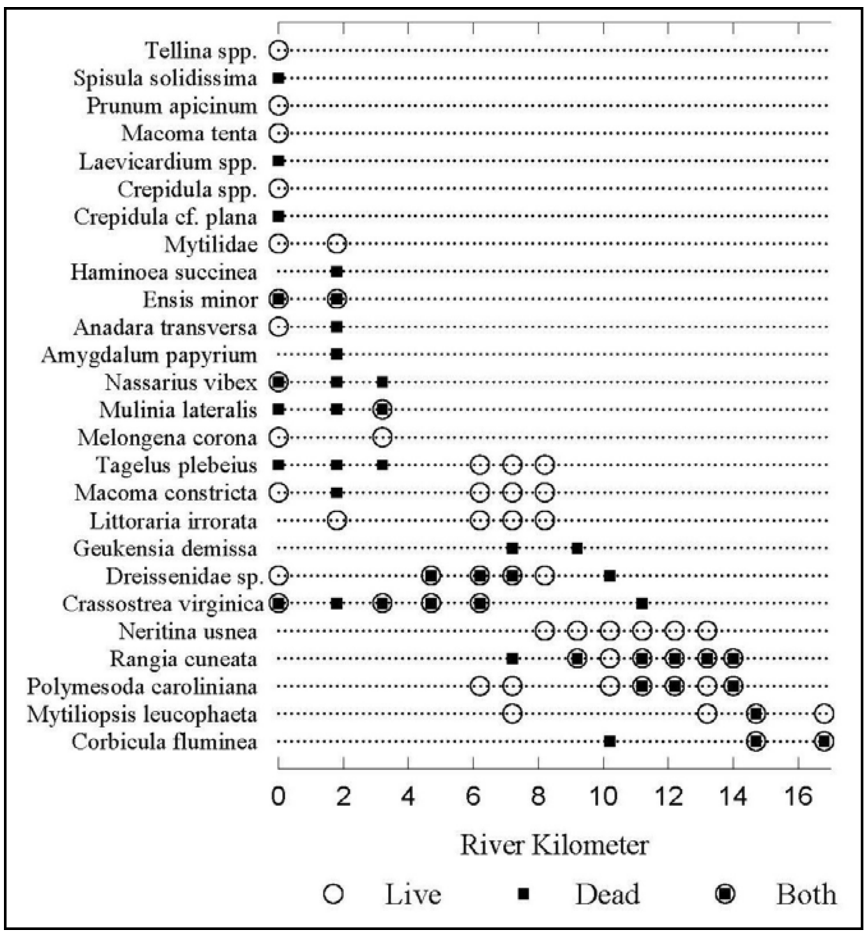
3.2 Mollusks (Suggested Text)

In August of 2006, Dr. Ernest Estevez of Mote Marine Laboratory performed a survey of the distribution of mollusk species in subtidal and intertidal habitats in the Lower Little Manatee River that identified both live mollusks and dead mollusk material (Estevez 2006). Sampling transects were established at 15 locations in the river ranging between river kilometers 0.4 and 16.8 In addition to their presence within the sampling transects, the distribution of oysters in the river was visually described, with large oyster reefs most conspicuous between kilometers 3 and 5 and in the back bays. Smaller oyster reefs with mostly dead material were near the river mouth, with small reefs widely distributed upstream to near kilometer 11, where only dead material was found.

A total of 26 mollusk species or taxa were found (Table x), which is similar to the species richness found using similar methods in other tidal rivers in the District. Mollusk species showed district distributional patterns in relation to salinity gradients in the lower river. In a study of mollusk communities from eleven tidal tributary systems within the District, Montagna et al. (2008) found that salinity was the primary factor affecting the distribution and species composition of mollusk communities.

Figure X. Distribution of mollusk species vs. kilometer in the Little Manatee River, including subtidal and intertidal samples with live mollusks and dead mollusk material, from Estevez (2006).



4.1 Overview – Vegetation in the lower river floodplain.

Section 4.1.2 in the draft minimum flows report describes vegetation communities along the tidal reach of the Lower Little Manatee River. The first sentence in the section says that estuarine conditions extend 15 miles (24 kilometers) upstream from the river mouth, but that is incorrect. Based on extensive field work, Peebles and Flannery (1992) report that brackish waters (>1 psu) typically do not extend farther than 16 to 18 kilometers upstream. Also, as described on page 17 in the minimum flows report, minor tidal fluctuations in water levels can sometimes occur about 1 kilometer upstream of the US 301 bridge, but brackish water does not extend nearly that far.

The description of vegetation communities in the river on pages 69 and 70 in the draft report is pretty good and it references the previous minimum flows report from 2011 (Hood et al. Appendix A). Such a description may be in Hood et al., but I ran out of time and could not find such a discussion in that report which focuses on the freshwater section of the river. However, other reports that can be cited that describe vegetation along the lower river (Peebles and Flannery 1992, Clewell et al. 2002).

Most importantly, vegetation communities along the tidal reach of the Little Manatee River were mapped by the Florida Marine Research Institute (FMRI 1997), with reference the given below. This study focused on five tidal rivers including the Little Manatee. Ground truthing was conducted on the Little Manatee and the report contains a very detailed map of vegetation communities along the river and a discussion of the distribution of plant species and communities.

> Florida Marine Research Institute. 1997. Development of GIS-based vegetation maps for the tidal reaches of five gulf coast rivers. Report prepared by the Florida Department of Environmental Protection Florida Marine Research Institute for the Southwest Florida Water Management District.

I showed a slide of the vegetation map from this project at the kick-off meeting of the peer review panel on October 5th. I strongly recommend the minimum flows report include the FMRI map and the cite the report that produced it, at it is much more detailed than the FLUCCS vegetation map shown in the draft report. In that regard, it better supports the District's recommended minimum flows that are based on the maintenance of low salinity habitats. The aerial photography on which the FMRI map is based was taken in 1990, but from my frequent trips on the river it does not appear that vegetation in this part of the river had changed or been altered significantly since that time.

If the District prefers, it could still include the FLUUCS map shown on page 70, but also present the more detailed FMRI map. The report could qualify that map was based on photography from 1990, but it is unlikely that vegetation in this section of the river has changed significantly since that time. This map is impressive and I suggest it be displayed full page with landscape orientation as shown on the following page. This would follow nicely the discussion on pages 69 to 71 in the draft minimum flows report. That discussion could possibly be slightly improved in a second round of edits, but getting the FMRI map and citation in the minimum flows report is very important, in no small part because he District should highlight the excellent work it has funded.

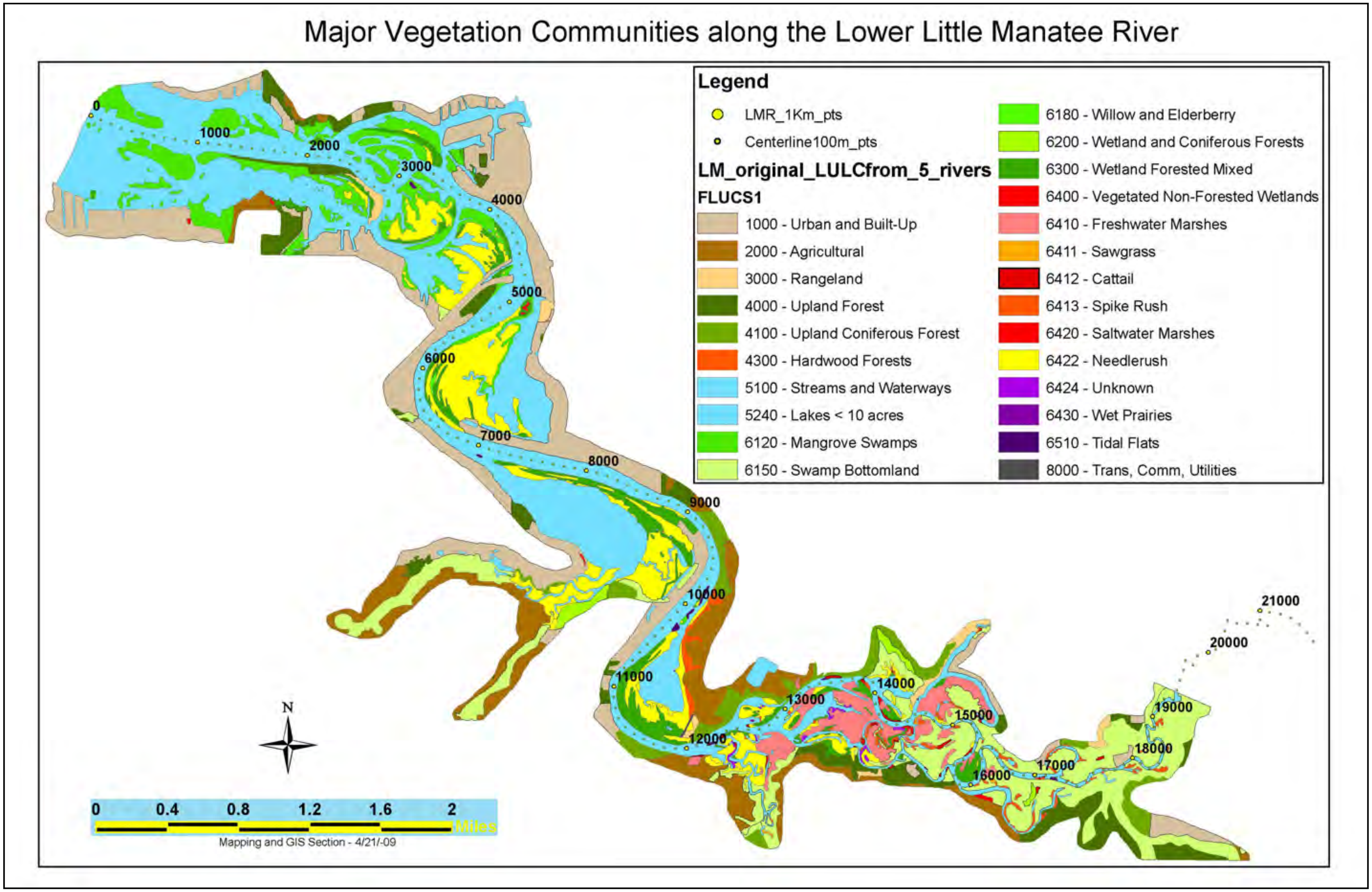


Figure X. Major vegetation communities along the Little Manatee Rive from FMRI (1997), with channel distances in meters.

5.1 Overview - Residence time analyses

In Section 5.4.5 the draft minimum flows report has a good description of EFDC hydrodynamic model for the Lower Little Manatee River that was developed by faculty and staff from FSU (Huang and Liu 2007). As in other tidal rivers (Alafia, Myakka, Lower Peace), model simulations of changes in salinity were a key analytical approach used to determine the minimum flows.

What the minimum flows report does not describe is that this project also included residence time simulations for the lower that were described in the project report (Huang and Liu 2007). This was pursued because the earlier minimum flows analyses for the Lower Alafia River found relationships between residence time (as water age) and very high chlorophyll *a* concentrations in sections of that tidal river. Since then, the District has made a point of having residence time simulations performed for tidal rivers, including the Lower Peace and the Little Manatee.

The project by Huang and Liu simulated residence time as Estuarine Residence Time (ERT) and Pulse Residence Time (PRT), with values of water age at ten locations in the tidal river used to calculate PRT at those locations. Two journal articles concerning residence time in the Little Manatee were also produced from this work (Huang et al. 2020, 2011), for which references are listed below.

> Huang, W., X. Liu, X. Chen and M. S. Flannery. 2010. Estimating river flow effects on water ages by hydrodynamic modeling in the Little Manatee River estuary. *Journal of Environmental Fluid Mechanics* 10(1-2):197-211.
>
> Huang, W., X. Liu, X. Chen and M. S. Flannery. 2011. Critical flow for water management in a shallow tidal river based on estuarine residence time. *Water Resources Management* 25(10): 2367-2385.

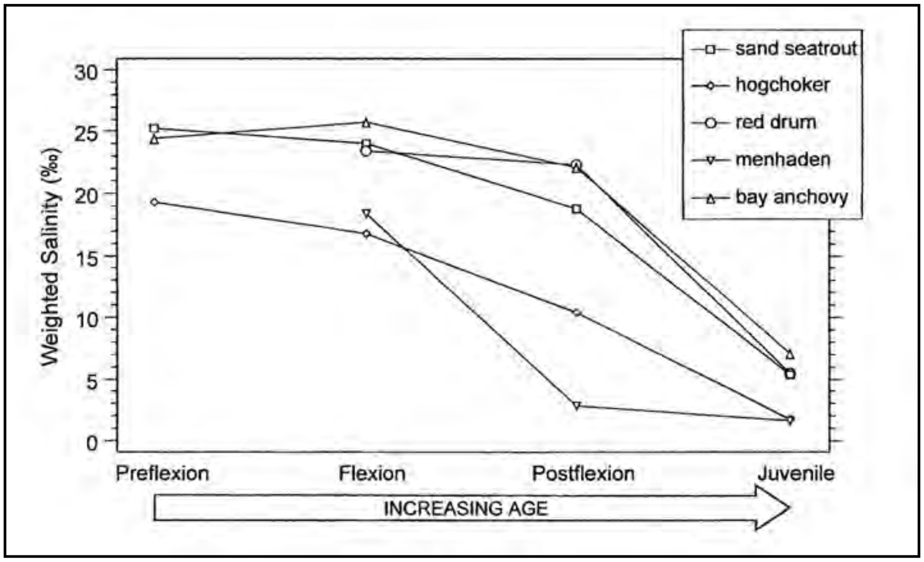
In comments I will submit in a week or so, I will recommend that further analyses be performed to evaluate flow thresholds for switching between low, medium, and high flow blocks specific to the lower river. At present, the thresholds for the flow blocks for the estuarine section of the river were based solely on freshwater analyses, which the District has never done before. This is probably not the best approach and needs to be addressed with additional analyses specific to the lower river.

In that regard, I think that examination of residence time as a function of freshwater inflow needs to be conducted, including evaluating the effects of various flow reductions on residence time. Next week, I will present some information concerning residence time (as water age) and the occurrence of high chlorophyll *a* concentrations in some segments of the tidal Little Manatee River.

But that is for another day. At this time, I recommend that the minimum flows report reference the residence time work performed by Huang and others, possibly showing the results of some residence time simulations in the minimum flows report.

6.1 Overview and suggested text for ichthyoplankton reports

On page 4.3.3 the report has one paragraph that summarizes the Ichthyoplankton work performed by Dr. Ernst Peebles of the University of South Florida College of Marine Science. This summary is good and well written, but I recommend two additions. First, the figure from Peebles and Flannery (1992) below be shown in the minimum flows report. As I mentioned at the peer review kick-off meeting, I think if there is one figure that best justifies the District's minimum flows program for tidal river estuaries, this is it.



Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages, from Peebles and Flannery (1992)

To reference this figure, the text could be added to say something like "Based on detailed microscopic work that identified early life stages as eggs, larvae, or juveniles, density weighted mean salinity values for different life stages were calculated. For a number of species, this showed a movement from higher salinity to lower salinity waters located further upstream as the species matured from larval to juvenile stages (Figure x). This occurs as these fish develop stronger swimming ability and have a change in food habits, switching from diets rich in zooplankton near the mouth of the river to more benthic food resources further upstream (Peebles 2005)." A reference for this second report is below.

Peebles, E. 2005. Review of feeding habits of juvenile estuarine dependent fishes and blue crabs: Identification of important prey. Report prepared by the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

The second addition I suggest pertains to the report by Peebles (2008). At present the draft minimum flows report has one sentence that says "These data were re-evaluated in 2008 using newly developed analytical methods (Peebles 2008)." Some of these findings in the 2008 report are very interesting and are relevant to freshwater inflow management. I suggest the District and JEI review

the summary section for this report and select two or three findings to briefly mention in the minimum flows report.   I suggest "These data were re-evaluated in 2008 using new analytical methods that included analyses of organism dispersion as a function of freshwater inflow and organism associations with water masses of varying water age. The study also assessed community heterogeneity as a function of freshwater inflow and mean salinity at the sampling stations in the river."

6.2 Overview and suggested text for Nekton sampling conducted as part of the Fisheries Independent Monitoring Program of the Florida Fish and Wildlife Conservation Commission

The consultant has done a very good job of accessing and analyzing the extensive data for nekton (fishes and free swimming macroinvertebrates) in the estuarine section of the Little Manatee River collected by the Fisheries Independent Monitoring Program (FIM) of the Florida Fish and Wildlife Conservation Commission (FFWCC or FWC). On page 93 the draft minimum flows report provides a one sentence summary of a report produced by the FFWCC for the District based on these same data collected between 1996 and 2006 (MacDonald et al. 2007).   That sentence mentions this study "demonstrated the importance of the Little Manatee River estuary for providing habitat throughout the year, as peaks in juvenile abundance of offshore spawners, juvenile nearshore spawners, estuarine spawners, and tidal-river residents occurred in different seasons (MacDdonald et al. 2007)."

Though this characterization is helpful, I suggest the minimum flows report could mention a couple other analyses or data presentations from the MacDonald et al. (2007) report. Also, it is not critical, but one page of figures from that report could be shown to highlight the types of information that are presented in it.   I suggest something like below, including the figures for Red drum shown on the following page.

"This report also provides useful analyses and tabular and graphical presentations of the abundance and distribution response of various species in relation to freshwater inflow, plus the size classes, salinity at capture, and abundance of species in different sections and habitats in the lower river.   As an example, a series of graphics for the seine catch of Red drum (*Sciaenops ocellatus*) from MacDonald et al. (2007) are shown on the following page."   (see figure on the following page).

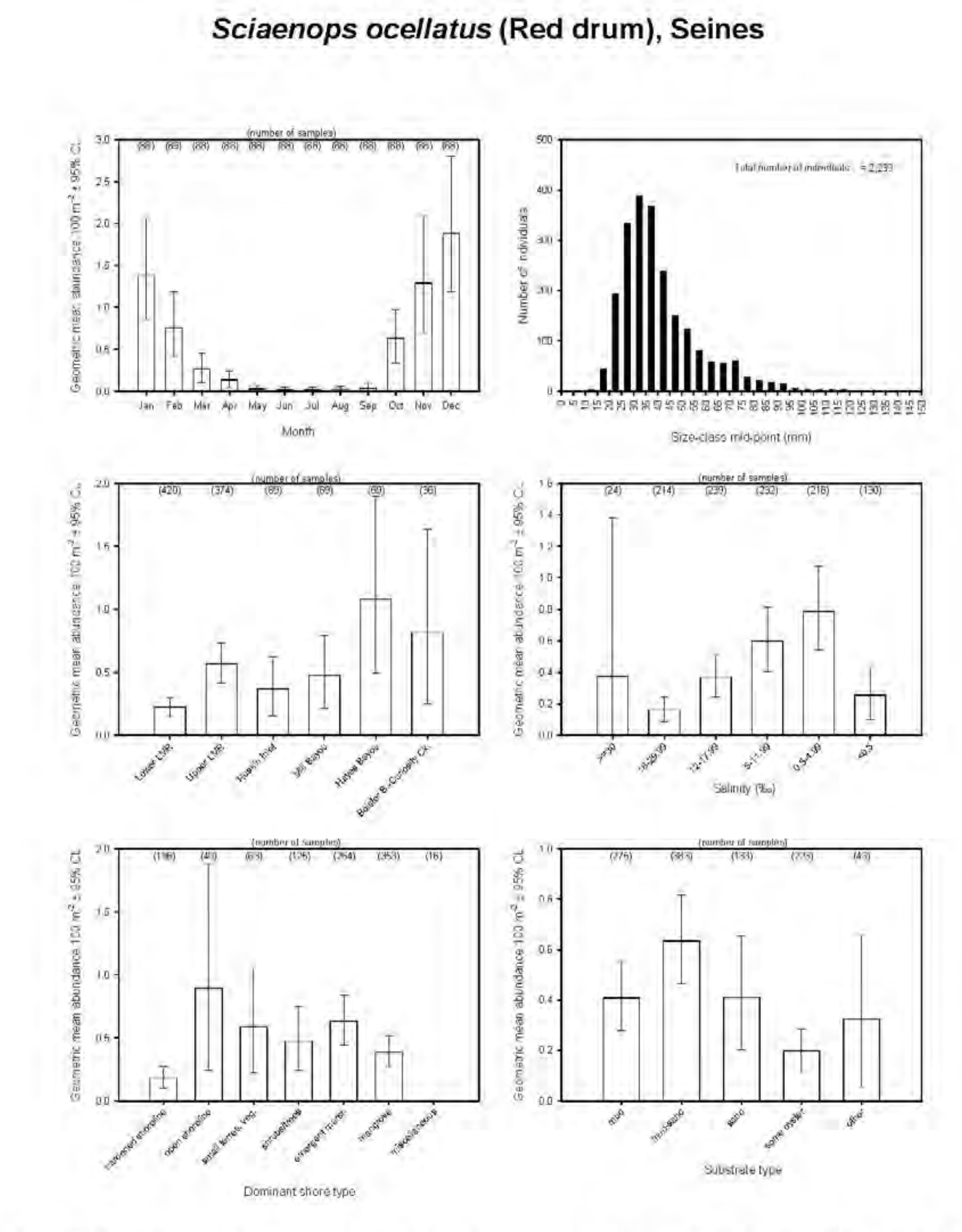


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

Figure X. Graphics for the seine catch of Red drum (*Sciaenops ocellatus*) in the Lower Little Manatee River reprinted from MacDonald et al. (2007).

6.3 Multi-River Fish Reports

Both FFWCC and USF prepared reports for the District that analyzed data pooled for the 18 or so rivers they studied for the District. The consultant might find some useful results in these reports that are relevant to the findings presented in the Little Manatee minimum flows report. References for these reports are below.

Hollander, D. and E.B. Peebles. 2004. Estuarine Nursery Function of Tidal Rivers in West-Central Florida: Ecosystem Analyses Using Multiple Stable Isotopes. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Peebles, E.B. 2005. Review of Feeding Habits of Juvenile Estuarine-Dependent Fishes and Blue Crabs: Identification of Important Prey. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Burghart, S.E. and E.B. Peebles. 2011. A Comparison of Spring-Fed and Surface-Fed Estuaries: Zooplankton, Ichthyoplankton, and Hyperbenthos. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Gunther, C.B., T.C. MacDonald and R.H. McMichael. 2011. Comparison of Nekton Community Structure Among Spring- and Surface-Fed Estuarine Rivers of Florida's West Coast. Report prepared by the Florida Fish and Wildlife Conservation Commission for the Southwest Florida Water Management District.

Verbal comments to be given at the Little Manatee River minimum flows peer review meeting, October 27, 2021

By Sid Flannery

Good afternoon. Today I would like to talk about the need to establish flow based, minimum flow blocks separately for the freshwater and estuarine sections of the Little Manatee River. I support the use of flow-based blocks, but on the Little Manatee the District based the thresholds for identifying low, medium, and two high flow blocks strictly on analyses of the freshwater section of the river, and then applied three of those same flow blocks to the estuary. Well this is a first, as the District has never done that before, and it is a serious misstep for the Little Manatee River and sets a bad precedent.

The District has previously used flow-based blocks to establish minimum flows for a number of estuarine rivers in the region. For example, last year, the District adopted minimum flows for the Lower Peace River for the second time, using three flow-based blocks that were based on salinity relationships in the estuarine section of the river.

The important thing is for these other tidal rivers, low flow cutoffs and flow-based blocks for the estuarine sections of the rivers were based on relationships of freshwater inflow to variables and parameters within the estuary.

An important factor to consider is that the response of many variables in estuarine rivers to freshwater inflow is nonlinear. Even if you take a fixed percentage of daily flow, say 20 percent, the relative effects of those withdrawals on habitats and other factors can be much greater at low flows than at high flows. Therefore, when applying the percent of flow method in a tidal river, you have to see if there are sensitive flow ranges for the response of different variables to freshwater inflow.

In that regard, I prepared a series of graphs of different variables vs. flow in the Lower Little Manatee that the District uploaded to the minimum flows WebForum this morning. I think the low flow cutoff of 35 cfs for the lower river is suitable, and similar to the 40 cfs cutoff currently in effect for the Florida Power Light withdrawals, which I was involved in evaluating years ago based on estuarine relationships.

However, the 72 cfs threshold for switching from medium to high flow blocks clearly looks to be too low for the lower river, as 72 cfs is in a very sensitive flow range for some important variables, particularly in the low salinity reaches of the river.

Also, based on gaged flows at US 301 for the last twenty years, flows would have been above 72 cfs fifty-two percent of the time. The estuarine section of the Little Manatee has a surface area of 2.2 square miles, and for the ecological functions, 72 cfs is not a high rate of inflow for an estuary of this size.

I strongly suggest the review panel recommend that flow rates to identify low, medium, and high flow blocks be evaluated separately for the fresh and estuarine sections of the Little Manatee. Given the modeling tools that have been developed, I think this could be done fairly quickly.

There is an interesting parallel to this. When minimum flows for the Lower Peace River were evaluated for the first time in 2010, the Section Manager wanted the minimum flows for the lower river to use seasonal blocks. As a check, we examined how the percent withdrawals for seasonal blocks 2 and 3 would perform if they were applied during low flows, which would have happened fairly frequently. We found that at low flows, the percentage withdrawals for seasonal blocks 2 and 3 would cause greater than a 15 percent change in salinity based habitats, but at higher flows they did not. Based on those findings, the first adopted rule for the Lower Peace River had a flow threshold that seasonal blocks 2 and 3 could not be applied until flows in the river went above 625 cfs.

That type of analysis could to done for the Little Manatee. For example, for a 30% withdrawal, for each day calculate the percent reduction in low salinity habitats relative to baseline, then plot these results vs. the corresponding rates of baseline flow. You will find that at some rate of increased flow, these withdrawals will not cause more than a 15 percent change in habitat, while at lower flows they will. You could examine these results to determine a threshold for identifying high flows. I expect that a similar approach could be taken the estuarine fish habitat analysis as well.

Also, From the water management perspective, it entirely practical to implement minimum flows rules that differ between the fresh and estuarine reaches of rivers, in fact that has been the standard District practice for years.

I hope the panel can review the documents that I have prepared for today and previous meetings, which can be found under the public comments section of the Webforum, as I think they provide very useful information pertaining to review of the draft report and the proposed minimum flows.

Finally, the Little Manatee River below Highway 301 is a State of Florida Aquatic Preserve and the crown jewel of the rivers flowing to Tampa Bay. If you are going to protect this valuable estuarine resource from significant harm, you need examine flow-based blocks that are analyzed specifically for this estuarine system.

Graphics related to the evaluation of flow thresholds for flow-based blocks for minimum flows for the estuarine section of the Little Manatee River

Submitted by Sid Flannery, October 27, 2021

Overview and organization of this document

This document provides a set of graphics and brief text related to the determination of flow rates that can serve as thresholds to identify flow, medium, and high flow blocks for minimum flows for the estuarine section of the Little Manatee River. It is being submitted as part of the independent peer review that is being conducted for the draft minimum flows report for the Little Manatee River published by the Southwest Florida Water Management District (the District).

As part of the review process, I have been commenting as a private citizen and have previously submitted three sets of documents to District staff and the peer review panel for their consideration. My comments that will be presented to the peer review panel meeting on October 27, 2021 are attached as an Appendix to this document.

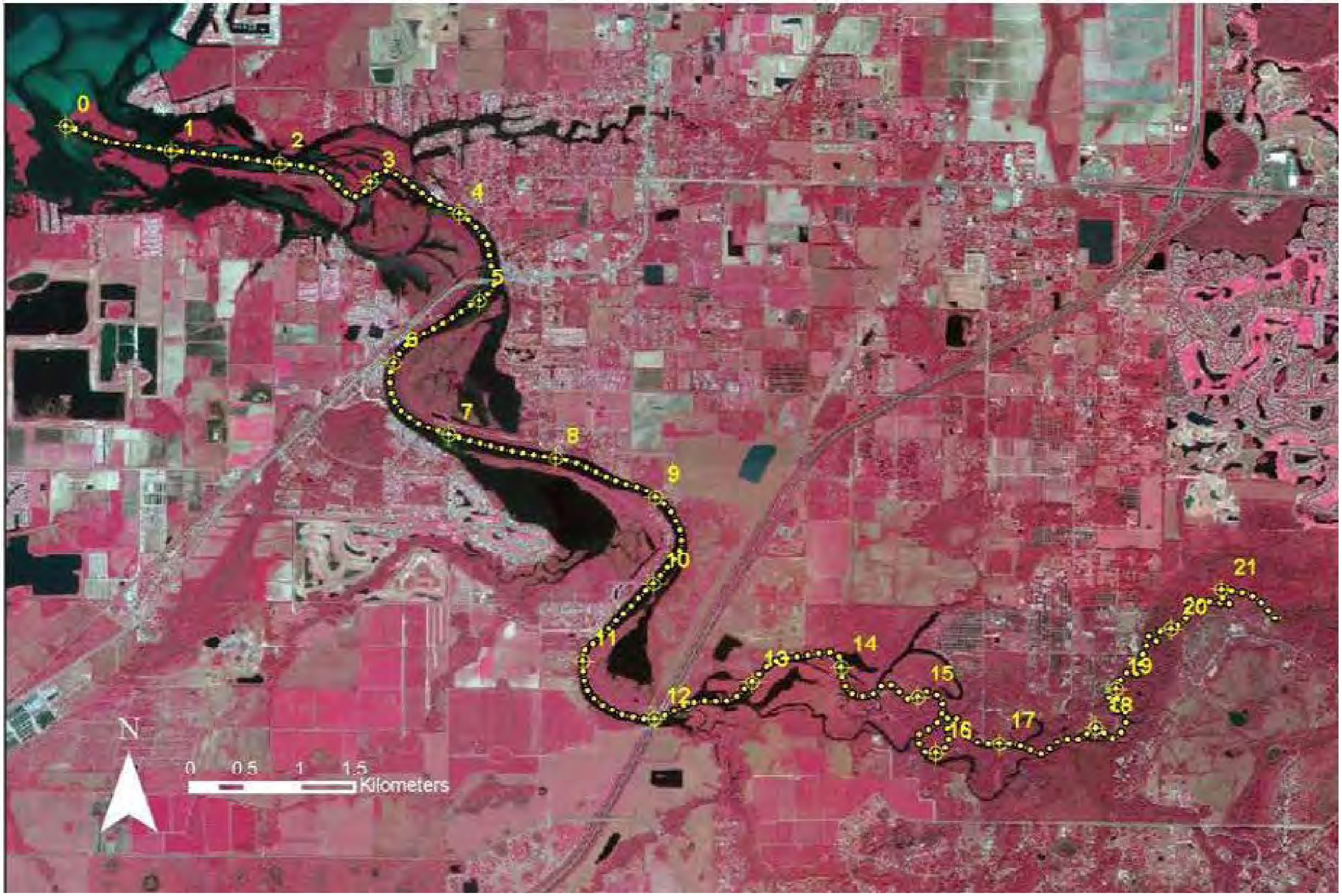
The draft minimum flows report for the Little Manatee identifies flow rates of 35 and 72 cfs to serve as thresholds to identify low, medium, and high flow blocks for the minimum flows. These flow rates were based solely on analyses of the freshwater reach of the river, but they are being applied to the estuarine reach of the river as well. As my comments in the Appendix state, the District has never done that before, and I strongly recommend that thresholds to identify flow-based blocks be evaluated separately for the freshwater and estuarine sections of the river. Those comments also describe a type of analysis that was done for the first determination of minimum flows for the Lower Peace River that I think should be performed for the Little Manatee to assess appropriate flow blocks for the estuarine reach of the river.

Given the very short time frame of the peer review process, the graphics presented in this document were put together very quickly and are by no means a comprehensive set of graphics related to this topic. I'm sure there are other relationships that could be examined. I did not have time to review biological information for the river in this regard, but plots of chlorophyll *a* vs. flow are included, which I think are very meaningful.

Many of the graphics have a reference line for 72 cfs, which was visually approximated using power point. As the Appendix states, I think the 72 cfs is clearly too low to serve as a threshold to identify the high flow block for the estuarine section of the Little Manatee. Some brief text is included with some of the graphics, particularly for chlorophyll *a*. All text was also was prepared quickly and is not a through treatment of these relationships.

For evaluating any apparent shifts or inflexion points in the data, readers should consider the following graphics essentially represent a baseline condition. That is, the application of minimum flows will reduce the flows, basically moving the relationships to the left. For example, with the proposed minimum flows, a flow of 70 cfs could be reduced to 56 cfs and a flow of 110 cfs could be reduced to 77 cfs. Therefore, in considering what might be an appropriate threshold to switch between flow-based blocks, the threshold should include a buffer that is slightly above the apparent inflexion point in order to best manage a sensitive flow range.

For reference, a centerline map of the Little Manatee River is shown on the next page.



Centerline map of the Lower Little Manatee River with distances in kilometers

Chlorophyll *a*

I have not had time to review appendices to the minimum flows report the deal with water quality, so I don't know if they contain graphics or analyses similar to what I have presented below. Regardless, it is very informative to plot chlorophyll *a* concentrations versus freshwater inflow in tidal rivers. When doing so, the relationships with inflow in the Little Manatee are similar to what have been observed in other tidal rivers for which there are abundant chlorophyll data (Lower Alafia, Lower Peace), with one difference that is discussed on the following page.

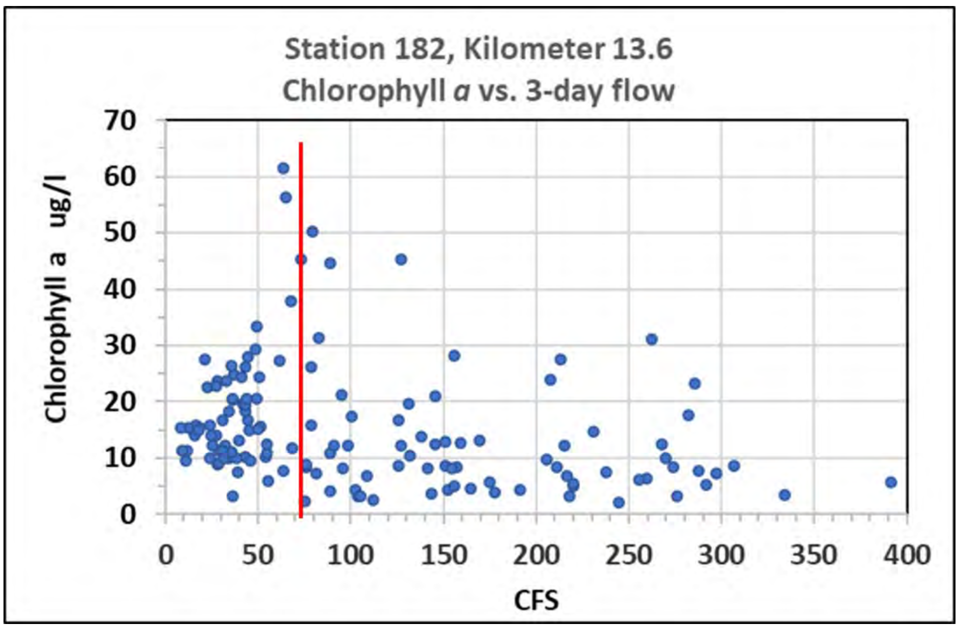
As part of the peer review process, I submitted a document titled *Overview and suggested text to describe technical reports about the Little Manatee River* that was posted on the minimum flows WebForum under public comments. That document provides citations and brief descriptions of District sponsored studies of phytoplankton related parameters (including chlorophyll *a*) in the estuarine reach of the Little Manatee, with one study also including data from the Lower Peace and Alafia rivers. I have not had time to access those data, but can make some comparisons and conclusions based on previously published findings.

The graphics below are taken from water quality sites monitored the Environmental Protection Commission of Hillsborough Country (EPCHC, often referred to simply as EPC) that were presented in the draft minimum flows report. The EPC is to be highly commended for expanding their water quality sampling network to add three new data collection sites in the Little Manatee, starting in 2009. These data, plus the longer-term site at Station 112, provide very extensive monthly water quality data at those four locations in the tidal Little Manatee River.

Go to next page

The figure below is from station 182, located in the braided oligohaline section of the river near kilometer 13.6. The pattern that is shown is typical of the upstream reaches of tidal rivers, in that high chlorophyll concentrations are not frequently observed at very low flows (20 to 30 cfs below) probably due to low nutrient loading. However, when flows increase, high chlorophyll concentrations can occur due to greater nutrient loading, with residence times that are still fairly long allowing phytoplankton blooms to develop.

However, at higher flows, high chlorophyll *a* concentrations are not frequently observed as water is moving through these upper reaches of the tidal river fairly rapidly with low residence times. Water color also increases at high flows, which limits light penetration. This tendency would be shown more clearly if the horizontal axis below was expanded to include higher flows, but the emphasis on this graphic is on lower flows. Three-day flow is the average flow for the day of sampling and the preceding two days.



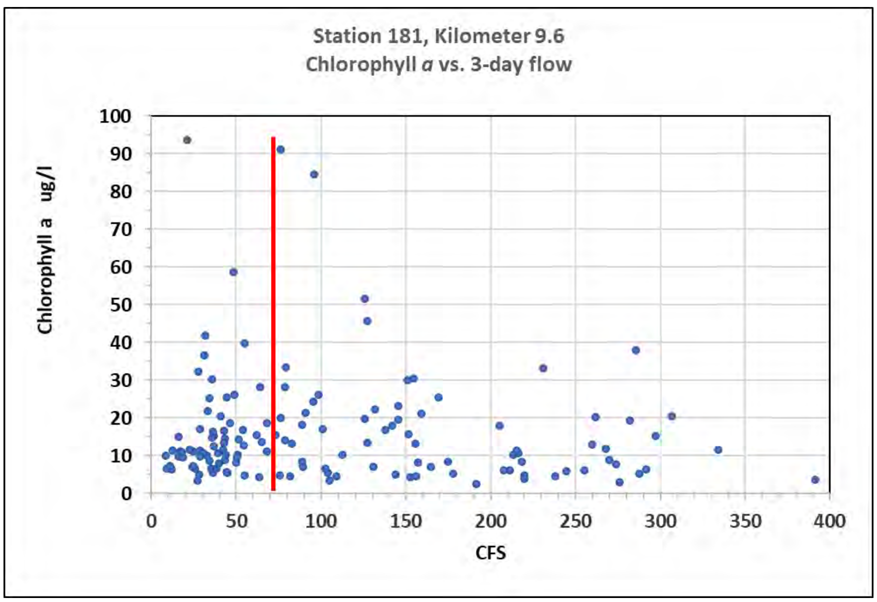
A red reference line is shown in the figure above at approximately 72 cfs, which is the threshold to switch from the medium to high flow block in the proposed minimum flows, which will allow a change in percent withdrawals from 20 percent to 30 percent. Again, this threshold was based solely on analyses of the freshwater reach of the river upstream of US highway 301. As shown in the figure above, 72 cfs is right in the middle of the flow range of when very high chlorophyll *a* concentrations can occur at this location.

What is interesting about the Little Manatee is that peak chlorophyll *a* concentrations often occur in very low salinity waters, even close to the tidal interface between fresh and brackish waters. As described in the *Overview and suggested text* document, peak chlorophyll *a* concentrations often occur in mesohaline waters in the tidal reaches of the Peace and Alafia Rivers. It appears

this difference in the Little Manatee is that water slows down considerably in the braided section of the river upstream of I-75, with longer residence times there compared to the upper reaches of other tidal rivers.

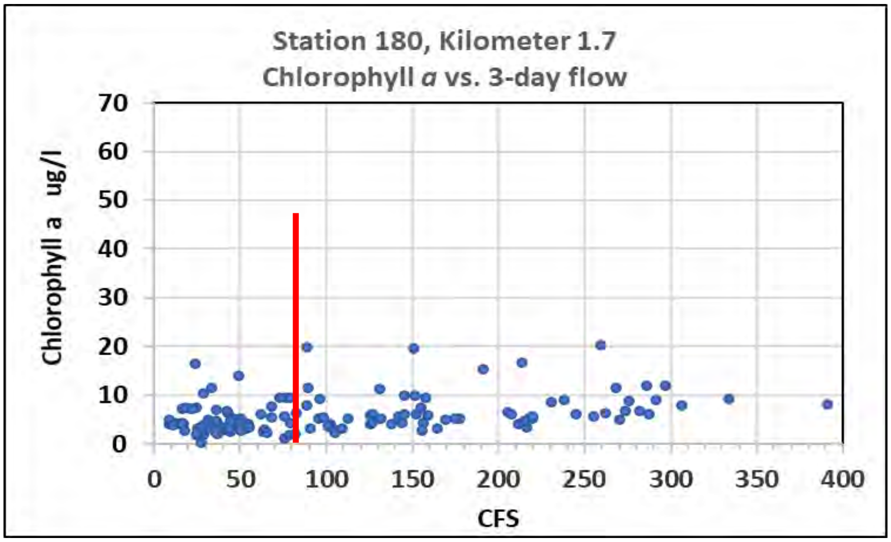
As part of the development of the EFDC hydrodynamic model for the Little Manatee, Drs. Huang and Liu of Florida State University did residence time simulations for the river that are summarized in the *Overview* document that was previously submitted. The District has also done residence time analyses in the Lower Peace and Alafia Rivers, with the minimum flows report for the Lower Alafia presenting a good discussion of the relationships of residence time to chlorophyll *a* in that river.

The relationship of flow to chlorophyll *a* will change at different locations in a tidal river due to changes in the volume of the estuary, residence time, available nutrients, light penetration and tidal exchange with the bay. Plots are presented for EPC stations 181 and 180 in the following discussion, with data shown below for station 181, which is located near kilometer 9.6.



The highest peak chlorophyl *a* concentrations in the Little Manatee recorded by the EPC are at Station 181. High concentrations above 80 µg/l were limited to when three-day average flows were less than 100 cfs, with two concentrations above 90 µg/l at flows below 77 cfs. The minimum flows report has a time series plot of yearly geometric means for chlorophyll *a* that shows that during some years, the FDEP impairment threshold of an annual geometric mean of 11 µg/l is exceeded at this station. I agree with some review panel comments that this threshold is probably too low for productive tidal rivers. However, individual chlorophyll *a* concentrations can be strongly affected by the rate of freshwater inflow, and the occurrence of problematic very high chlorophyll concentrations from large phytoplankton blooms can be exacerbated by flow reductions in sensitive flow ranges in various sections of a tidal river.

The graph below is for station 180, which is located near 1.7 kilometers upstream of the mouth of the river. For easier comparison to the other figures, the Y axis is taken up to 70 µg/l. It is obvious that chlorophyll *a* concentrations are much lower at this location and have a very different relationship with freshwater inflow, due likely to the volume of the estuary, tidal flushing from the bay, and limited available nutrients at low flows. However, at this location there is a tendency for slightly higher chlorophyll *a* concentrations at higher flows, as nutrient delivery from the watershed is increased.



It should be noted that the Little Manatee River has been enriched with nitrogen due to human activities in the watershed. The draft minimum flows report found that with the exception of organic nitrogen at one site, trends for various forms of nitrogen have either been showing no trend or decreasing at EPC stations in the lower river in recent years. However, as described in the document I submitted titled *Technical review of the Little Manatee River flow characterization,* as part of a large study of the Little Manatee River watershed that was conducted by the District and other agencies in the late 1980s, long-term nitrogen data indicated that agriculture activities have increased nitrate concentrations in the river considerably compared to decades prior to the mid-1970s. Given that the river is nitrogen enriched, it is important to carefully manage the effects of flow reductions on excessive phytoplankton blooms and high chlorophyll *a* concentrations in the river.

Again, I have not had time to review the appendices to the minimum flows report that deal with water quality, but the data for stations 181 and 182 in the mid to upper reaches of the tidal river indicate the 72 cfs threshold to switch to 30 percent withdrawals is too low, as it could exacerbate excessive phytoplankton blooms in that part of the river. New analyses should be conducted to develop a threshold for a high flow block for the estuary based on relationships in the lower river, rather than from the freshwater reach where the 72 cfs flow threshold was derived.

SALINTY

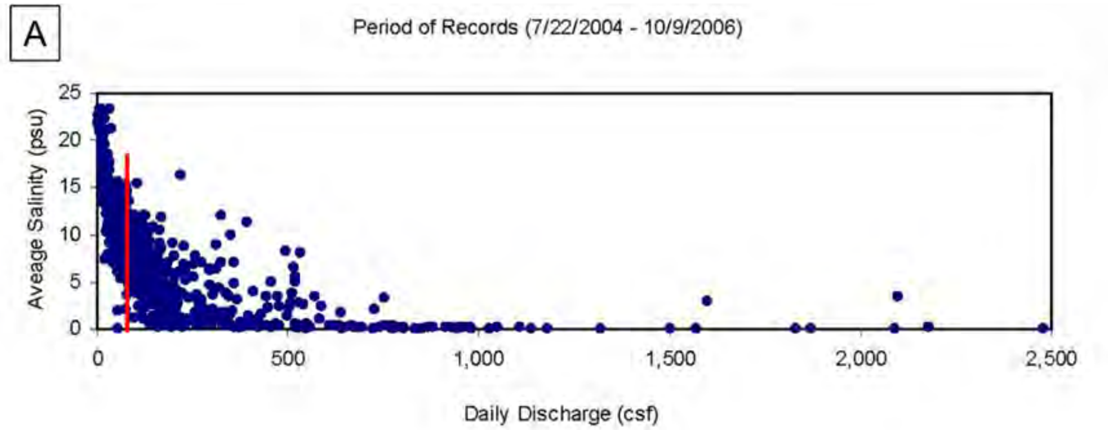
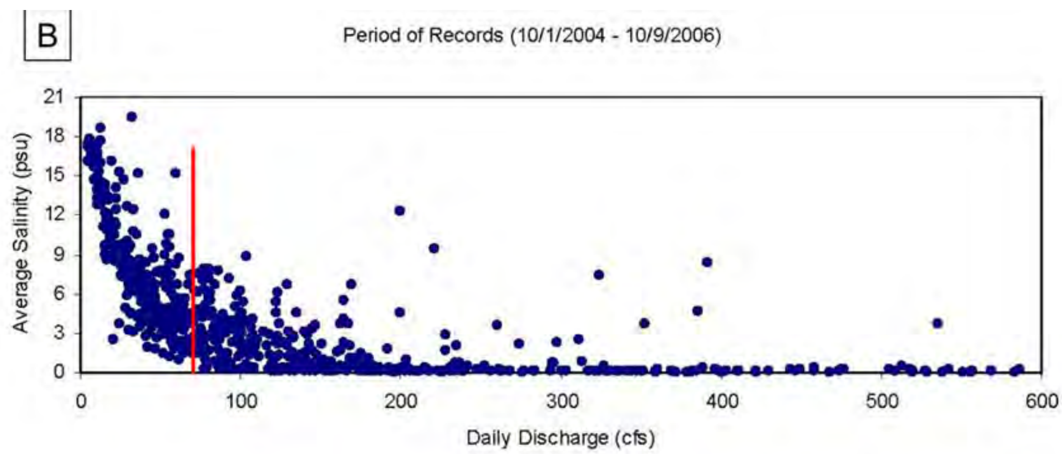


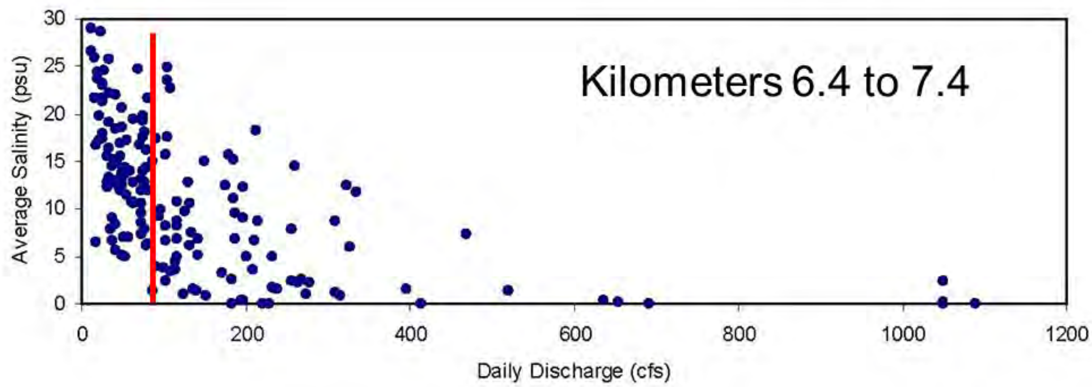
Figure 15. Salinity versus daily discharge for the USGS 02300546 gage, Little Manatee Rive at Ruskin, FL (RKM = 8.3)

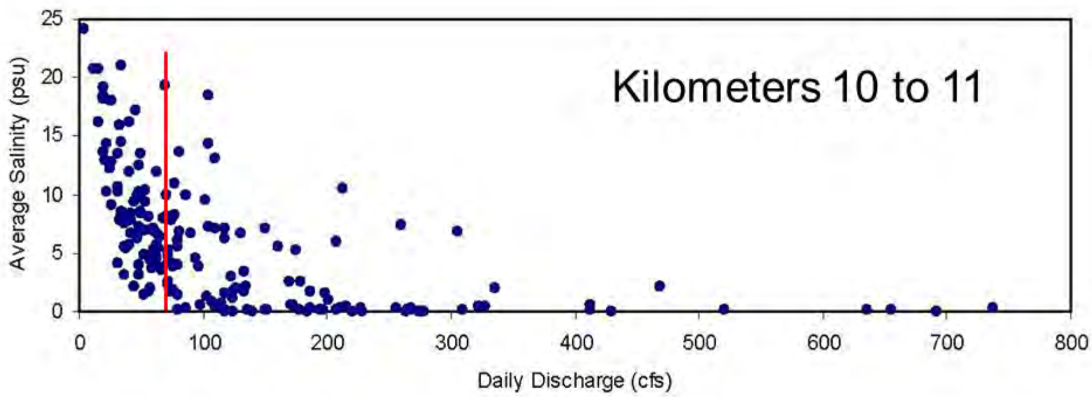


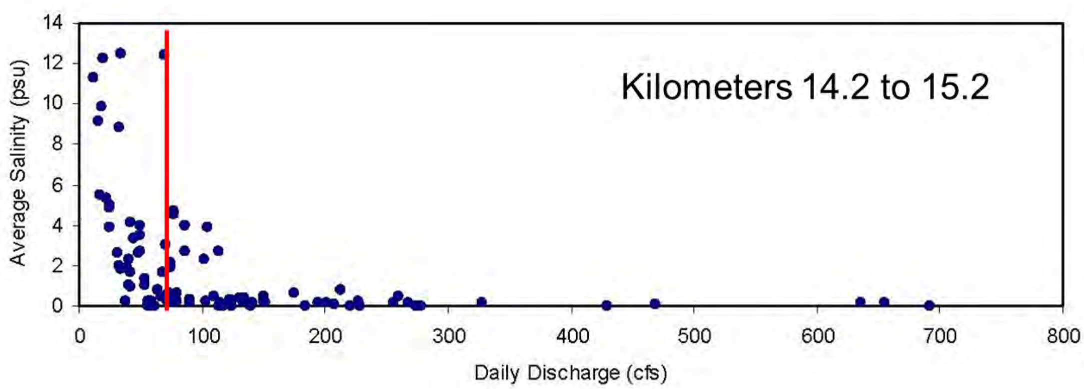
igure 16. Salinity versus daily discharge for the USGS 02300542 gage, Little Manatee River at I 75 near Ruskin, FL (RKM = 12.1)

Red reference lines inserted at approximately 72 cfs

The USGS operated a series of continuous salinity recorders in the river to support the development of the EFDC hydrodynamic model for the river during 2004 to 2006. Plots of average daily salinity from the top and bottom sensors at each location are shown above for two recorders located at kilometers 8.3 and 12.1. The recorder at 12.1 is at the I-75 bridge, which is just downstream of the braided zone of the river that contains abundant oligohaline marshes that grade upstream to tidal freshwater marshes and forest. Salinity is very responsive to flow in the range of 72 cfs at this location, with the response dampening at higher flows.

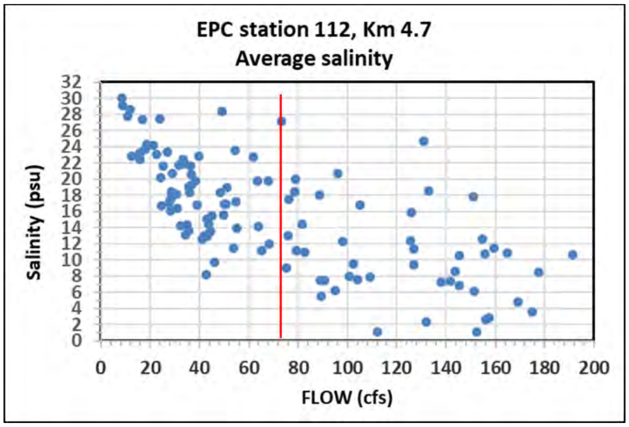


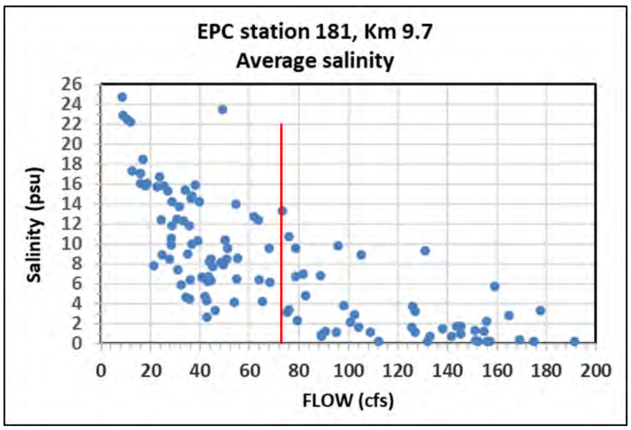


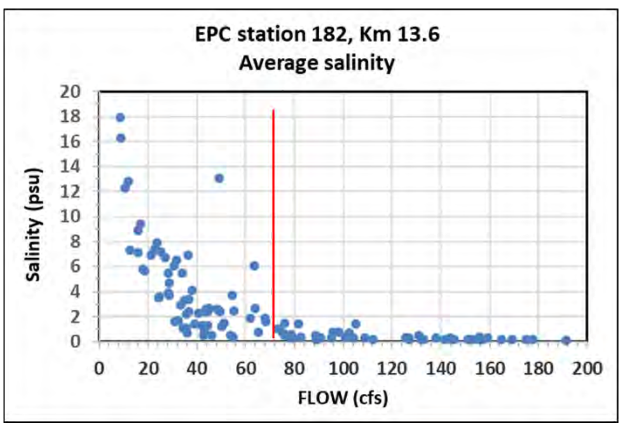


Red Line reference lines inserted at approximately 72 cfs

These graphics on this page are average salinity values from vertical profiles taken by the District and other parties between March 1985 and October 2006. I don't think that 72 cfs represents a good high flow threshold to increase withdrawals, as salinity is very responsive to flow reductions at these sites near that flow value, with a dampened and flatter response at higher flows. Considering that for the most recent twenty year period, 72 cfs has been exceeded 52 percent of the time, a higher threshold to identify high flows would be more appropriate for this estuarine system.







The graphics above are from the Hillsborough County EPC's water quality stations in the tidal river that have been monitored since 2009. At these stations, EPC measures salinity at top, middle and bottom depths, with the average of these values shown above. For station 181 (middle graph), 72 cfs again appears to be too low to serve as a high flow threshold compared to a higher flow rates. The data at station 182 seem more supportive of the 72 cfs threshold, but these salinity values are lower than some average values for kilometers 14.2 to 15.2 reported by the District shown on the previous page. This might be because the District frequently sampled near high tide, or possibly because the District took salinity profiles at surface and 1 meter intervals.

Management Approach for Unimpounded Rivers **1321**

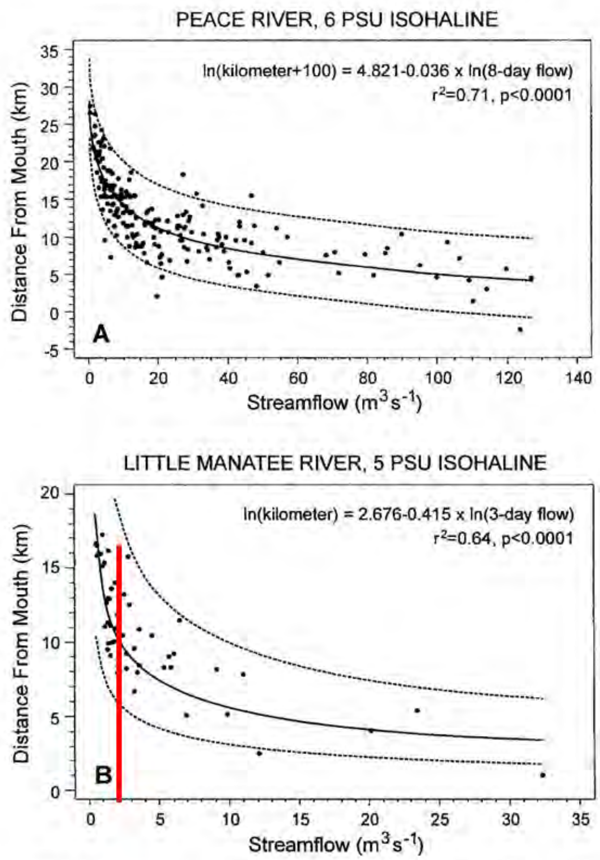


Fig. 3. Regressions of freshwater inflow with (A) the location of the 6 psu surface isohaline in the Peace River (adapted from Janicki Environmental 2001) and (B) the location of the 5 psu surface isohaline in the Little Manatee River (adapted from Peebles and Flannery 1992), with the 95% confidence limits for the predicted values. Regressions are plotted using non-transformed data.

The Figure above shows the strong nonlinear response that salinity isohalines can have with regard to changes in freshwater inflow. The red reference line for the Little Manatee River is near 2 m3/sec, which is equivalent to a flow of 72 cfs. Note there are three occurrences of the surface 5 psu isohaline between kilometers 13 and 16 near a flow rate of 72 cfs and others just below that flow rate. This graphic was taken from an article by Flannery et al (2002) in the journal *Estuaries* that dealt with the percent of flow method, which is referenced in the District's draft minimum flows report.

It should be noted the Little Manatee was one of the three estuarine rivers that provided data and findings that were very important to the initial development of the percent-of-flow method for regulating withdrawals and determining minimum flows for tidal rivers.

208 Environ Fluid Mech (2010) 10:197–211

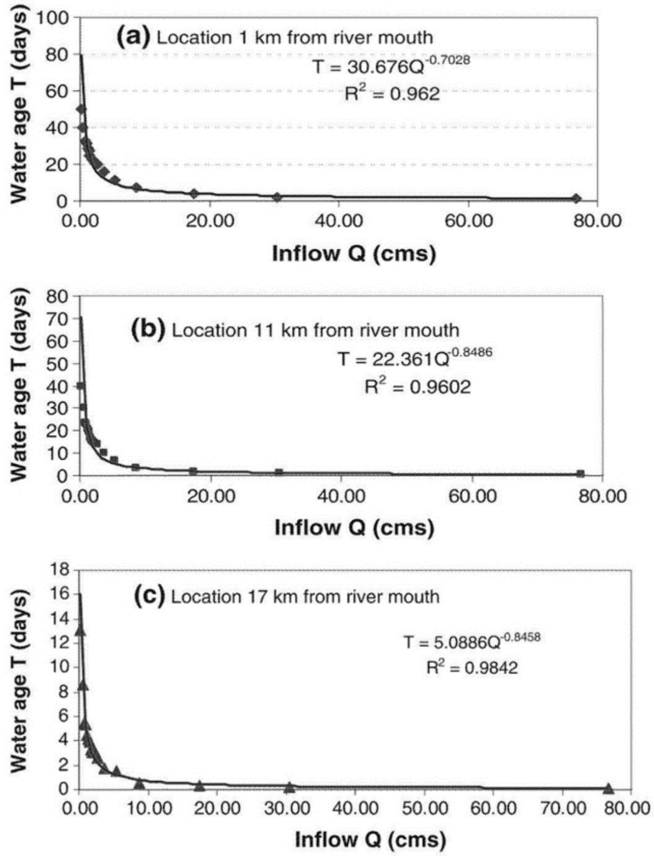


Fig. 9 Tidally-averaged water ages T (days) in responses to river inflows $Q(\mathrm{m}^3/\mathrm{s})$ at different locations along the river main channel. Least-square regressions were done by using power law. Data were obtained from hydrodynamic model simulations

The graphic above was taken from a journal article about water age simulations in the Little Manatee River by Huang et al. (2010) that is cited in the *Overview* document. Water age is a form of residence time, that is the travel time of fresh water from the head of the estuary to a given location, with three sites shown above. The horizontal axes in these figures cover a very high range of flows in m3/sec (for reference 72 cfs is equal to about 2 m3/sec and 4 m3/sec equal to about 141 cfs). Even so, the strong nonlinear response of water age at low flows river is clearly apparent at these locations. The Lower Alafia minimum flows report found that water age can be an important factor affecting very high chlorophyll concentrations.

I did not have time to analyze relationships between chlorophyll *a* and water age in the Little Manatee, but the relationships of chlorophyll *a* with flow shown on pages 5 and 6 are probably due in part to differences in water age at low, medium, and high flows. As such, the nonlinear response of residence time and water age to freshwater inflow should be considered in determining what are truly high flows for the estuarine section of the river. In my opinion, 72 cfs is too low a value for identifying high flows in that regard.

Finally, it interesting to note that the peer review panel for the previous minimum flows report included a graphic that indicated that simulations of residence time and water age can be important for assessing phytoplankton abundance in estuarine rivers. The graphic below was taken from page 9 in that report, with red arrows inserted to highlight the suggested work for hydrodynamic modeling for salinity and water age analysis.

I believe that in fairly short order, the data for the estuarine reach of the Little Manatee River can be reassessed to come up with a threshold to identify high flows that much better protects the lower river from significant harm, compared to the proposed 72 cfs threshold which is clearly too low.

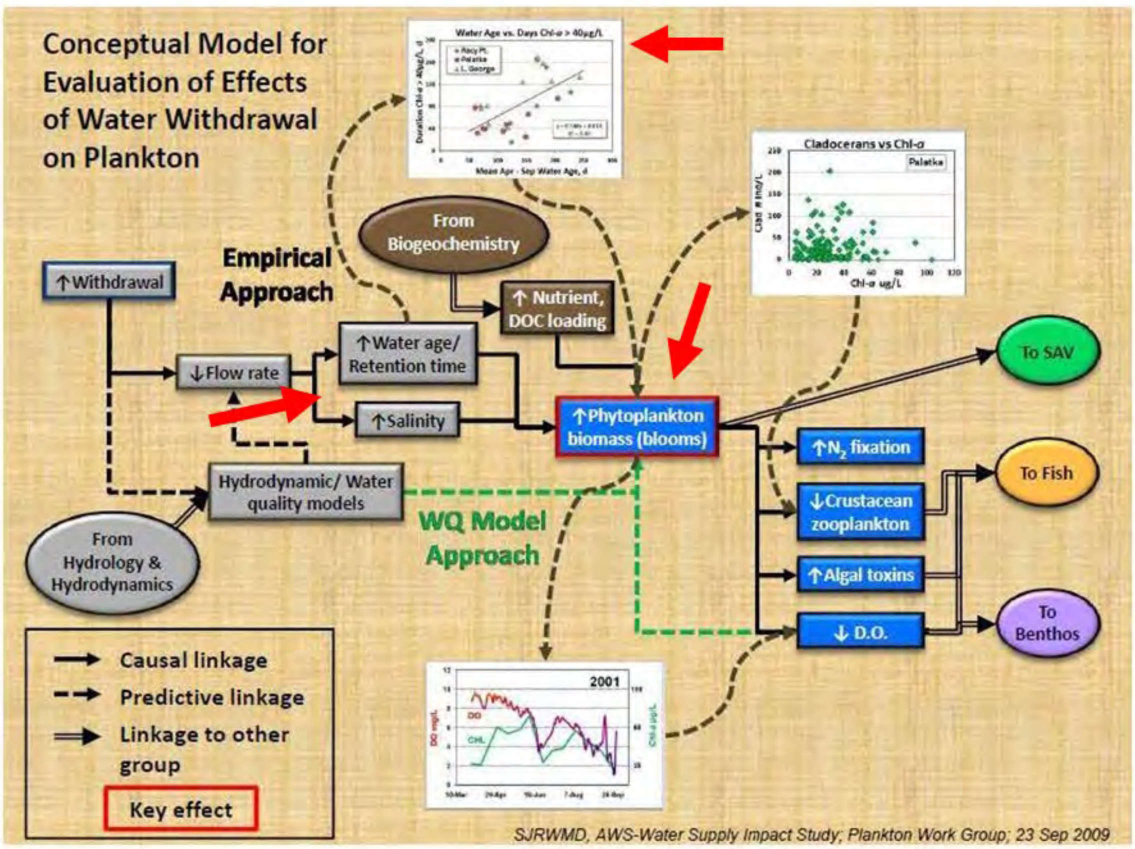


Figure 2. Multidisciplinary studies for assessing water withdrawal impacts on plankton. (SJRWMD 2009)

Figure adapted from Figure 2 in the peer review report for the previous minimum flows report for the Little Manatee River

Verbal comments for November 3 Little Manatee River minimum flows peer review meeting.

Prepared by Sid Flannery (ADDED PARAGRAPHS IN BLUE)

Today I would like to speak about how minimum flows are implemented using flow-based blocks. The review panel is considering whether the flow blocks should, or should not be, the same for the fresh and estuarine sections of the Little Manatee.

Well, they are not entirely the same in the currently proposed rule, which is shown in the table on your screen (below). Note than in Block 3 the freshwater minimum flows have a second high flow threshold of 174 cfs that is highlighted in yellow, which is not assigned to the estuarine minimum flows. You can subtract the numbers shown in red to calculate the percent withdrawals in each block. So, for block 3 in the freshwater section, flows cannot be reduced by 13 or 11 percent depending on the rate of flow   Further downstream, flows to the lower river cannot be reduced by more than 30 percent at flows above 72 cfs.

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		

So, lets hypothetically change the threshold to switch from block 2 to block 3 for the lower river to 120 cfs. We still have the 13 and 11 percent limits to withdrawals in block 3 in the freshwater section, but flow reductions to the lower river cannot exceed 20 percent until flows go above 120 cfs, when percent withdrawals can increase to 30 percent. This is very simple and straightforward and poses no water management complications whatsoever.

There are two factors that typically make the percent of flow method very workable within the District. Estuaries in the region are generally not as sensitive to ecological impacts from flow reductions as are freshwater rivers, and minimum flows adopted for estuarine rivers usually allow for the same, or more often, greater percent withdrawals than for the corresponding freshwater sections. And, it is an obvious point, but the estuary is always downstream. If these two types of ecosystems were interspersed along the river channel it could be complicated, but that is not the case.

If we are to protect both the freshwater and estuarine sections of our rivers, it is critical to first evaluate the most effective flow blocks separately for these two very different ecosystems, then write the rules accordingly. Based on years of experience applying the percent of flow method to existing water use permits, I don't think that having separate flow blocks for the fresh and estuarine sections of a river would cause complications for water management, and changing the block 3 threshold for the lower Little Manatee certainly would not.

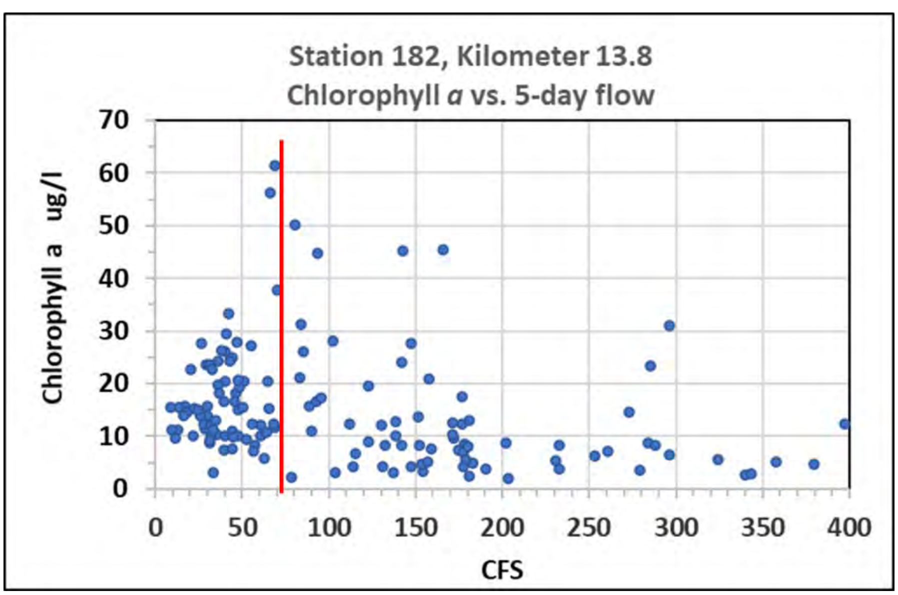
For years the District has included flow-based blocks in estuarine minimum flow rules based on analyses of relationships within those tidal rivers. However, with the Little Manatee, the District for the first time has assigned flow blocks developed for the freshwater section of the river to the estuarine section as well.

Assigning 72 cfs as the high flow block for the estuary does not allow for the evaluation of important ecological relationships in the lower river above that flow rate, which by the way, was near the median flow for the river for the last 20 years. Many of these relationships at higher flows are important to the ecological functions of the lower river, which could be evaluated to come up with a revised block 3.

For example, last week Dr. Ernst Peebles said that the combined zooplankton/ichthyoplankton catch in the lower river showed a shift in community heterogeneity around 100 cfs. Last week I also submitted to the WebForum a series of plots of salinity and other parameters vs freshwater inflow that showed these parameters respond strongly to freshwater inflow near 72 cfs, but less acutely at slightly higher flow rates, which could be evaluated to develop a revised block 3.

For example, upstream of I-75 there are widespread oligohaline marshes dominated by freshwater plants that have some salt tolerance such as sawgrass and cattails. The inundation of these marshes with fresh water in the wet season is important to their health and productivity. Plots of salinity versus flow in the graphics document show that salinity is very sensitive to flow reductions at 72 cfs in this reach of the river, but not so much at flows above 100 to 150 cfs.

The graphics document also includes plots of chlorophyll *a* concentrations versus flow at three locations in the river. Due to a combination of factors, the response of chlorophyll *a* vs. flow differs greatly between the lower and upper sections of the tidal river. At the two uppermost stations, 72 cfs is in the flow range where chlorophyll *a* is reaches peak values in the range of 40 to 90 ug/l (data from kilometer 13.8 shown below, some higher values observed at kilometer 9.6). It could be argued whether that represents an ecological imbalance or not, but in my opinion, 72 cfs is not a flow rate where there should be an increase in the percent withdrawal.



Also, a very useful analysis is to examine daily output from the EFDC model see in what flow range does a specific percent withdrawal rate cause usually reductions in low salinity habitats greater than 15 percent, similar to what was done for the Lower Peace River. I suspect the fish habitat analysis could be used in a similar manner.

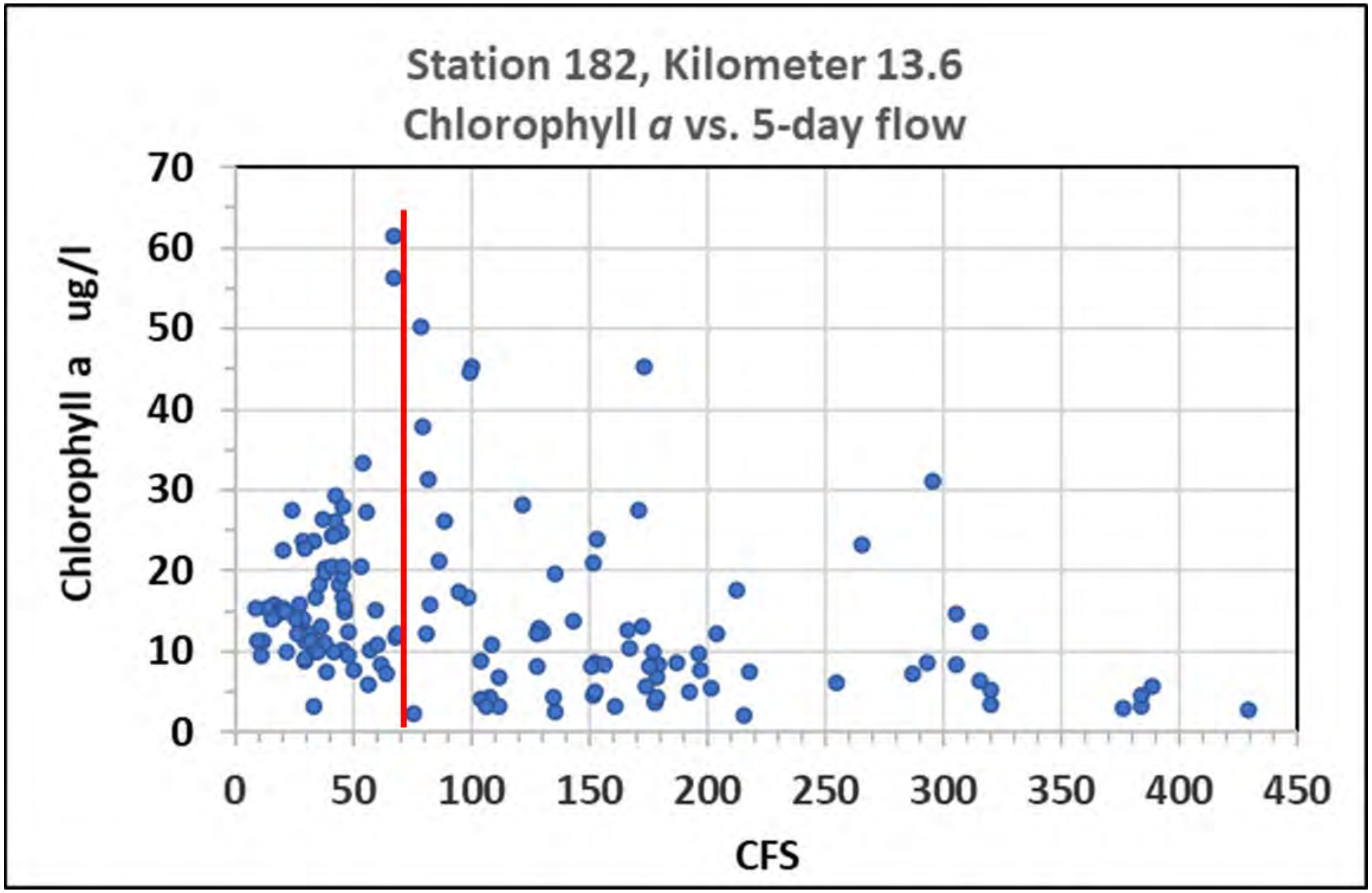
In closing, over the last 30 years the District had spent considerable time, effort, and money to conduct detailed technical investigations of the relationships of streamflow to the ecology of freshwater and estuarine rivers. In doing so, it has developed the very progressive percent of flow method, which has been successfully applied to many rivers.

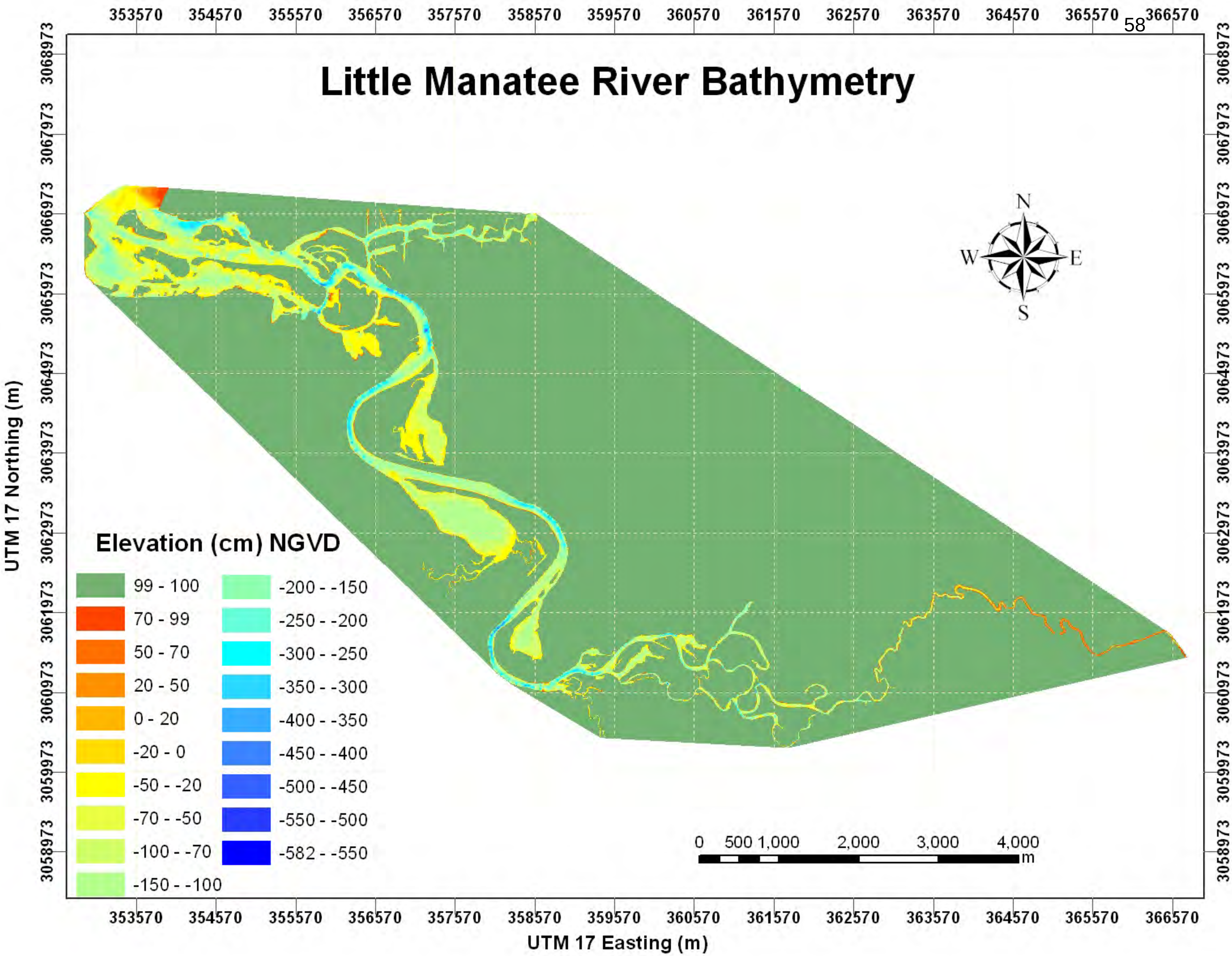
However, the percent of flow method is at a critical juncture right now. The topic of whether the flow blocks have to be the same for fresh and estuarine sections of rivers is extremely important and the Little Manatee could be viewed a precedent. Based on a number of ecological factors and practical water management considerations, I strongly believe that flow blocks for fresh and estuarine sections of rivers need to be evaluated separately. At a minimum, you don't want to simply apply the blocks that were developed for the freshwater section of a river to the estuary, as was done for the Little Manatee.

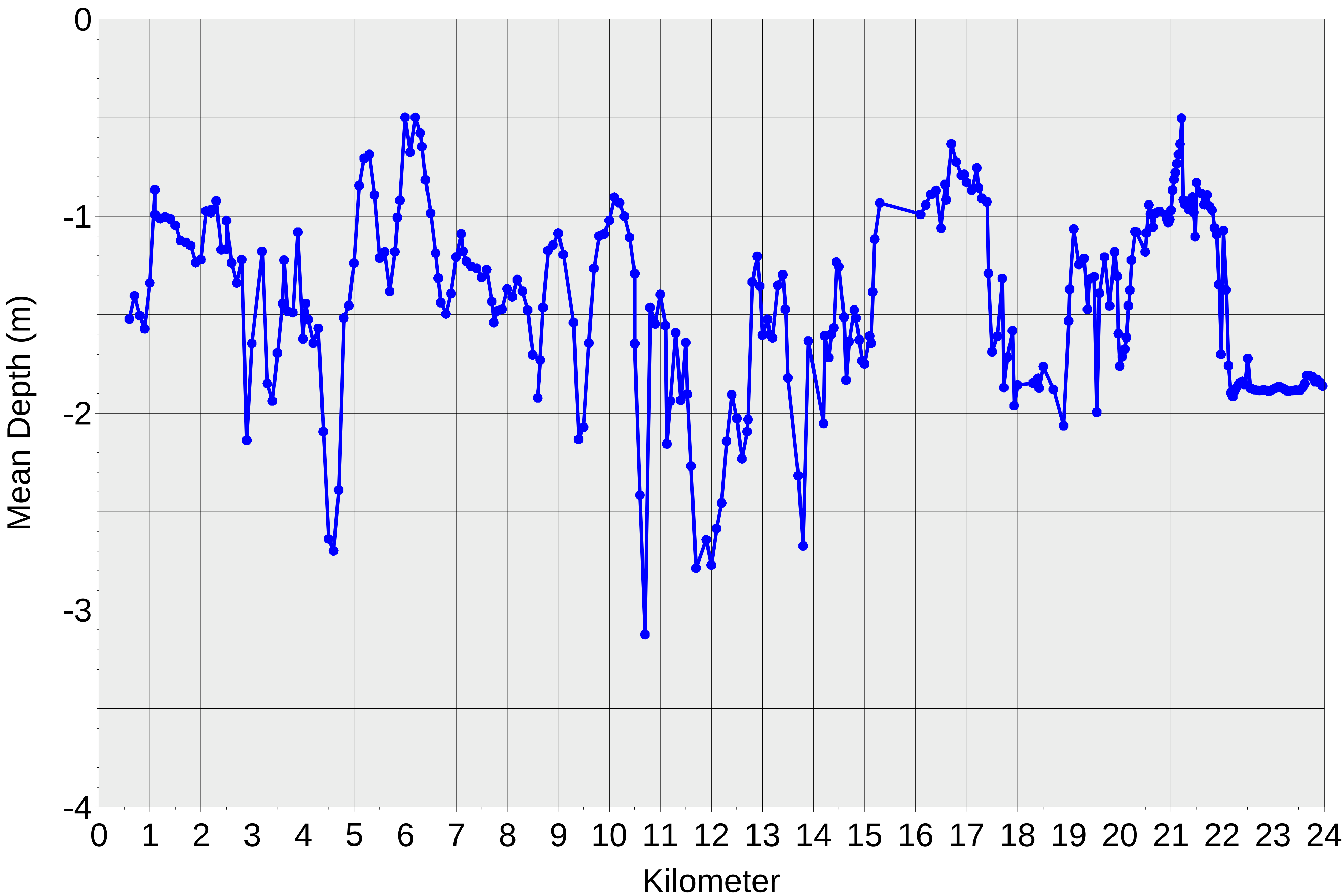
It looks like the review of the Little Manatee River minimum flows report is on a very fast track. I suggest the panel take additional time to consider further the flow blocks issue. The panel could get input from other parties, continue discussions with District staff, and consider some other analyses. There is no real need to hurry on this minimum flow on this very valuable river, and this is a critical factor that needs to be thoroughly assessed.

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

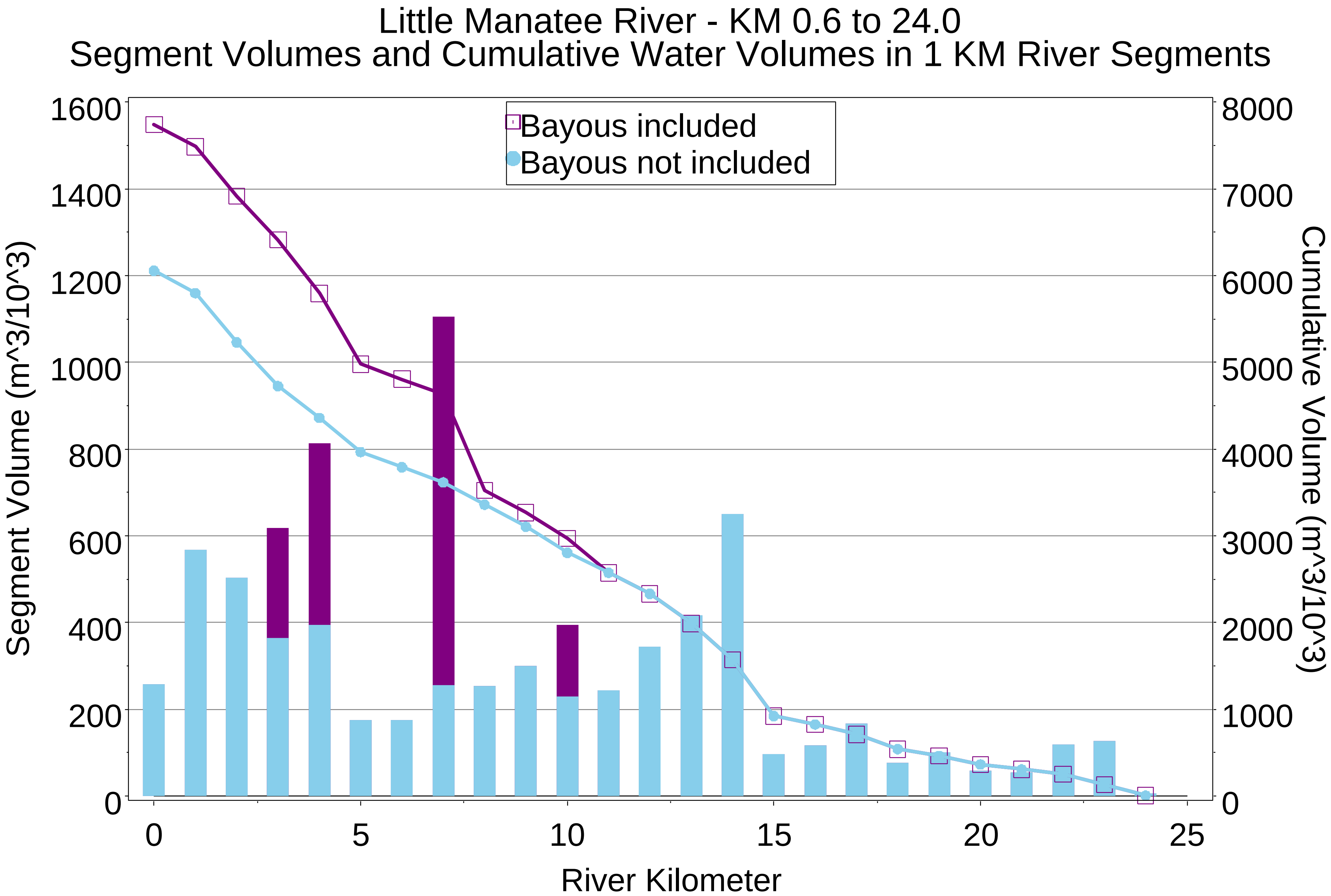
	Block 1 (≤ 35 cfs)	Block 2 (> 35 cfs and ≤ 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	87% of the flow on the previous day when the previous day's flow was > 72 cfs and ≤ 174 cfs, or 89% of the 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		


Station 182, Kilometer 13.6
Chlorophyll *a* vs. 5-day flow
Chlorophyll a ug/l
0
10
20
30
40
50
60
70
0
50
100
150
200
250
300
350
400
450
CFS

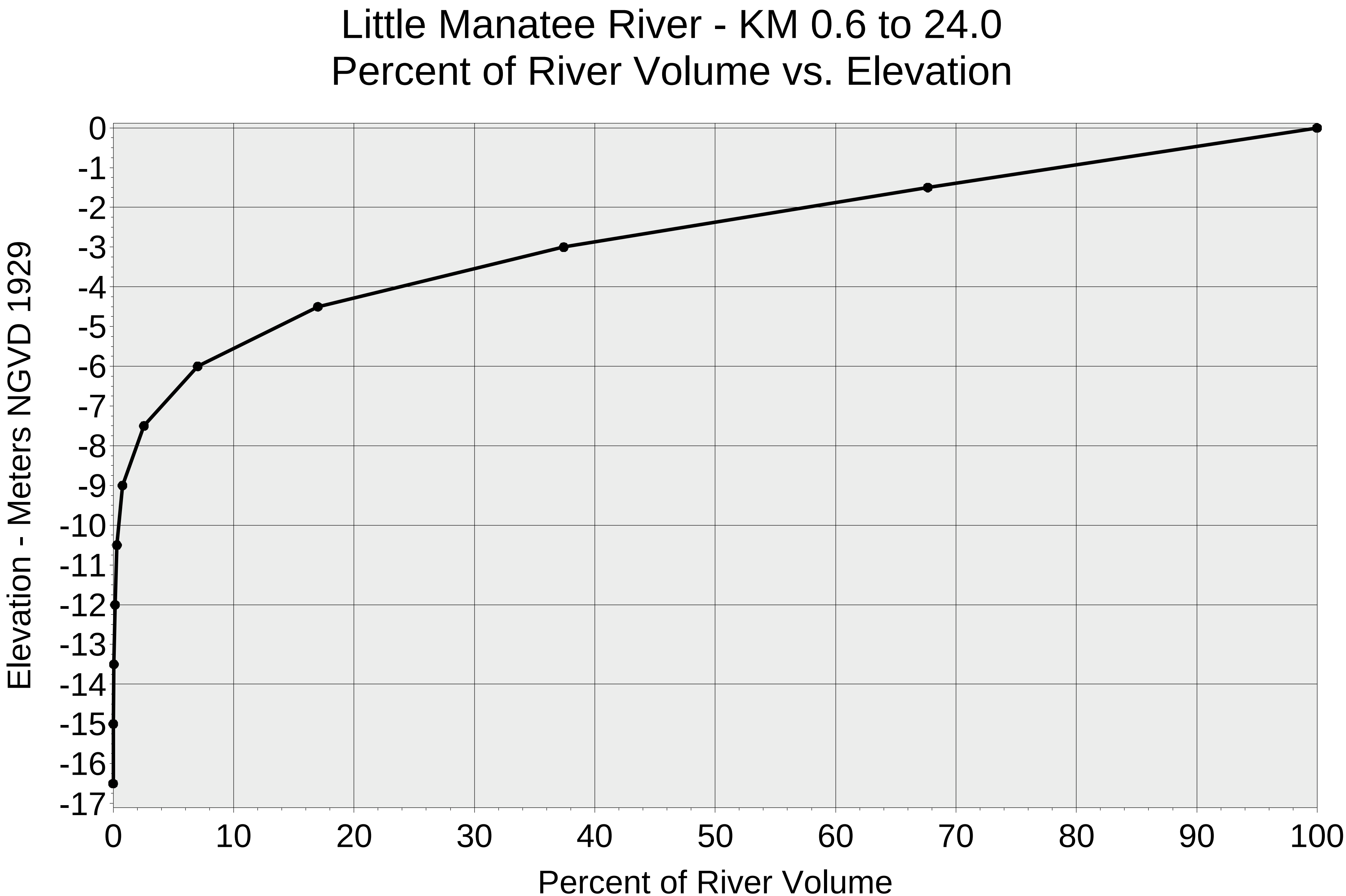

Little Manatee River Bathymetry
Elevation (cm) NGVD
99 - 100
70 - 99
50 - 70
20 - 50
0 - 20
-20 - 0
-50 - -20
-70 - -50
-100 - -70
-150 - -100
-200 - -150
-250 - -200
-300 - -250
-350 - -300
-400 - -350
-450 - -400
-500 - -450
-550 - -500
-582 - -550
N
S
E
W
0 500 1,000 2,000 3,000 4,000 m
UTM 17 Easting (m)
UTM 17 Northing (m)
353570 354570 355570 356570 357570 358570 359570 360570 361570 362570 363570 364570 365570 366570
3068973 3067973 3066973 3065973 3064973 3063973 3062973 3061973 3060973 3059973 3058973

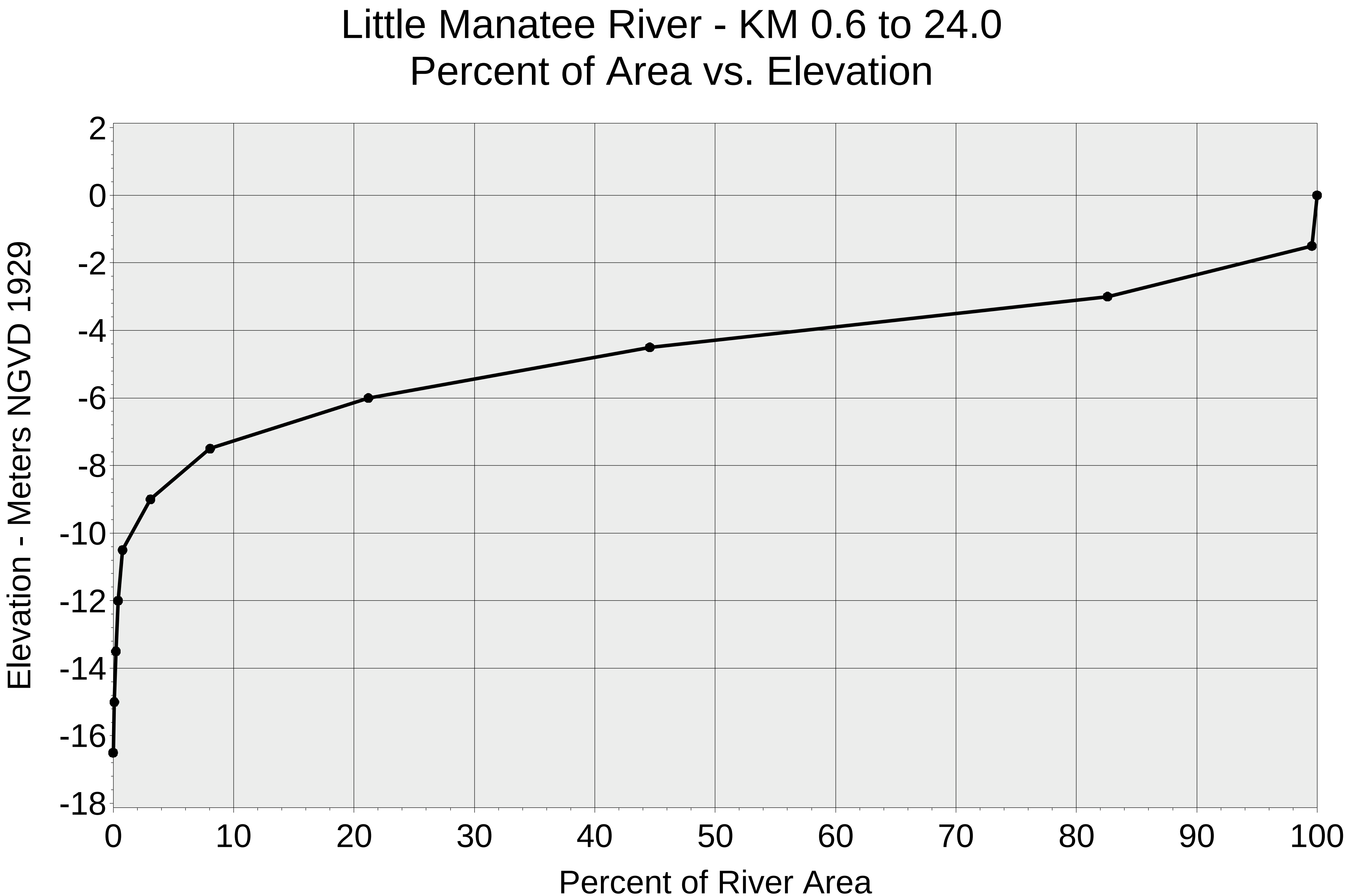


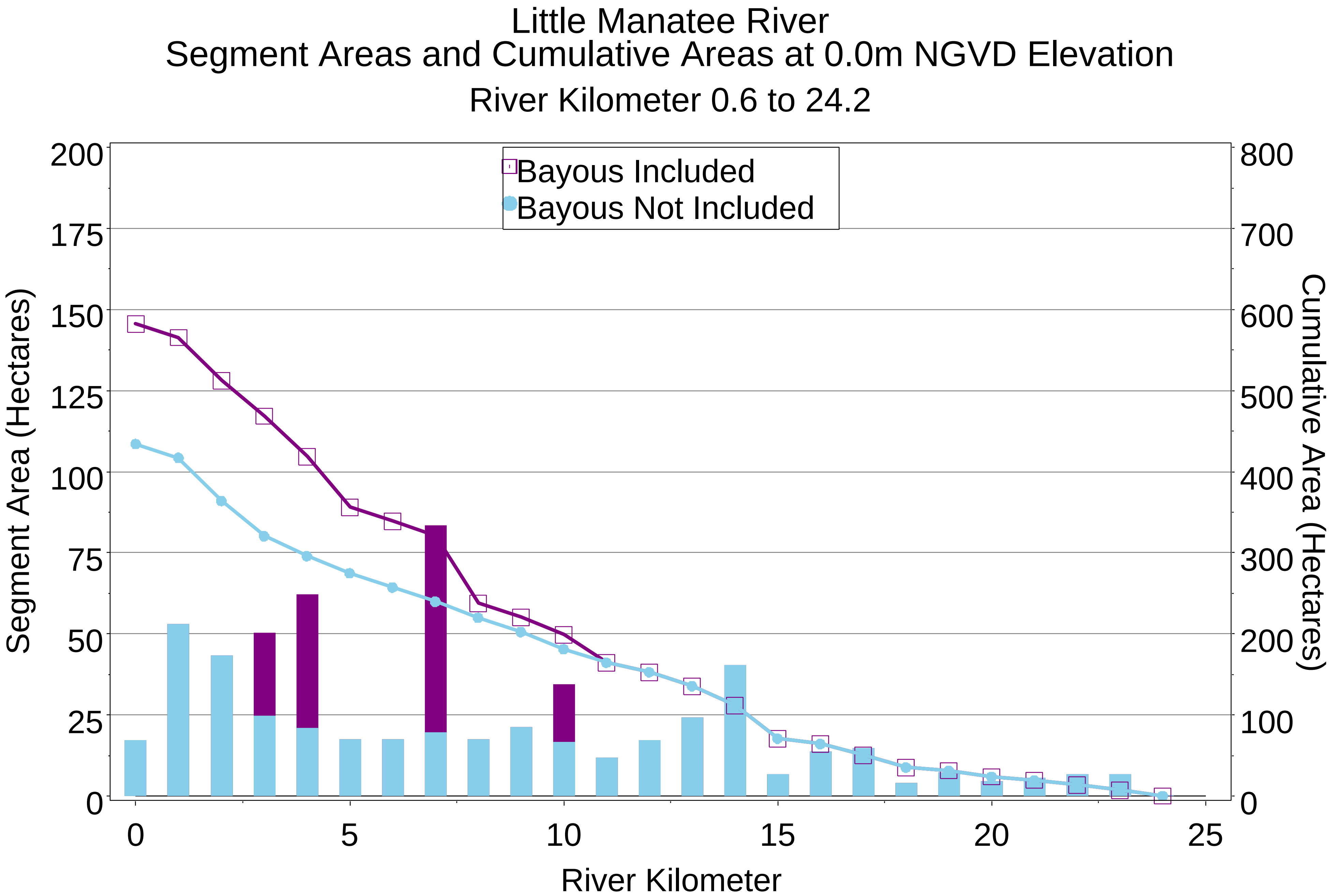
0
-1
-2
-3
-4
Mean Depth (m)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Kilometer

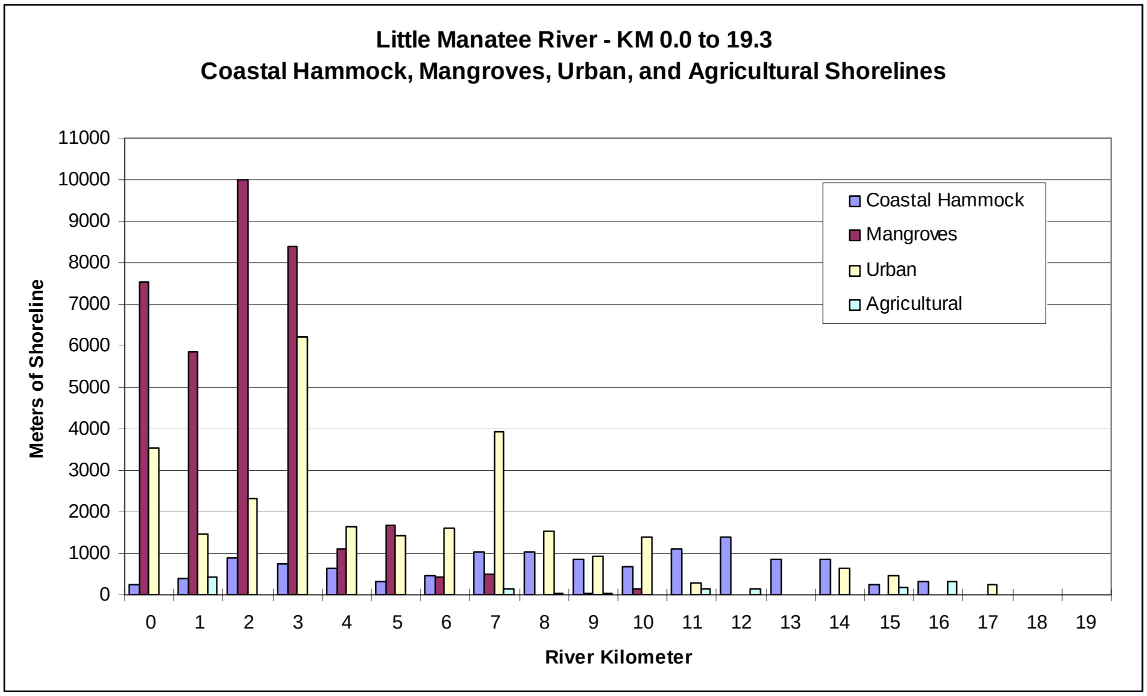


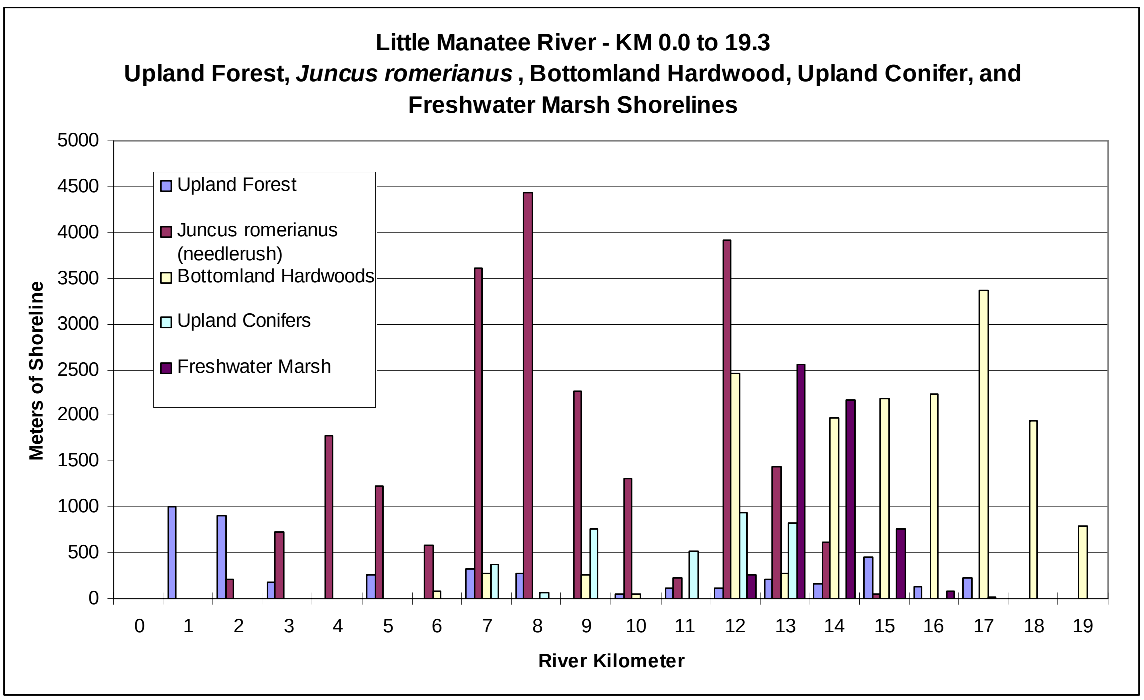
Little Manatee River - KM 0.6 to 24.0
Segment Volumes and Cumulative Water Volumes in 1 KM River Segments
Bayous included
Bayous not included
Segment Volume (m^3/10^3)
Cumulative Volume (m^3/10^3)
River Kilometer
0
200
400
600
800
1000
1200
1400
1600
0
1000
2000
3000
4000
5000
6000
7000
8000
0
5
10
15
20
25

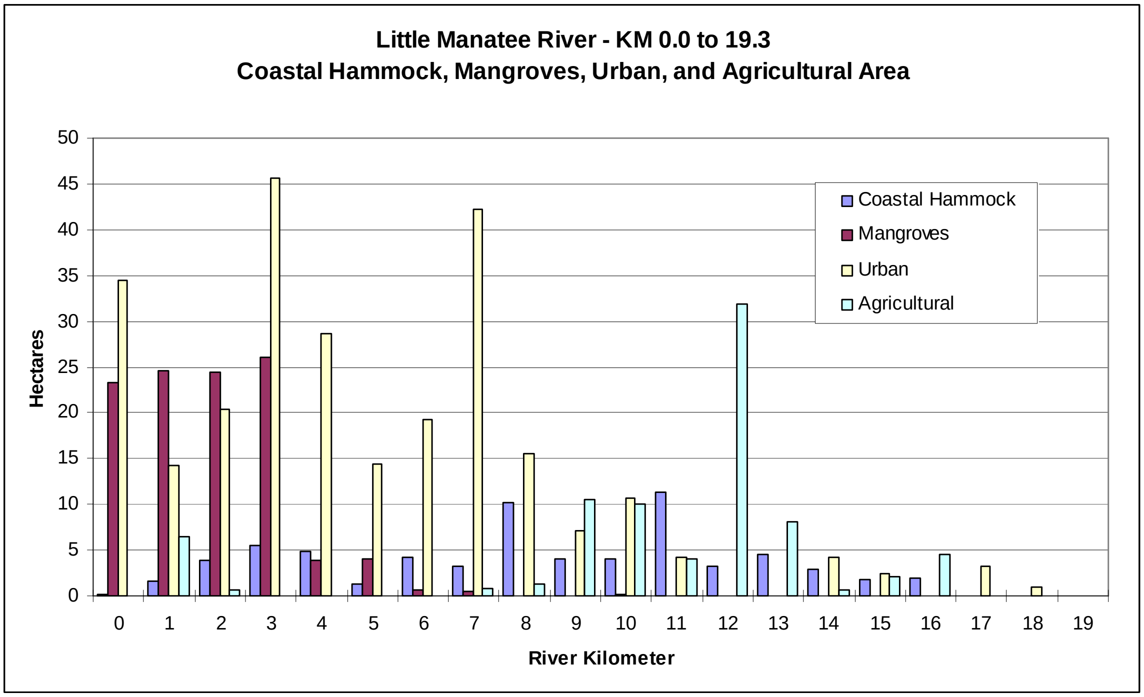

Little Manatee River - KM 0.6 to 24.0
Percent of River Volume vs. Elevation
Elevation - Meters NGVD 1929
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
0
10
20
30
40
50
60
70
80
90
100
Percent of River Volume

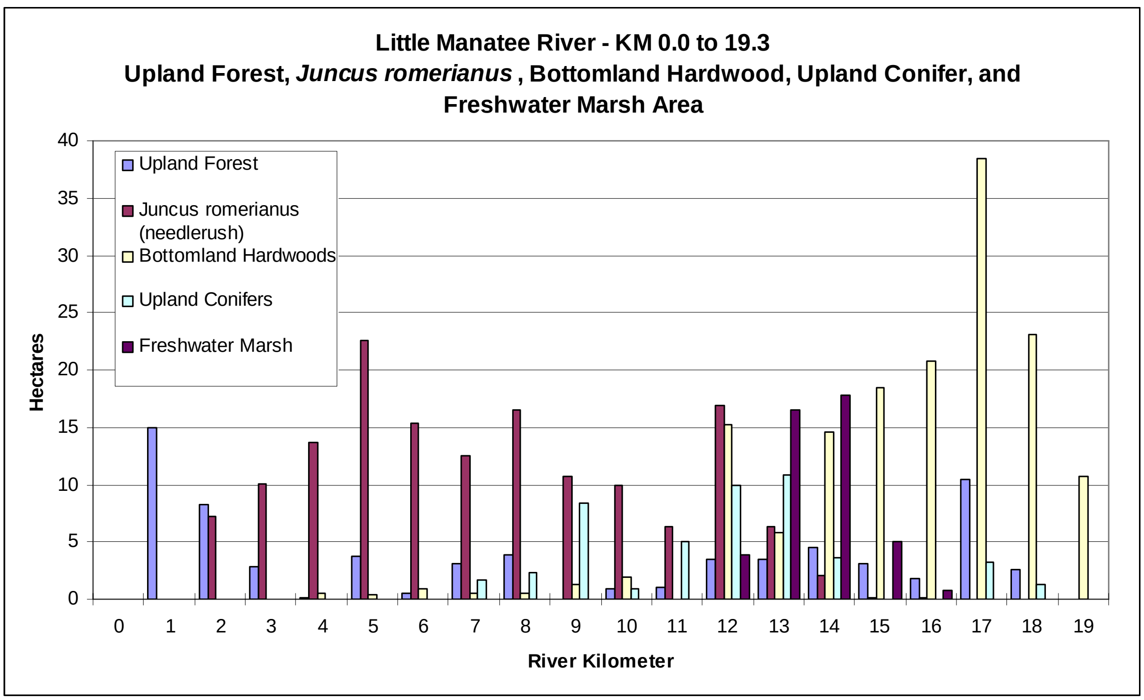

Little Manatee River - KM 0.6 to 24.0
Percent of Area vs. Elevation
Elevation - Meters NGVD 1929
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
10
20
30
40
50
60
70
80
90
100
Percent of River Area

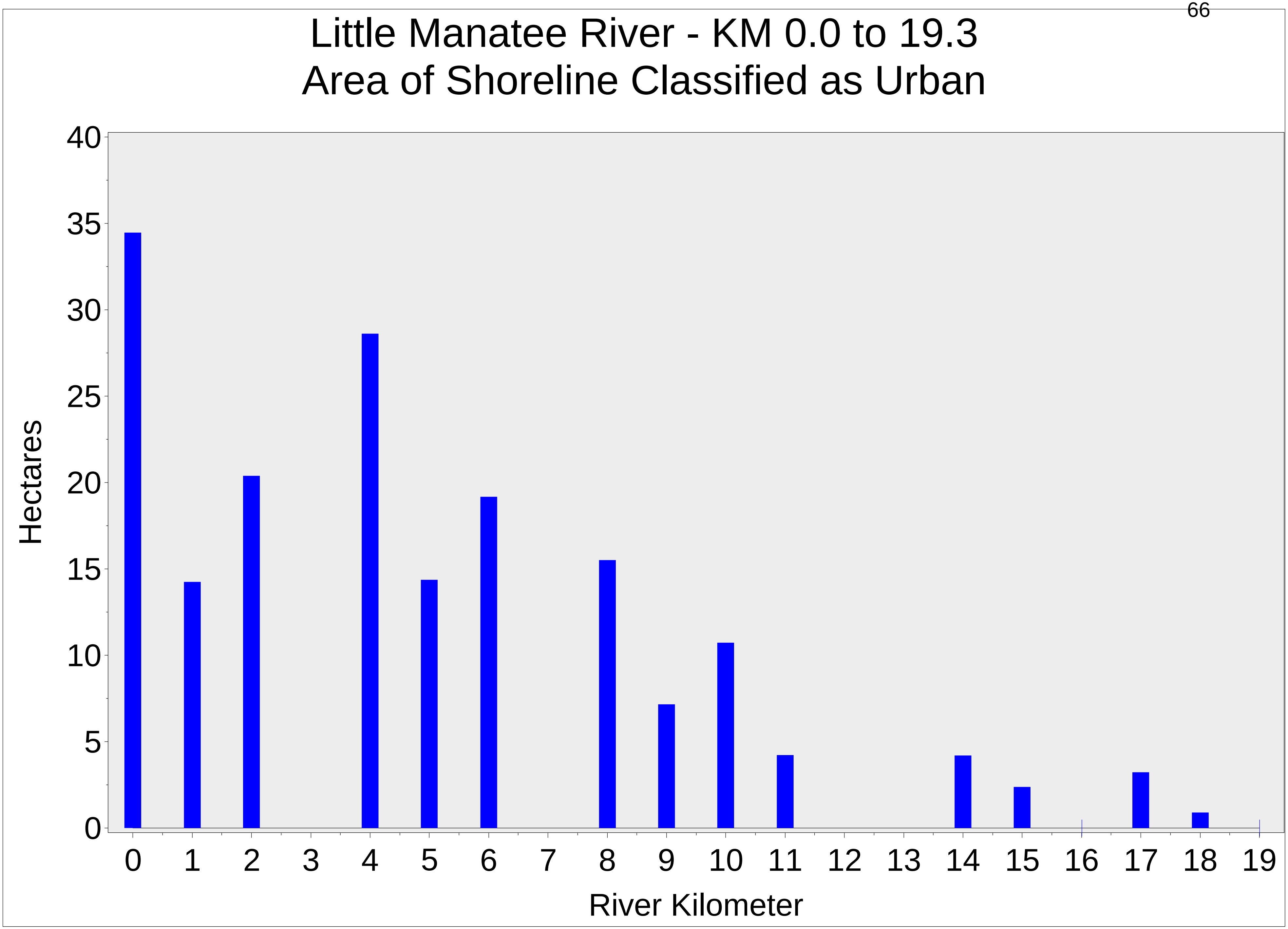

Little Manatee River
Segment Areas and Cumulative Areas at 0.0m NGVD Elevation
River Kilometer 0.6 to 24.2
Bayous Included
Bayous Not Included
Segment Area (Hectares)
Cumulative Area (Hectares)
River Kilometer
0
25
50
75
100
125
150
175
200
0
100
200
300
400
500
600
700
800
0
5
10
15
20
25

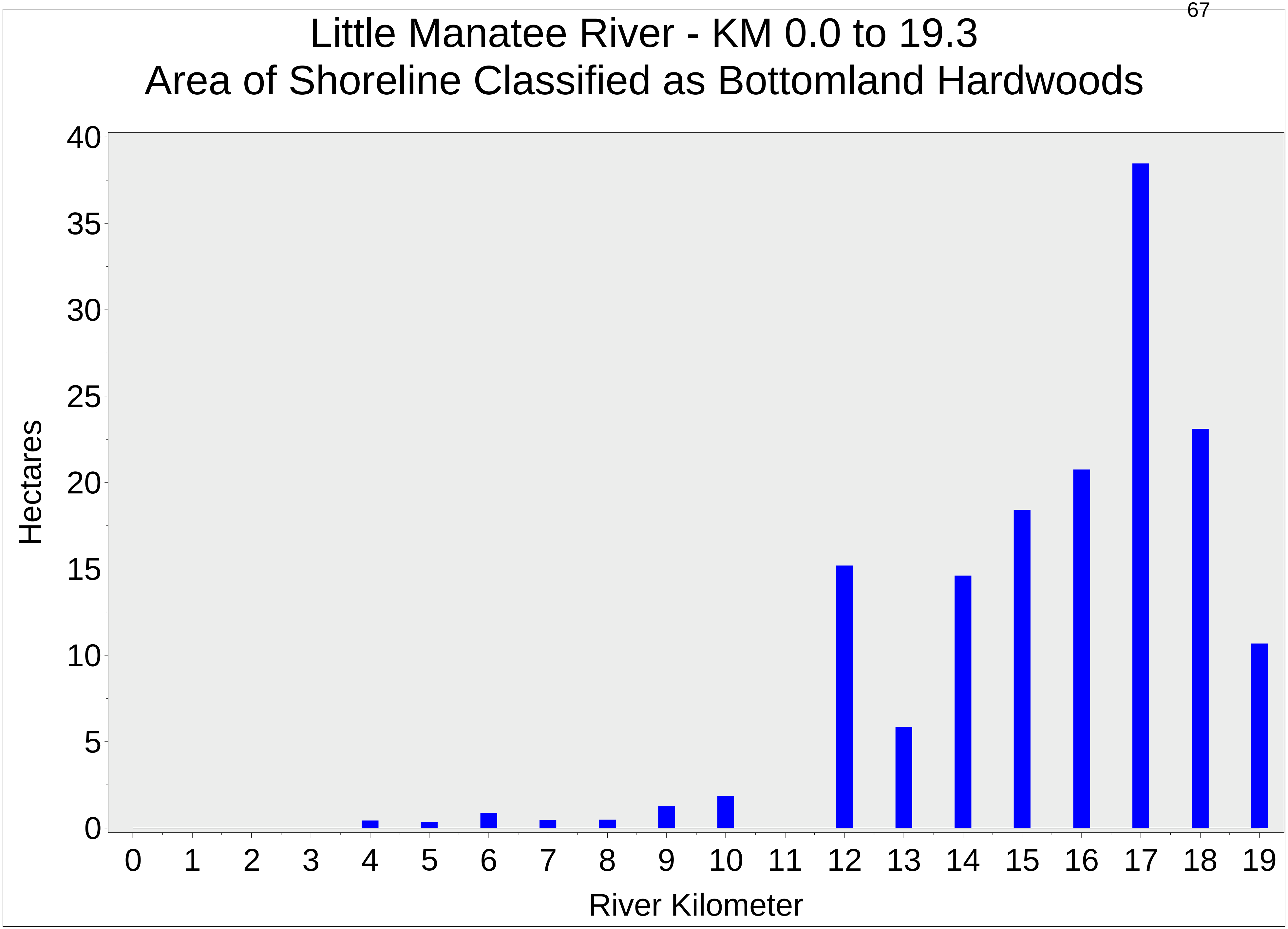

Little Manatee River - KM 0.0 to 19.3
Coastal Hammock, Mangroves, Urban, and Agricultural Shorelines
Meters of Shoreline
River Kilometer
Coastal Hammock
Mangroves
Urban
Agricultural
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

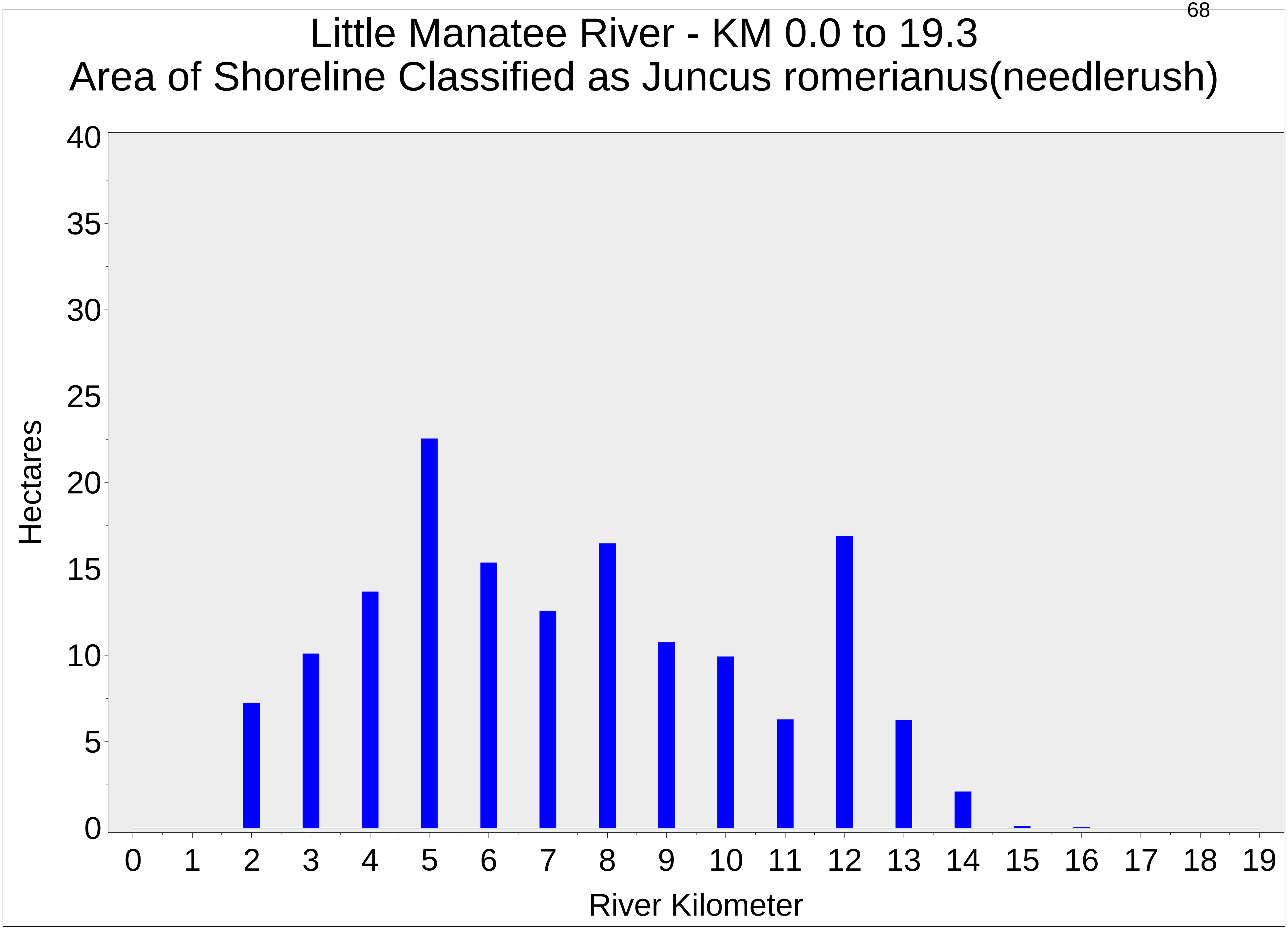

Little Manatee River - KM 0.0 to 19.3
Upland Forest, *Juncus romerianus* , Bottomland Hardwood, Upland Conifer, and Freshwater Marsh Shorelines
Meters of Shoreline
River Kilometer
Upland Forest
Juncus romerianus (needlerush)
Bottomland Hardwoods
Upland Conifers
Freshwater Marsh
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Little Manatee River - KM 0.0 to 19.3
Coastal Hammock, Mangroves, Urban, and Agricultural Area
Hectares
River Kilometer
Coastal Hammock
Mangroves
Urban
Agricultural

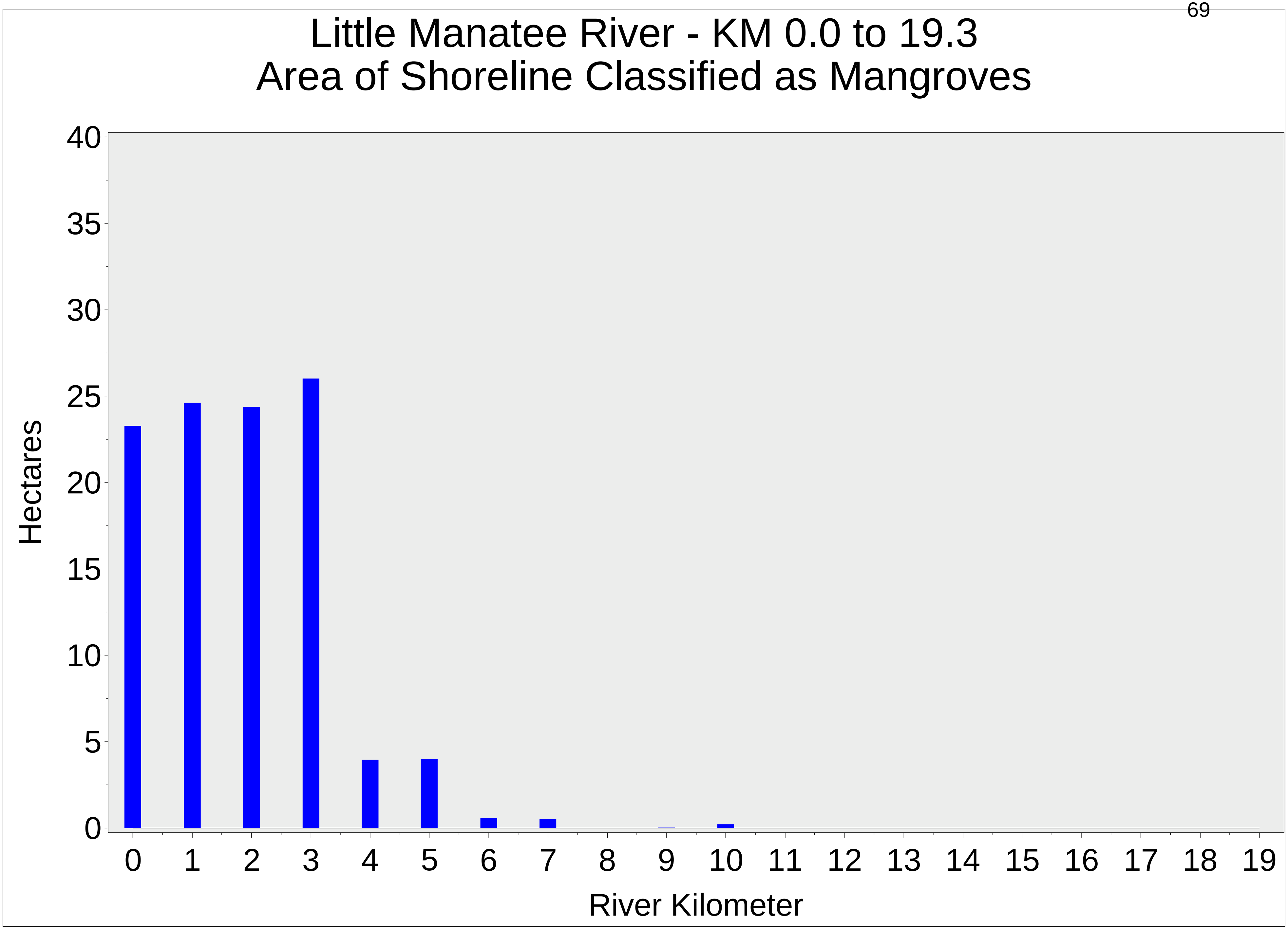

Little Manatee River - KM 0.0 to 19.3
Upland Forest, *Juncus romerianus* , Bottomland Hardwood, Upland Conifer, and Freshwater Marsh Area
Hectares
River Kilometer
Upland Forest
Juncus romerianus (needlerush)
Bottomland Hardwoods
Upland Conifers
Freshwater Marsh

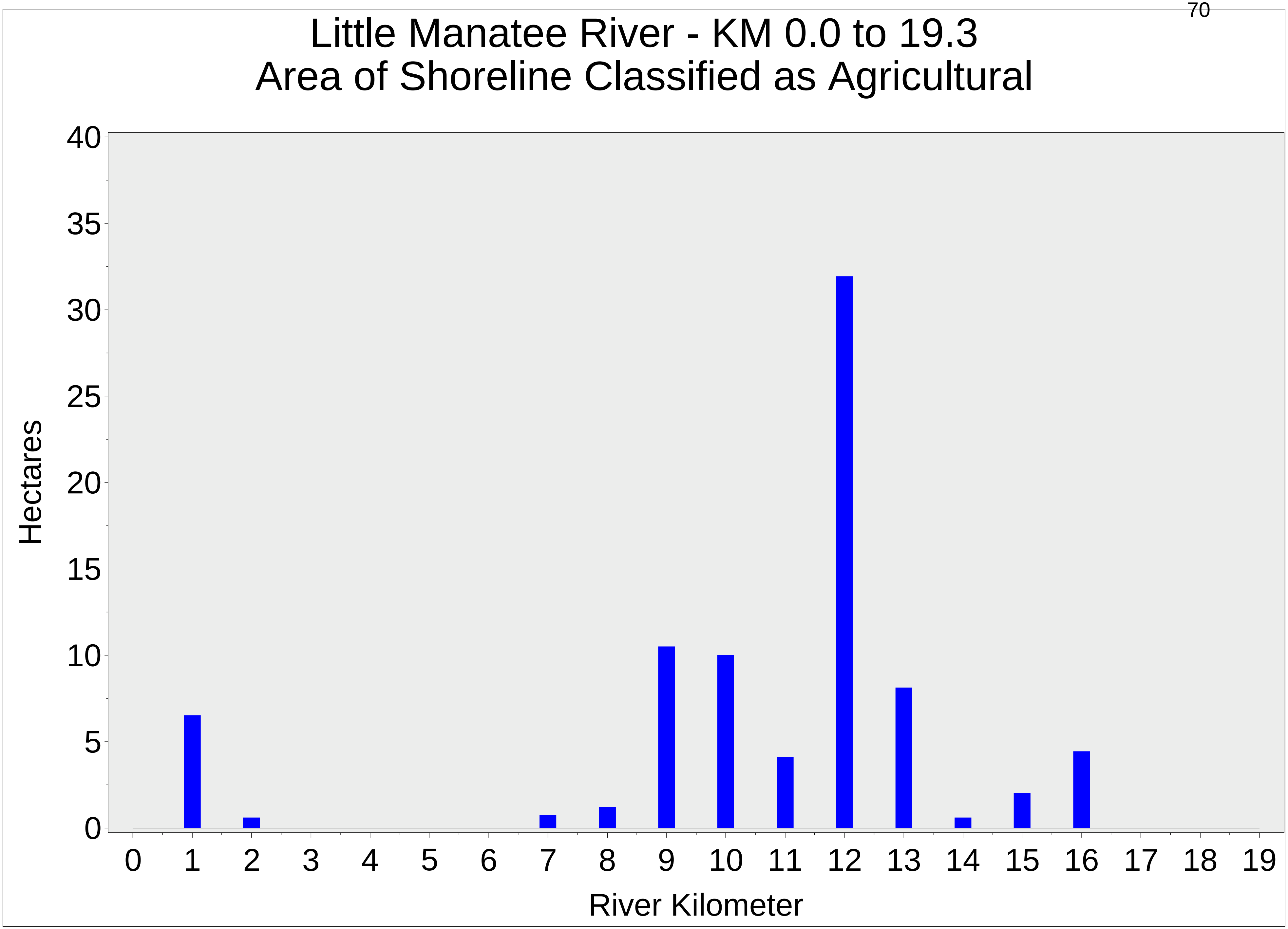

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Urban
Hectares
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

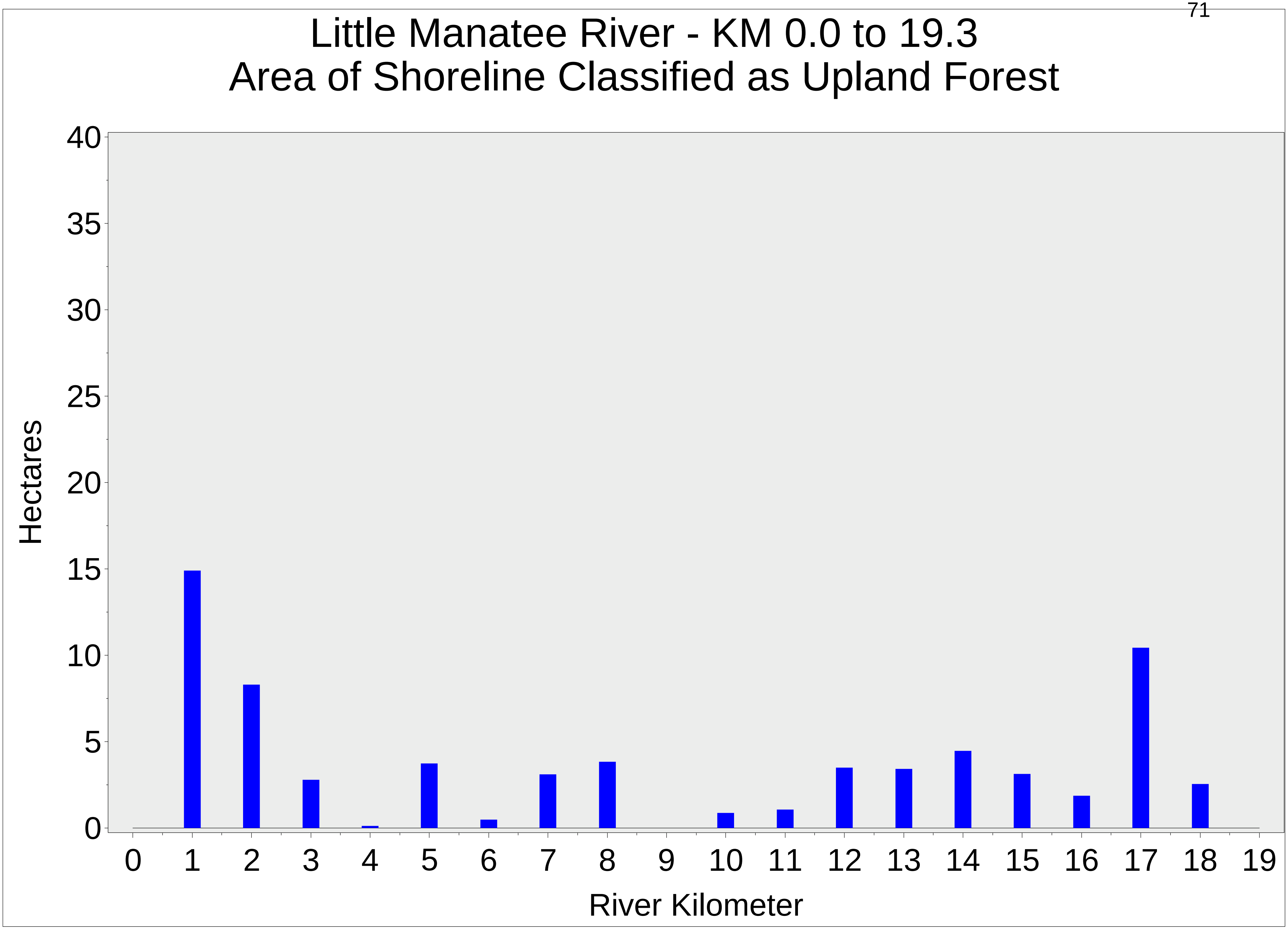

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Bottomland Hardwoods
Hectares
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
River Kilometer

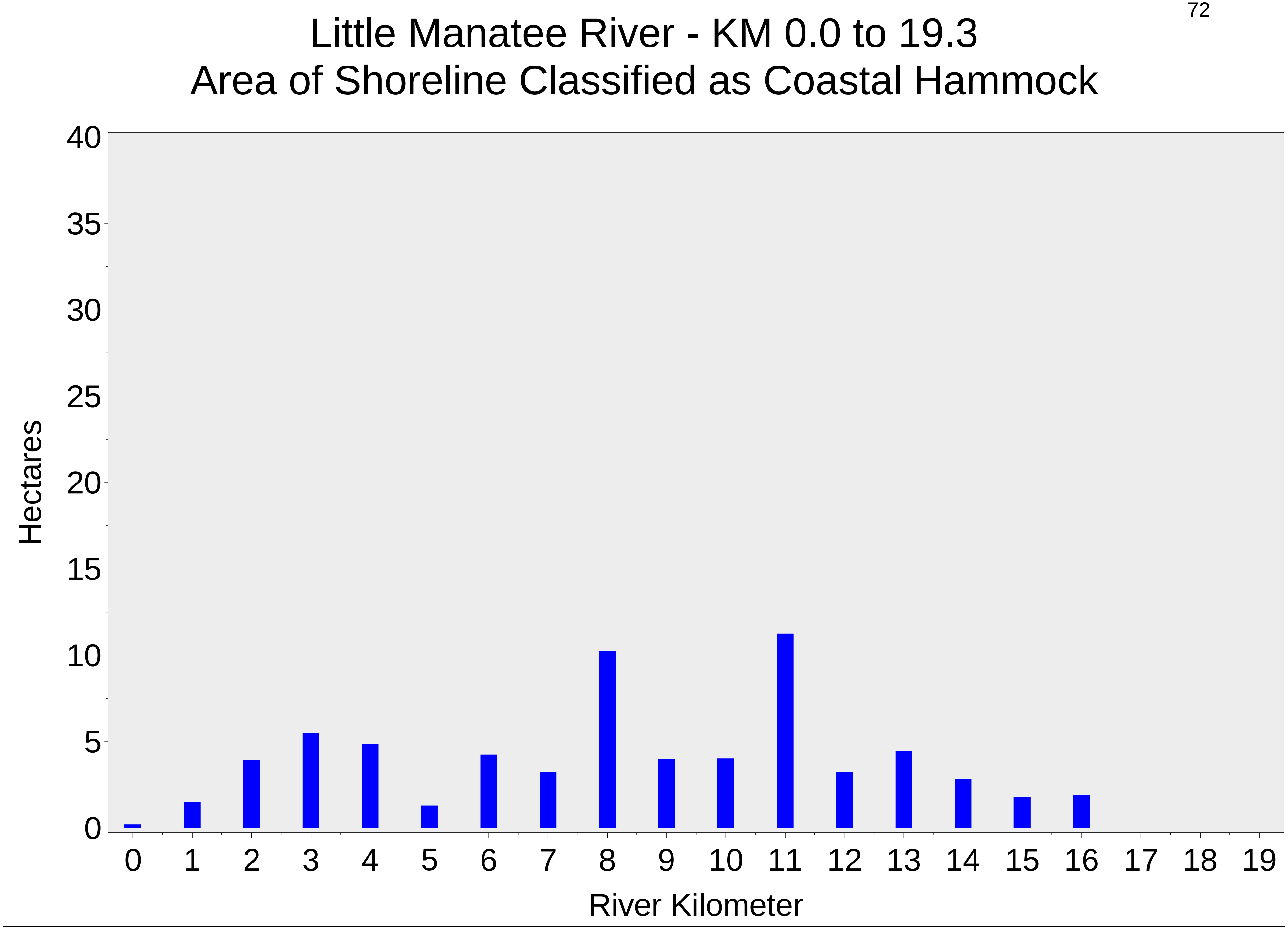


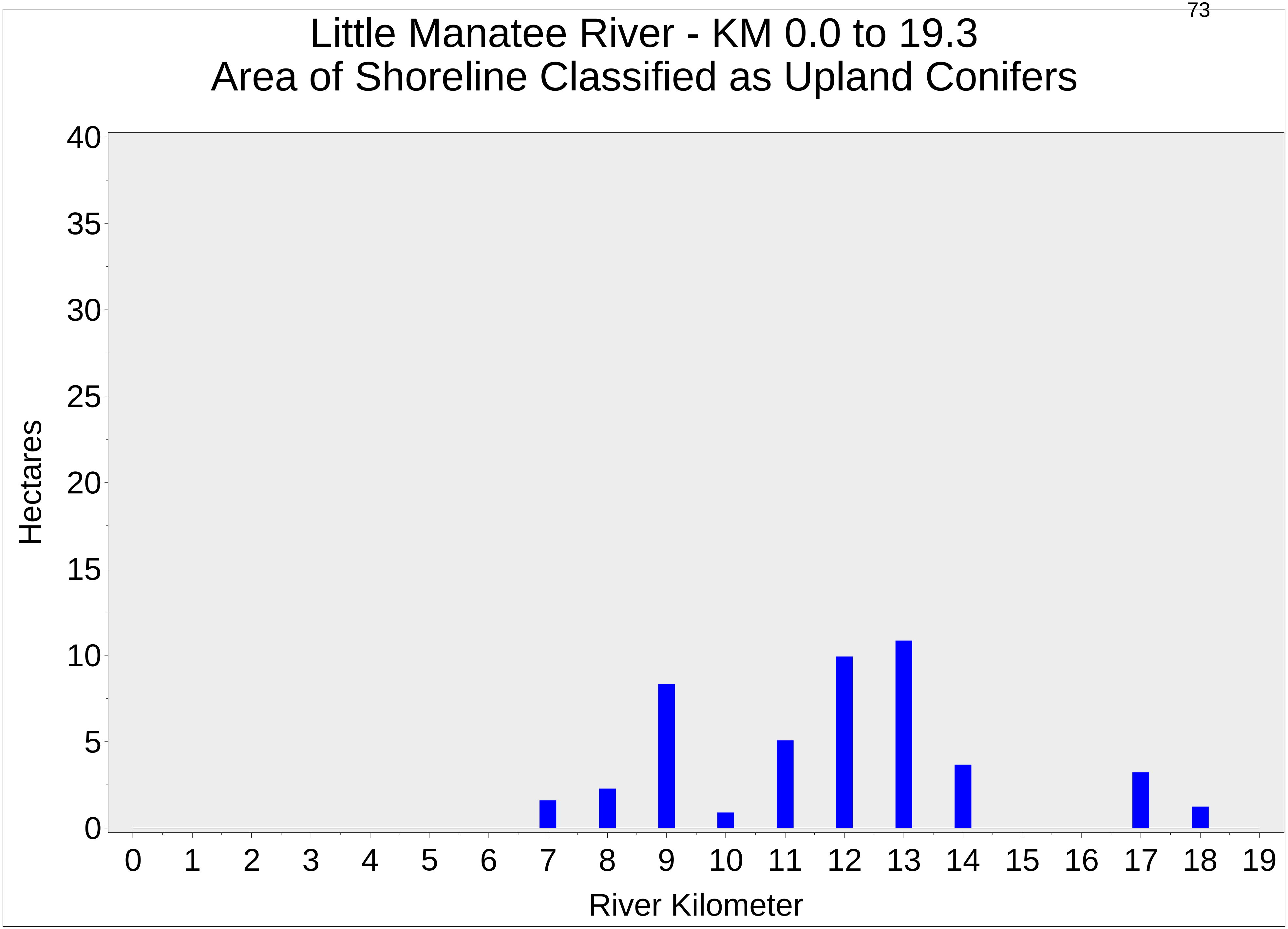
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Juncus romerianus(needlerush)
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Mangroves
Hectares
0
5
10
15
20
25
30
35
40
River Kilometer
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

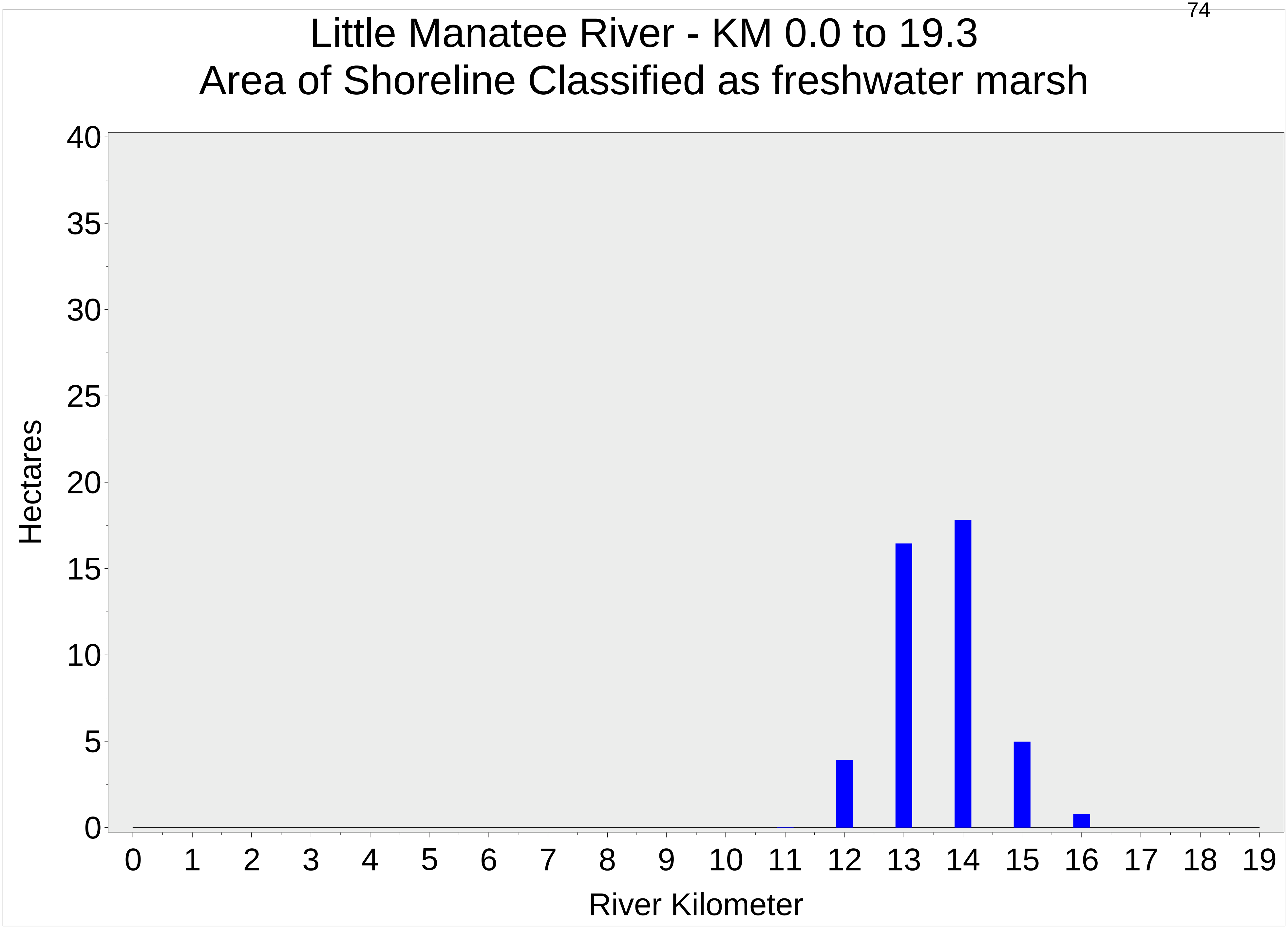

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Agricultural
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

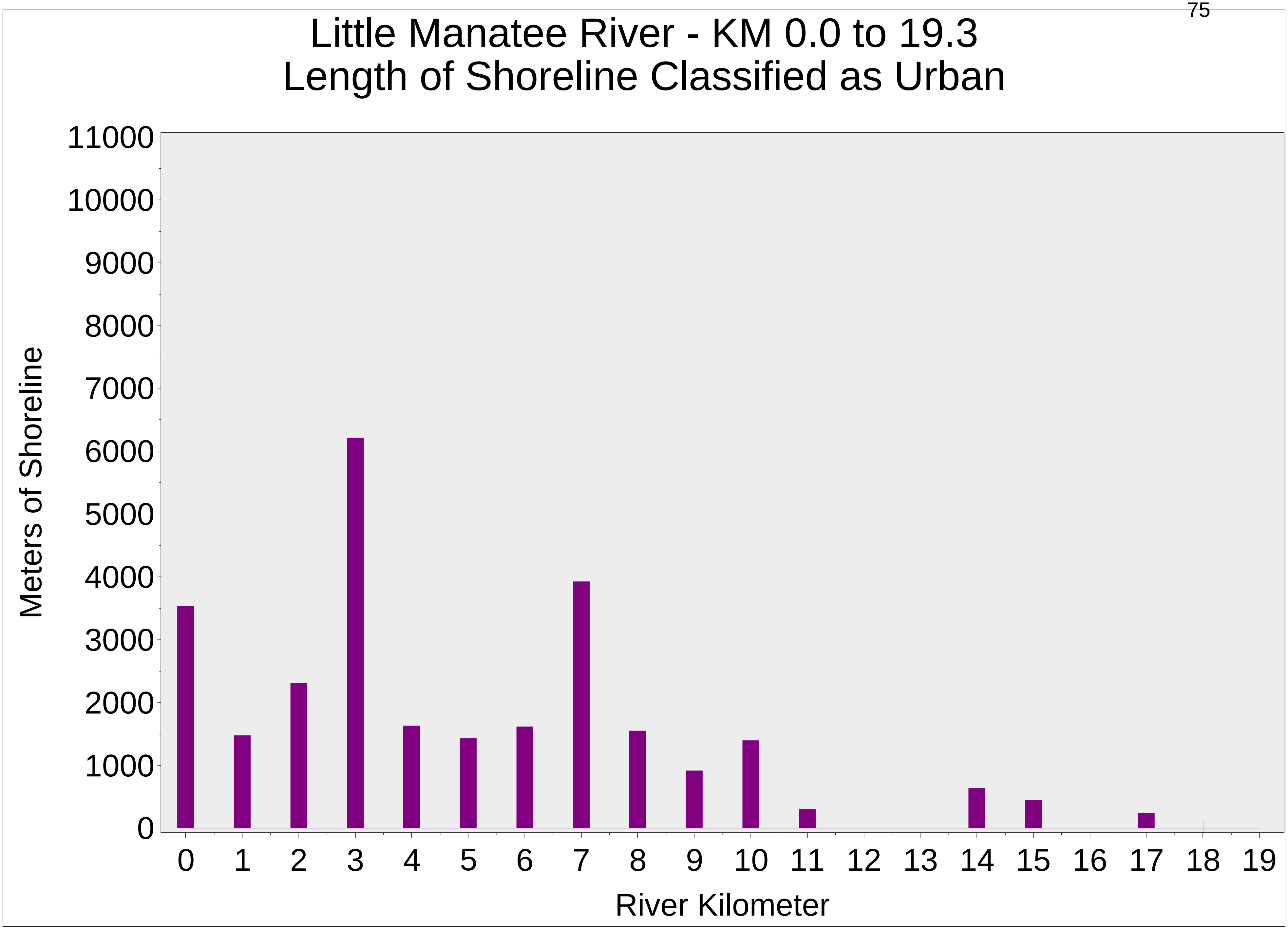

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Upland Forest
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

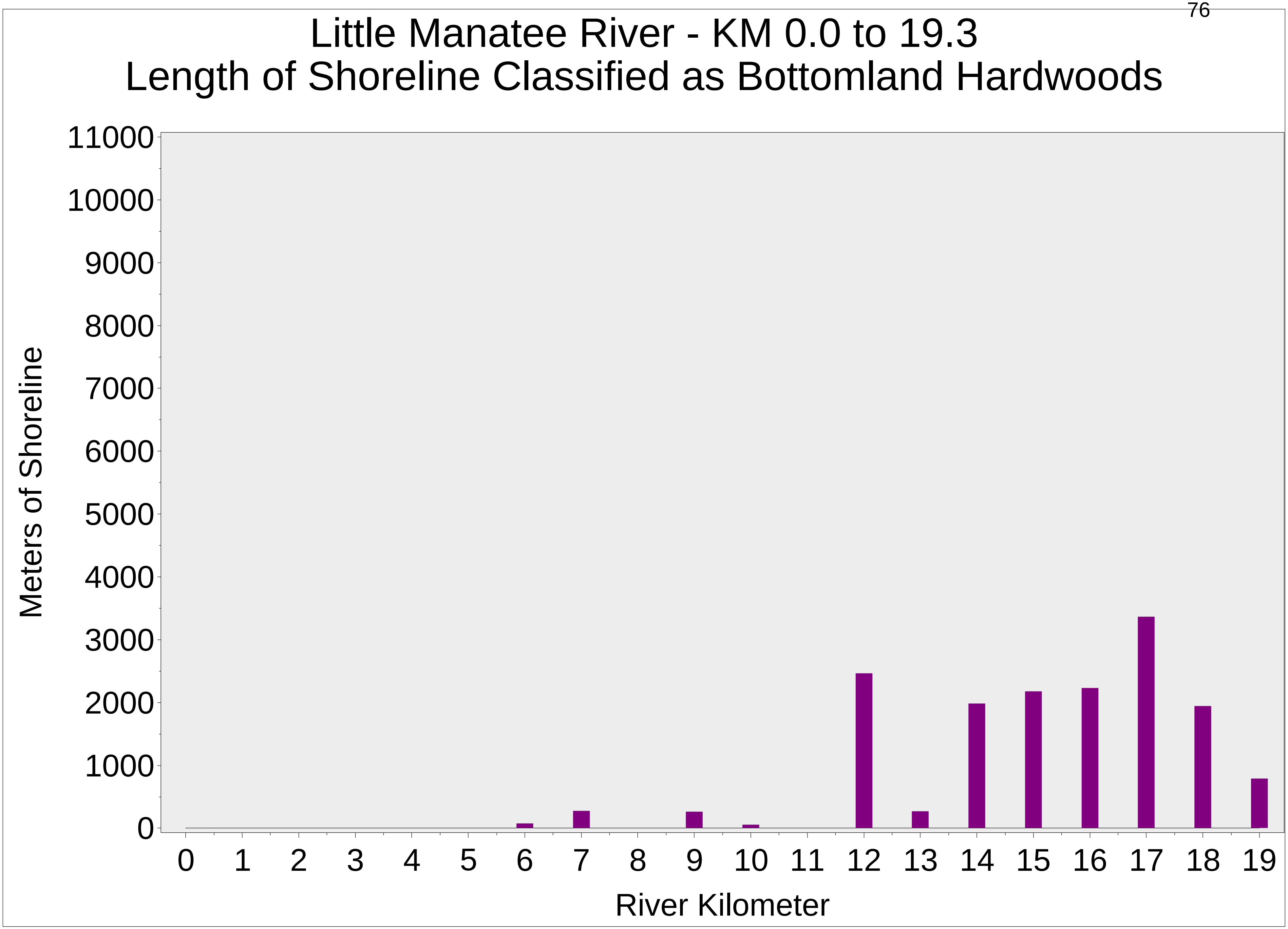

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Coastal Hammock
Hectares
0
5
10
15
20
25
30
35
40
River Kilometer
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

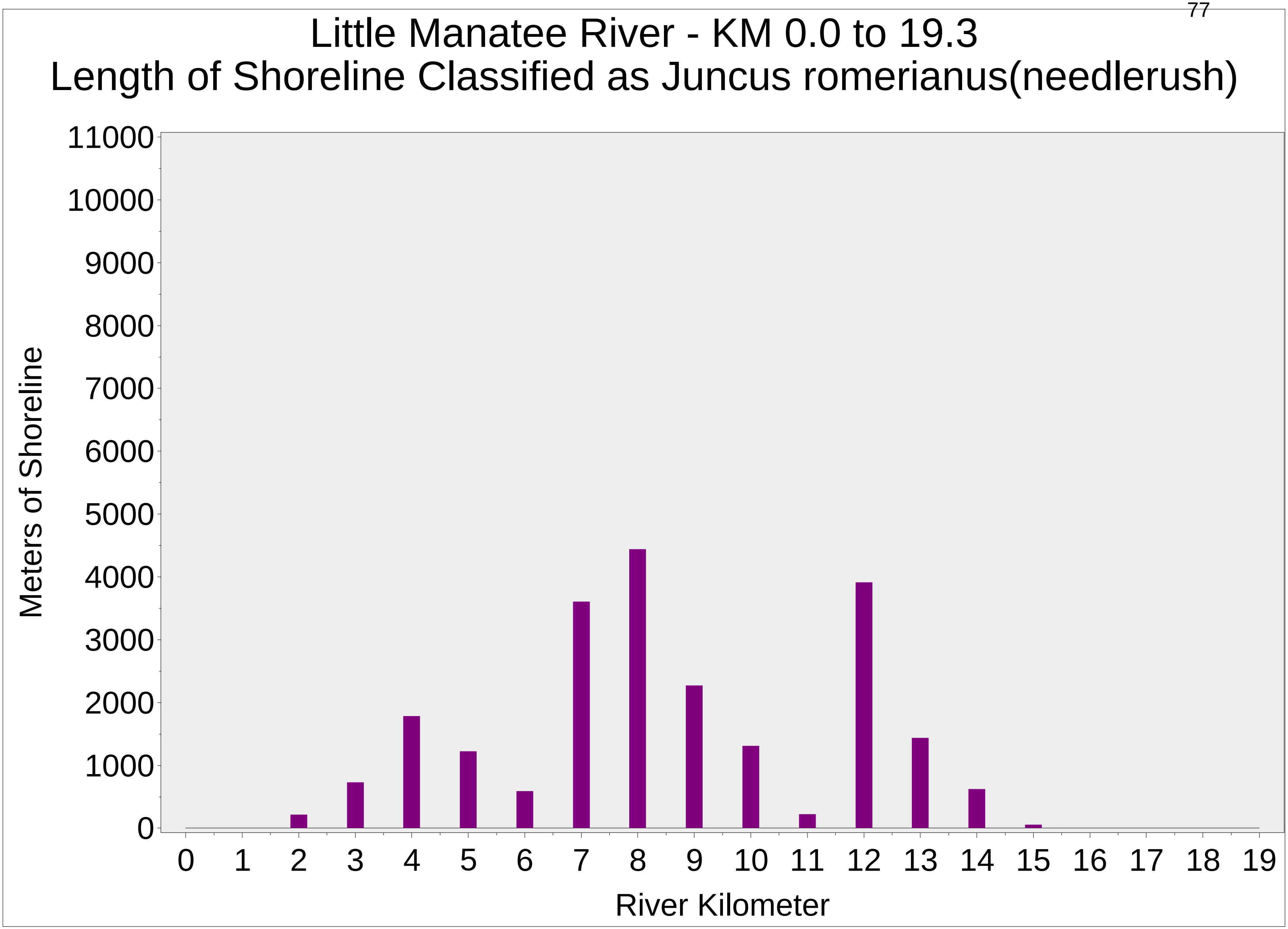


Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Upland Conifers
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

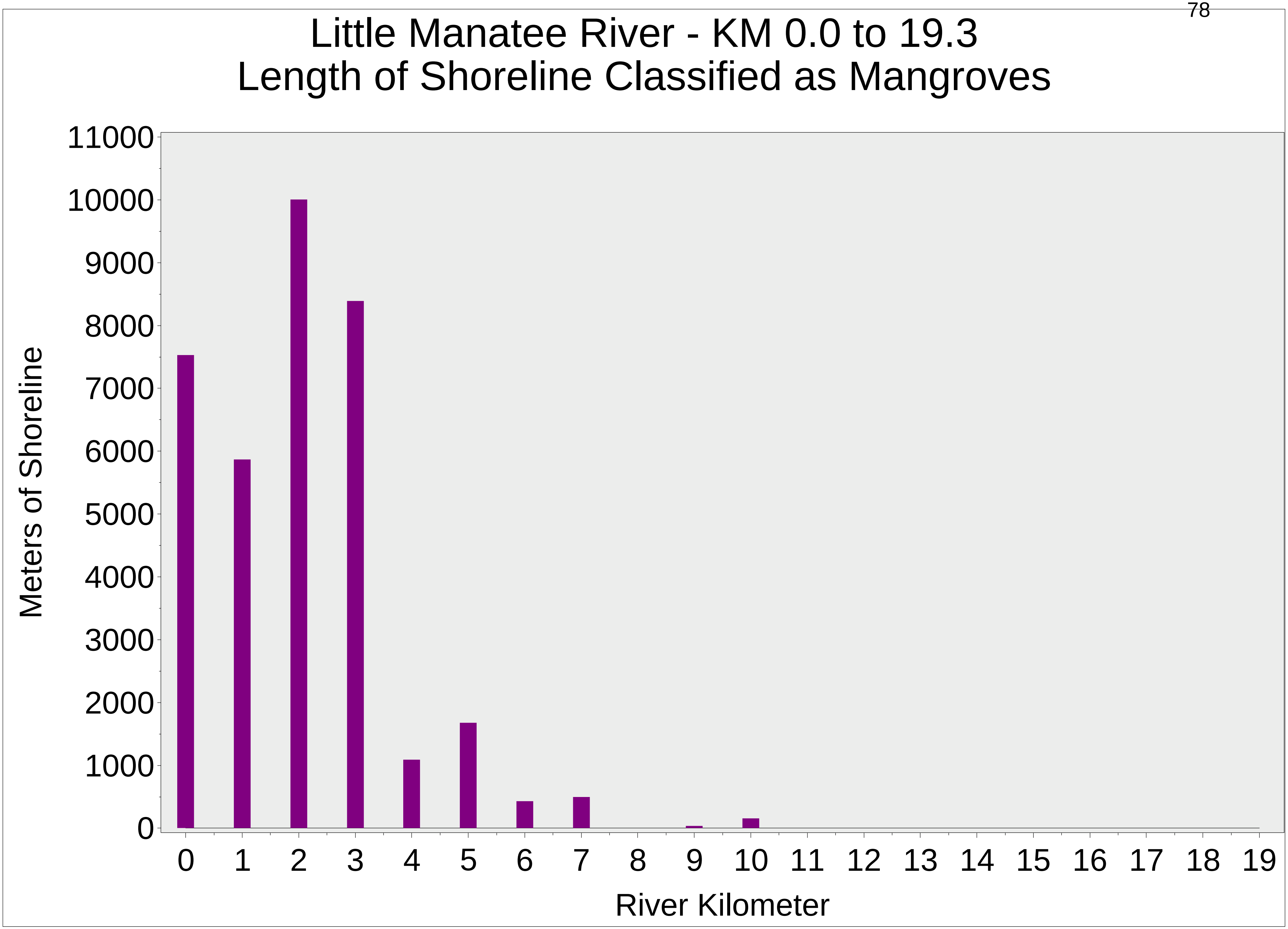

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as freshwater marsh
Hectares
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

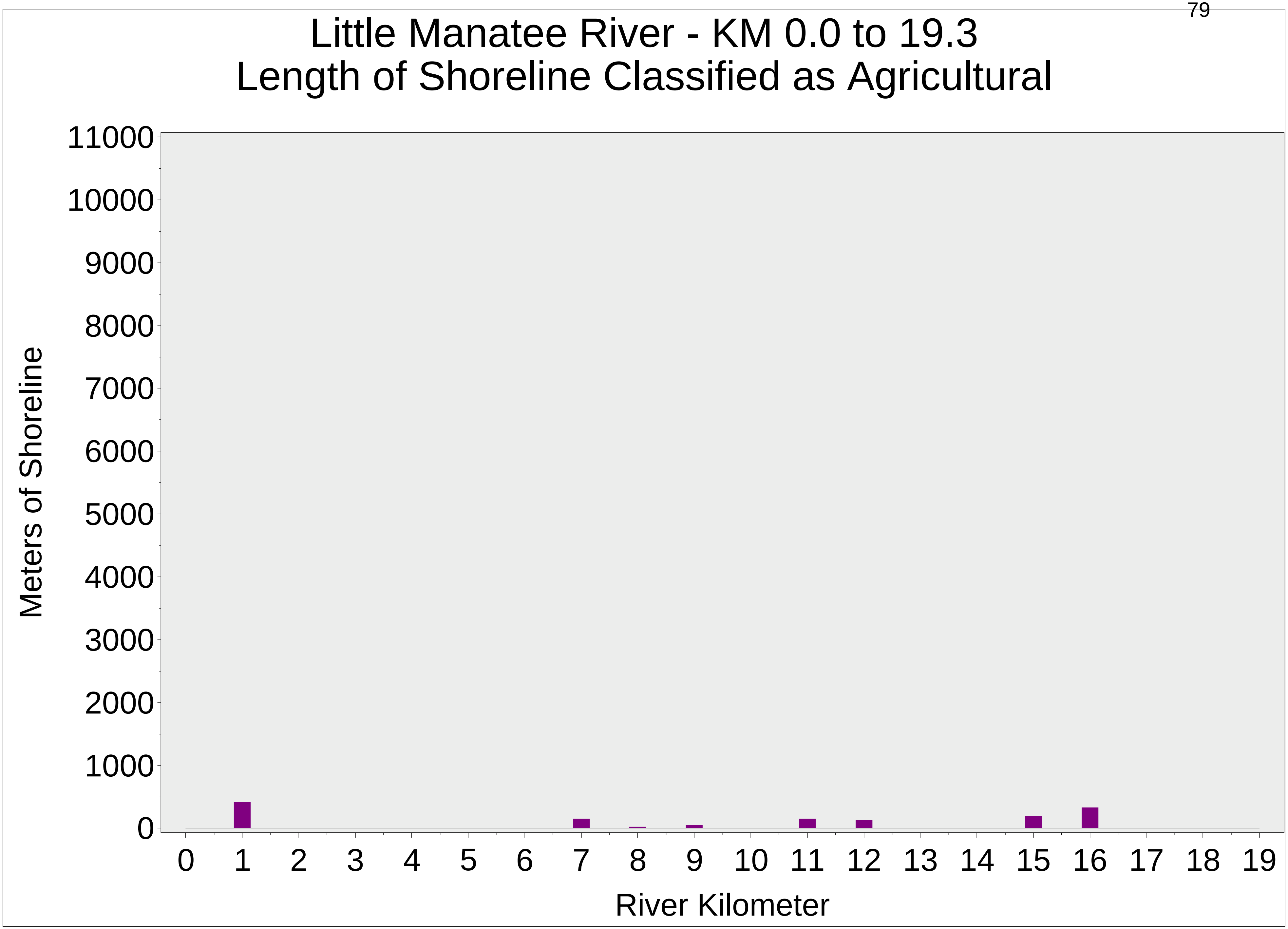

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Urban
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

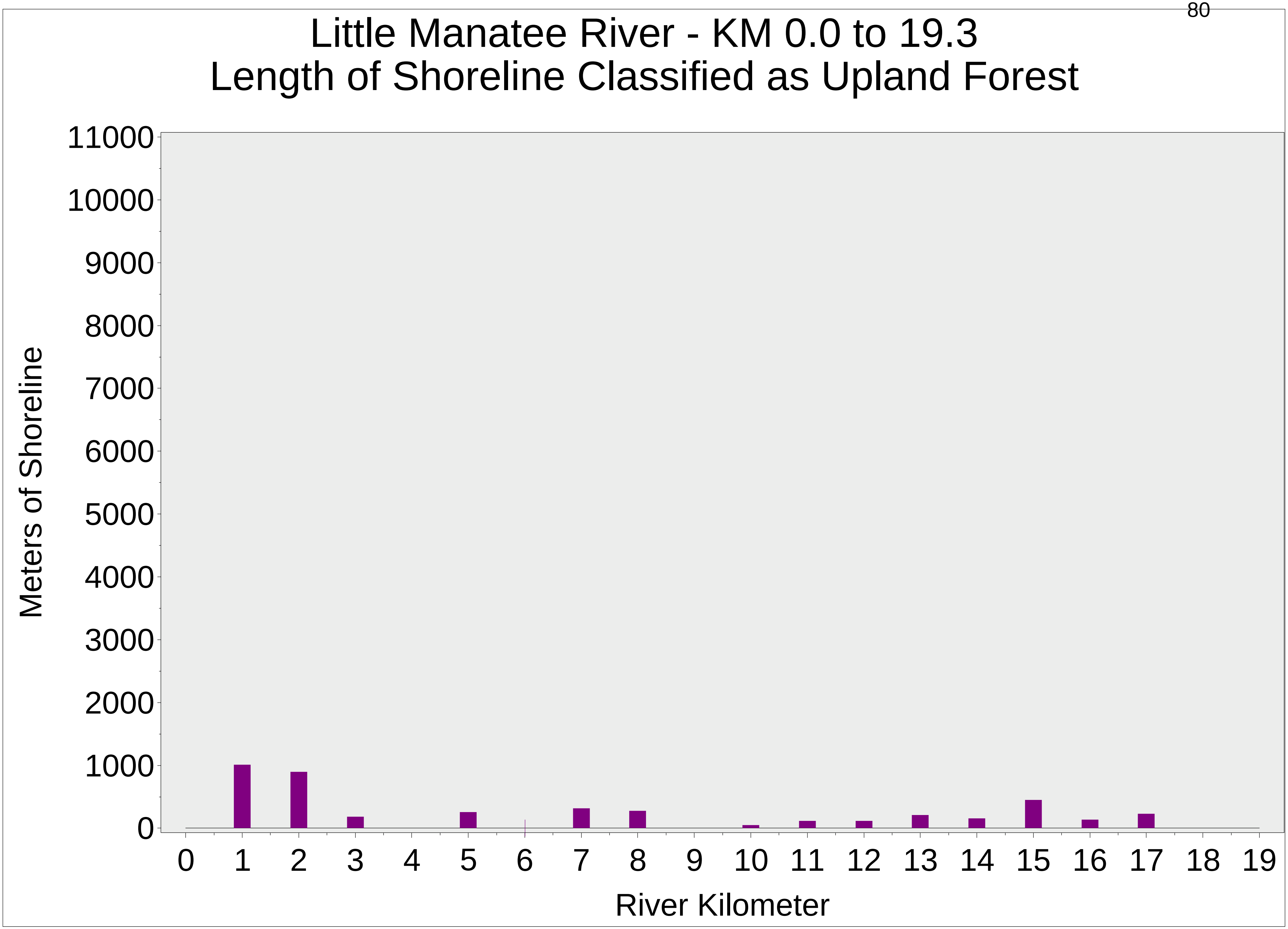

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Bottomland Hardwoods
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

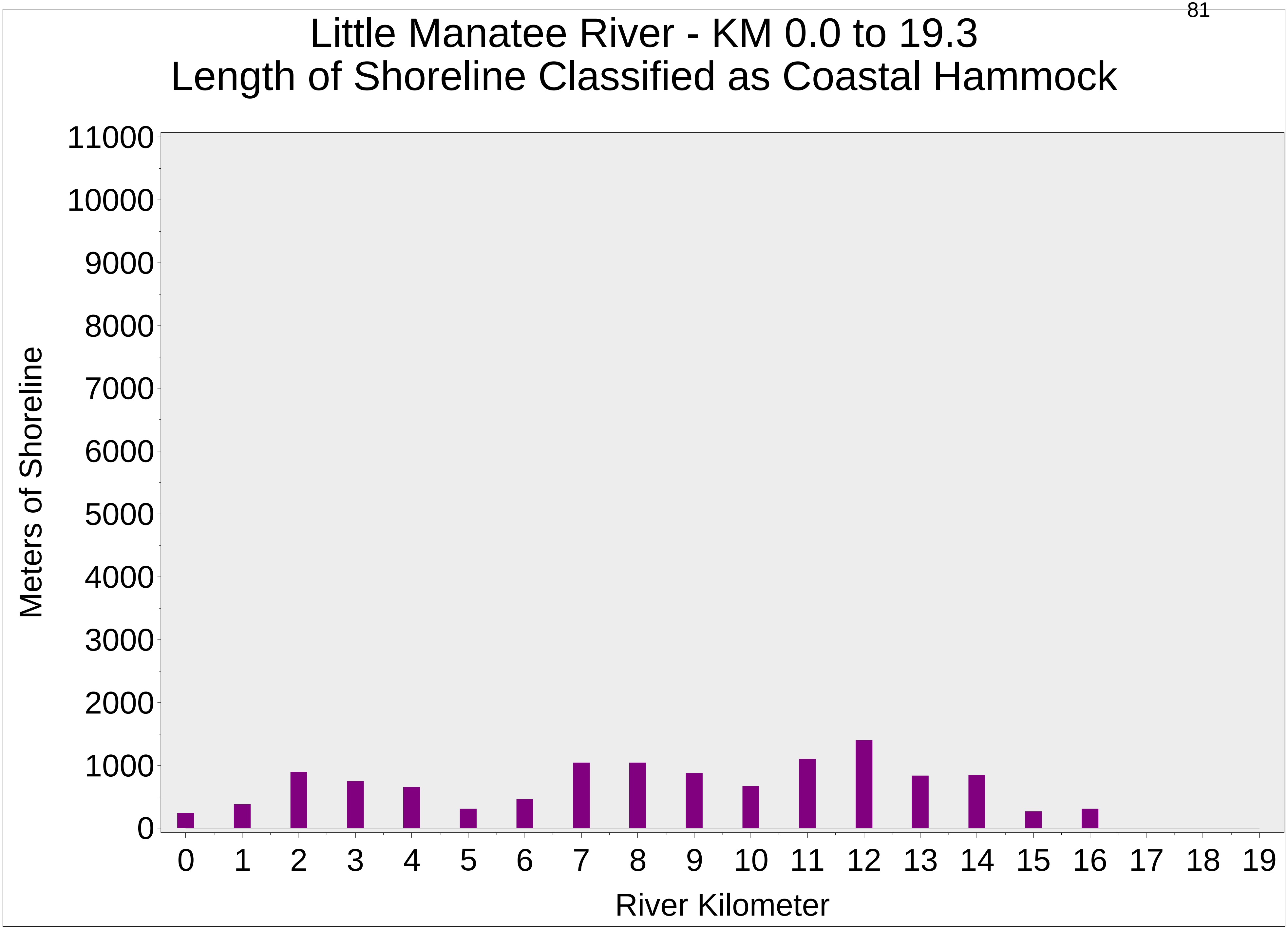


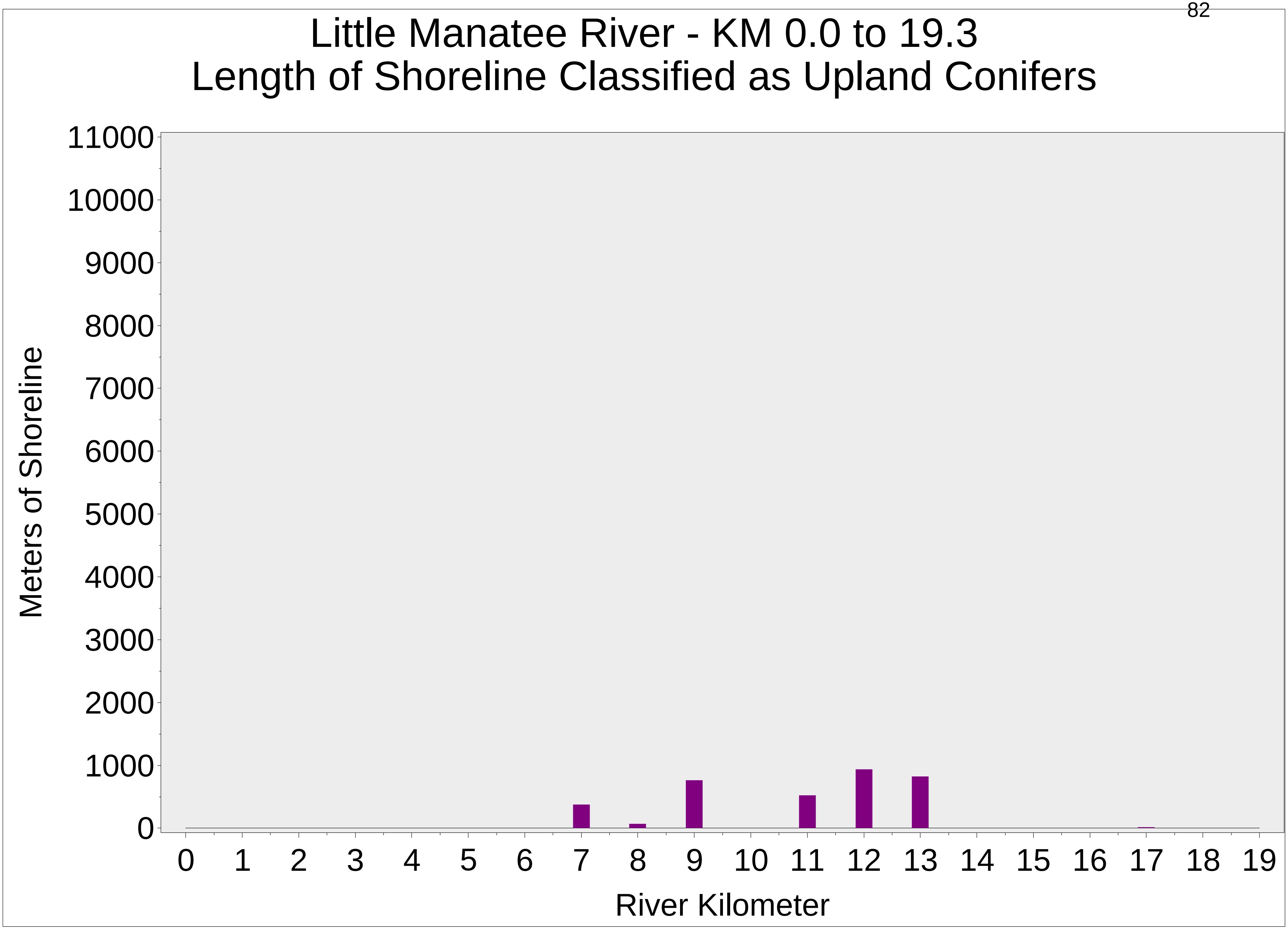
Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Juncus romerianus(needlerush)
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

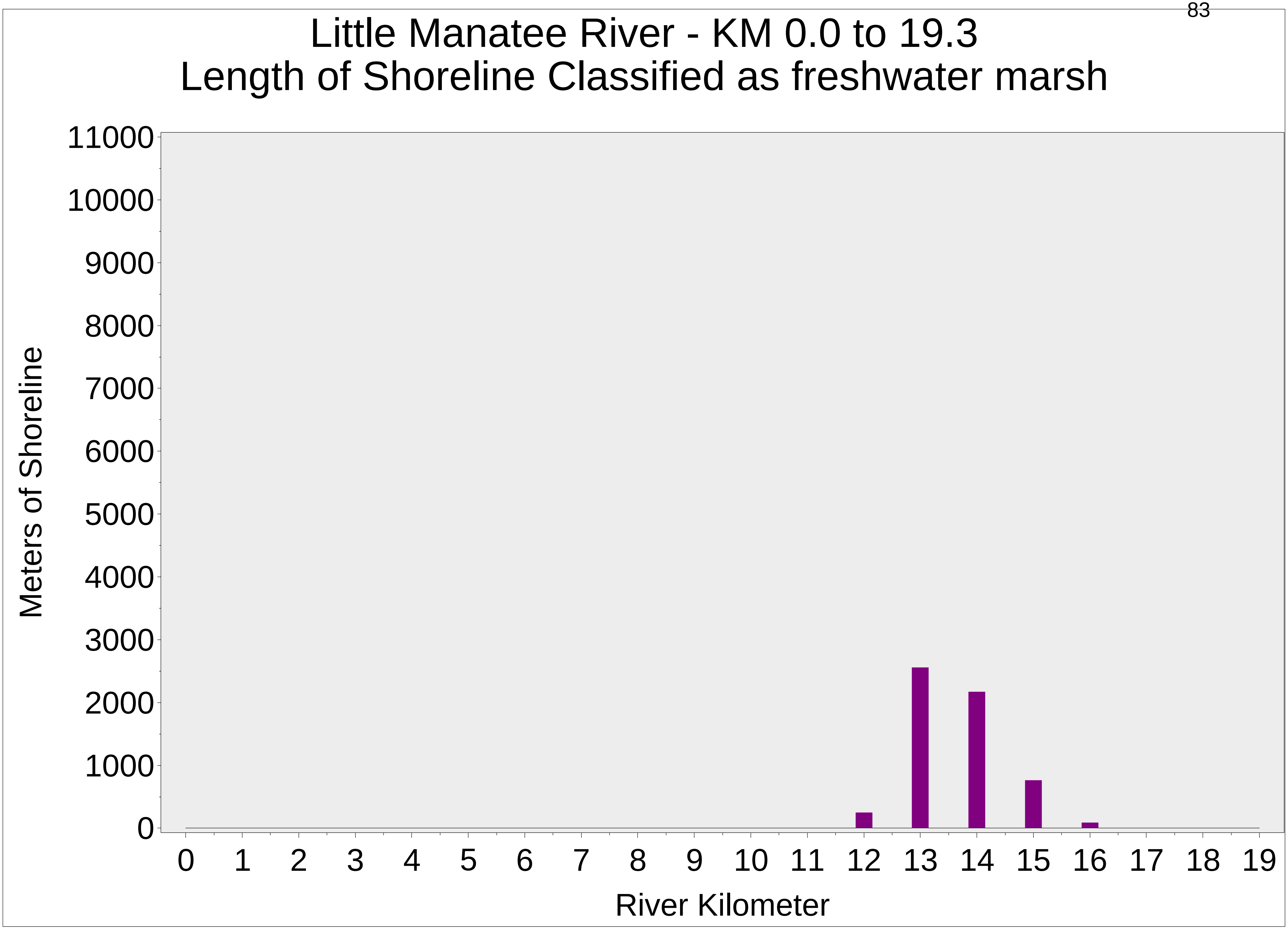

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Mangroves
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

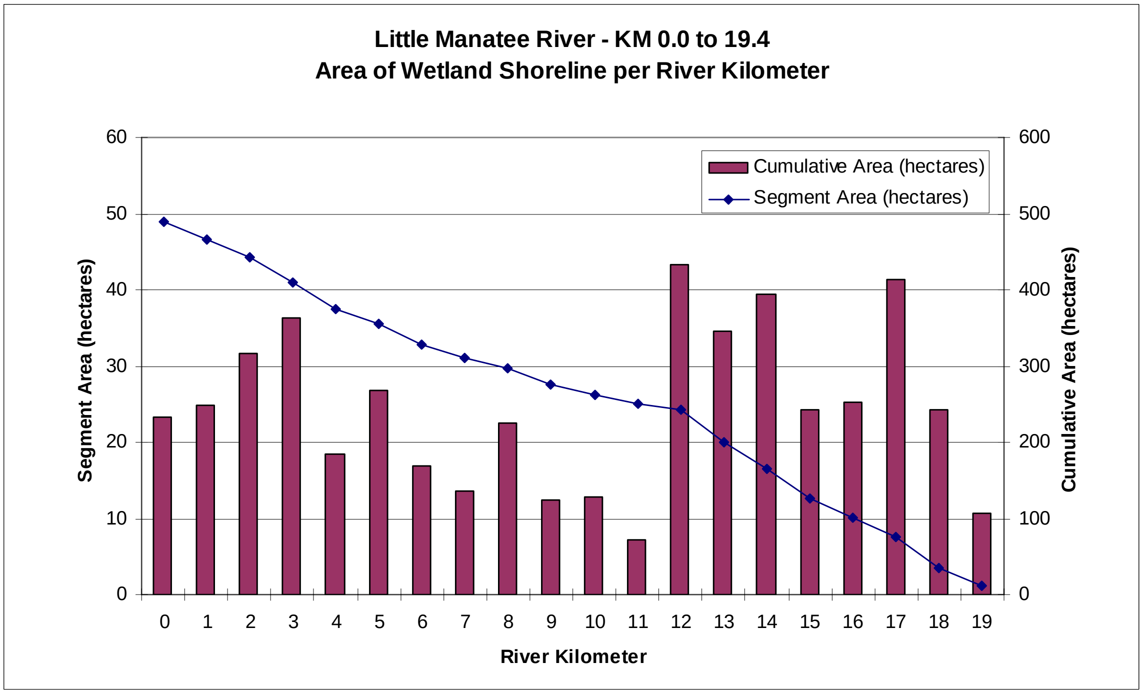

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Agricultural
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

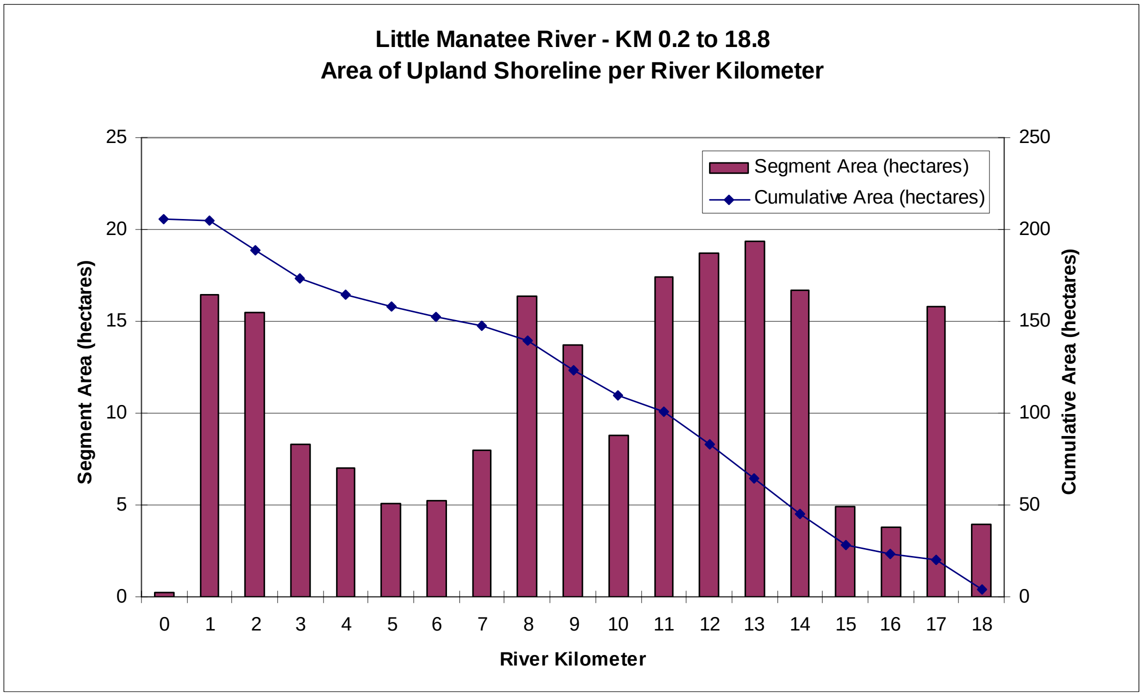

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Upland Forest
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
River Kilometer
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

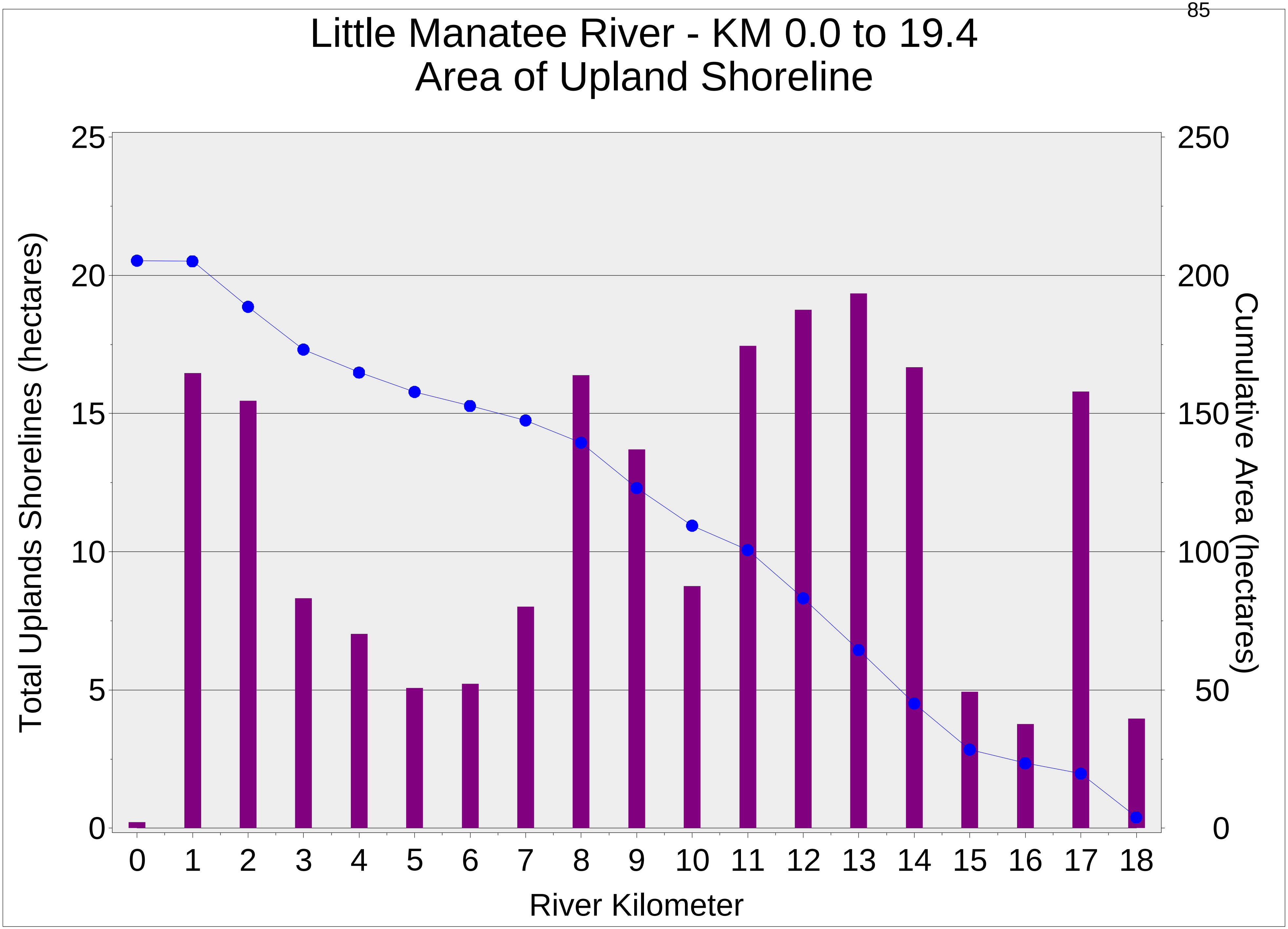

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Coastal Hammock
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
River Kilometer

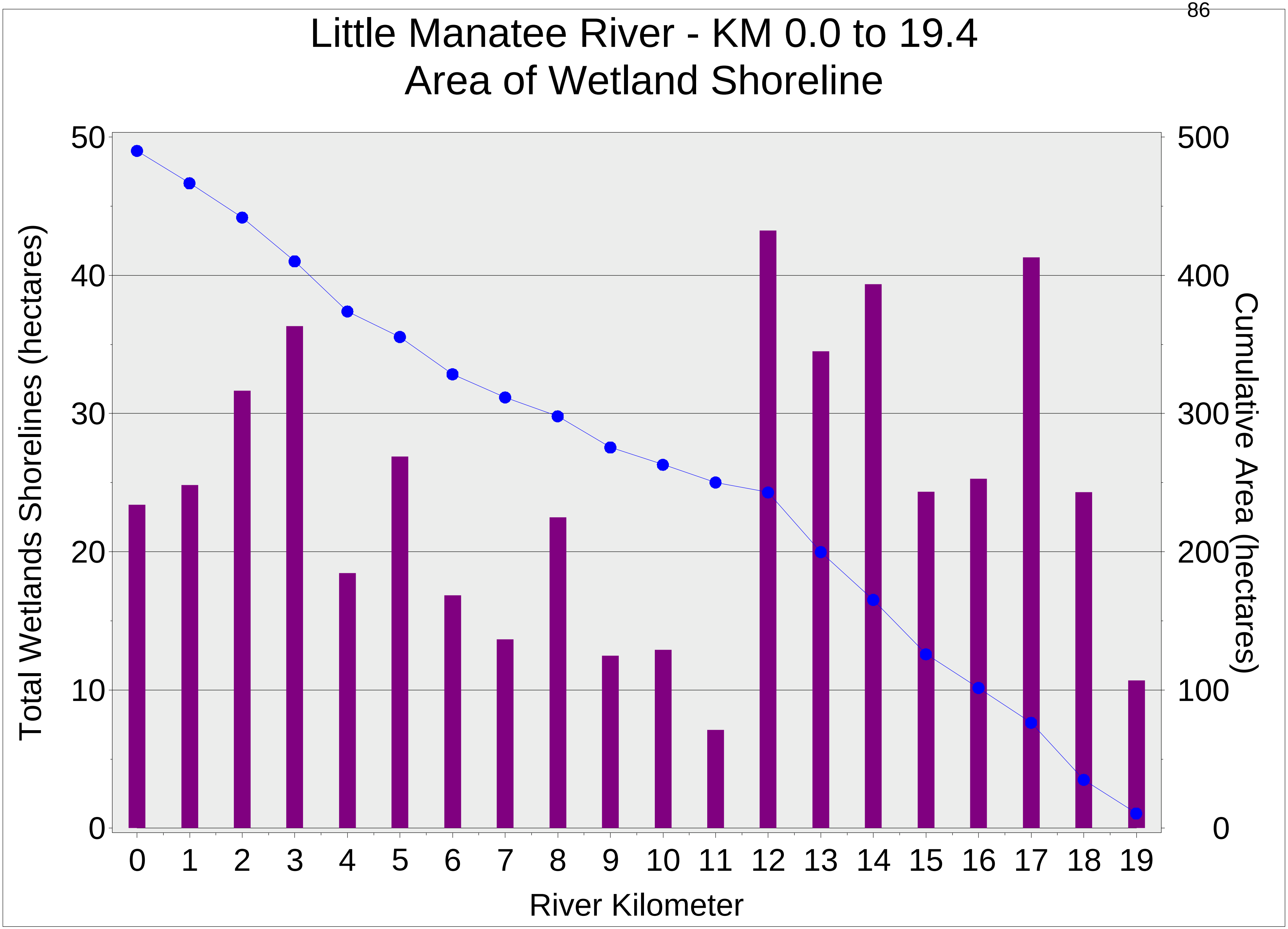

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Upland Conifers
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as freshwater marsh
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
River Kilometer


Little Manatee River - KM 0.0 to 19.4
Area of Wetland Shoreline per River Kilometer
Cumulative Area (hectares)
Segment Area (hectares)
Segment Area (hectares)
Cumulative Area (hectares)
River Kilometer
0
10
20
30
40
50
60
100
200
300
400
500
600
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

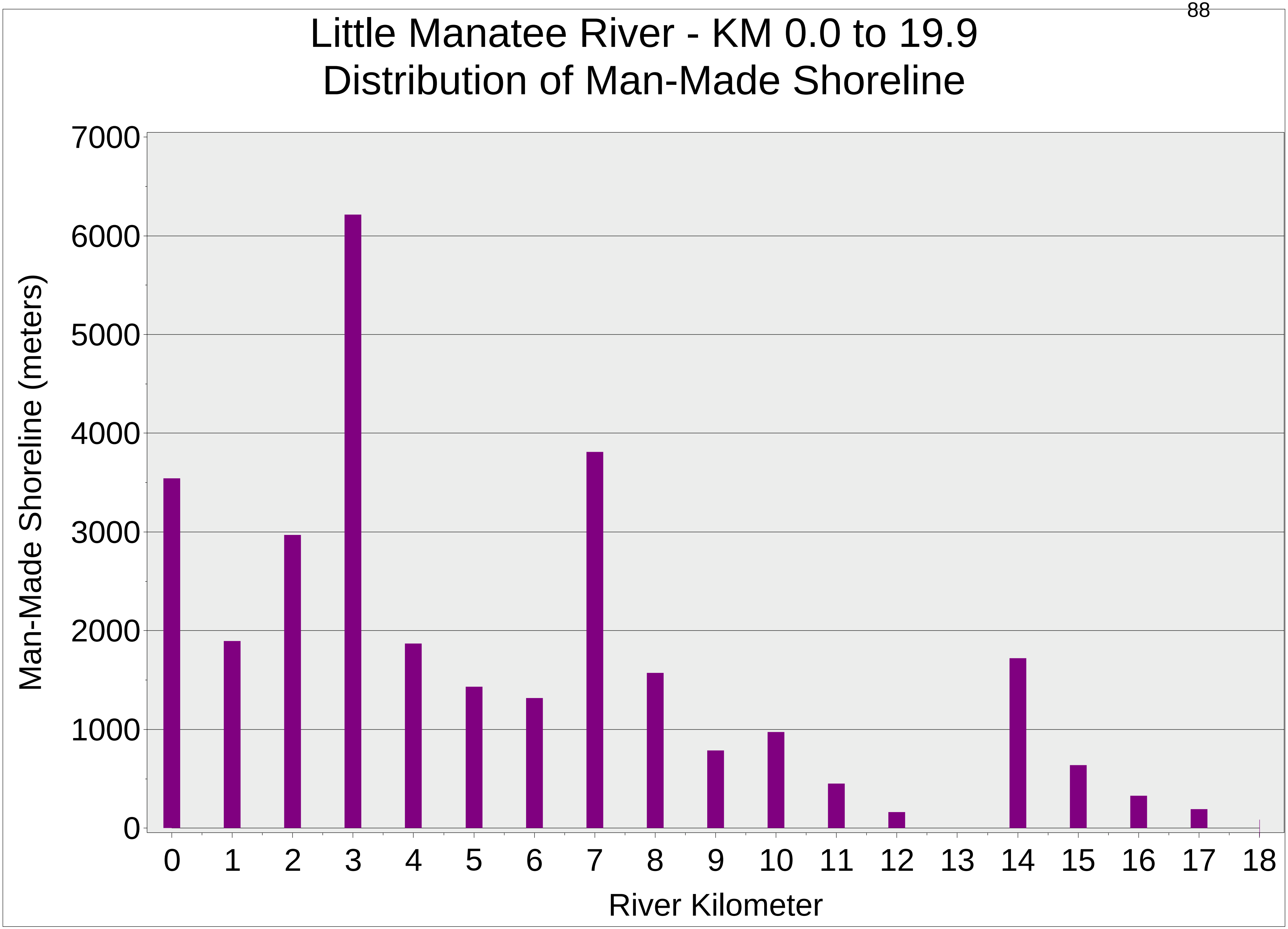

Little Manatee River - KM 0.2 to 18.8
Area of Upland Shoreline per River Kilometer
Segment Area (hectares)
Cumulative Area (hectares)
Segment Area (hectares)
Cumulative Area (hectares)
River Kilometer
0
5
10
15
20
25
50
100
150
200
250
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18


Little Manatee River - KM 0.0 to 19.4
Area of Upland Shoreline
Total Uplands Shorelines (hectares)
Cumulative Area (hectares)
River Kilometer
0
5
10
15
20
25
50
100
150
200
250
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

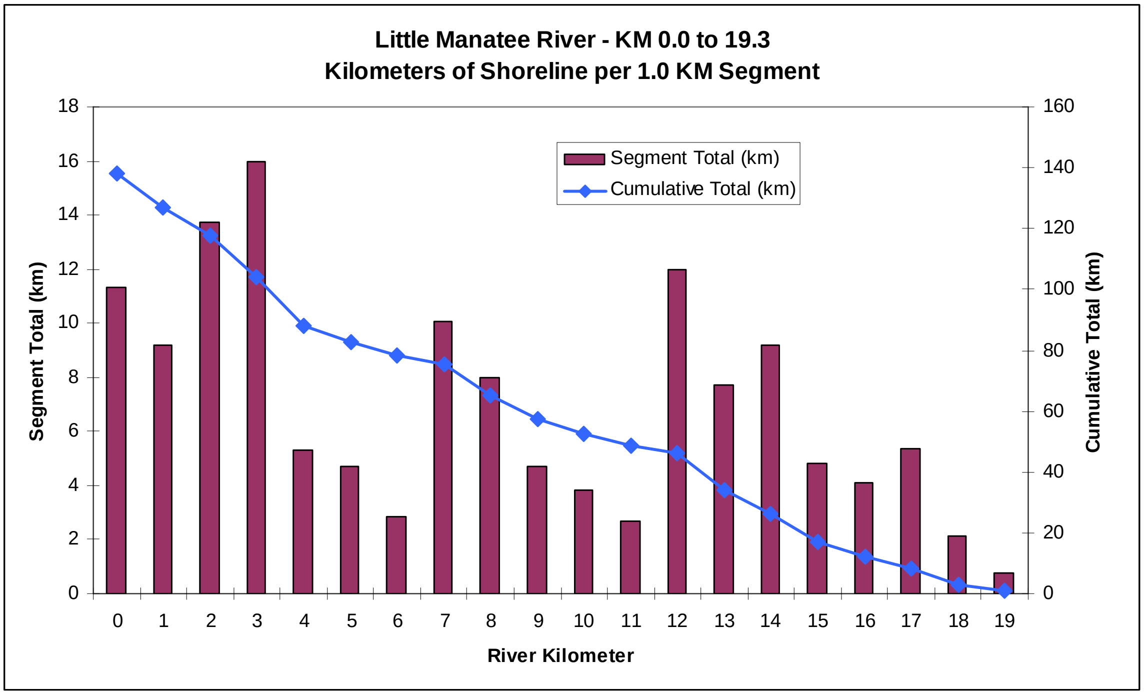

Little Manatee River - KM 0.0 to 19.4
Area of Wetland Shoreline
Total Wetlands Shorelines (hectares)
Cumulative Area (hectares)
River Kilometer
0
10
20
30
40
50
100
200
300
400
500
1
2
3
4
5
6
7
8
9
11
12
13
14
15
16
17
18
19

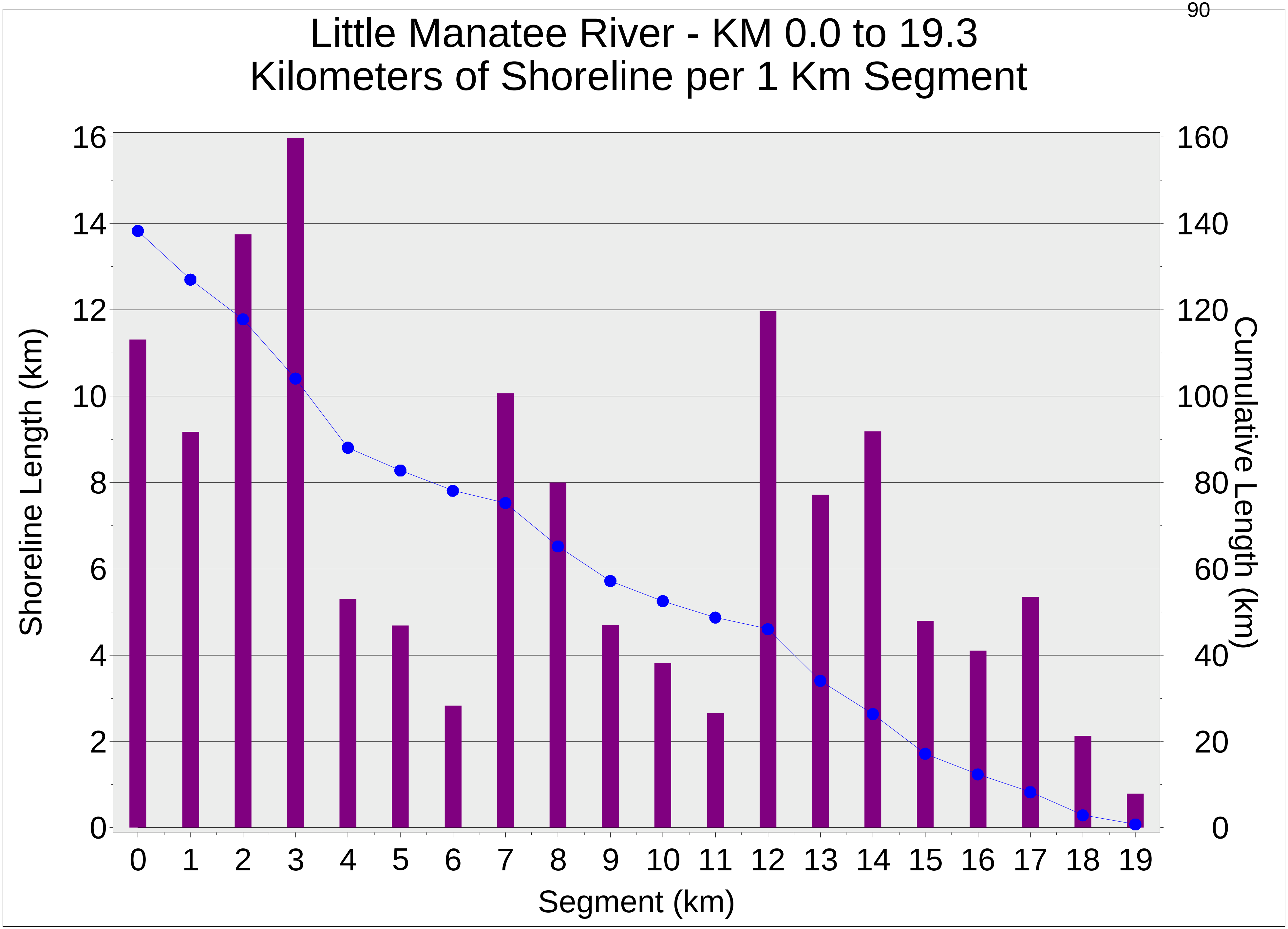
Area of Major Shoreline Plant Communities Along the Little Manatee River Shoreline

Species or Group	Area (hectares)	Percent of Total
Urban	267.63	25.6%
Bottomland Hardwoods	152.91	14.6%
Juncus romerianus(needlerush)	150.54	14.4%
Mangroves	107.64	10.3%
Agricultural	81.02	7.8%
Upland Forest	68.80	6.6%
Coastal Hammock	68.78	6.6%
Upland Conifers	47.21	4.5%
Freshwater Marsh	44.01	4.2%
Range	14.76	1.4%
Echinochloa	9.97	1.0%
Wetland Conifers	8.93	0.9%
Upland Hardwoods	5.29	0.5%
Marsh with Cladium (sawgrass)	4.56	0.4%
Typha (cattail)	3.38	0.3%
Leatherfern	2.35	0.2%
Juncus and Leatherfern	1.91	0.2%
Tidal Flat	1.65	0.2%
Wetland Marsh	0.88	0.1%
Cladium (sawgrass)	0.72	0.1%
Saltmarsh	0.48	0.0%
Sabal Palmetto	0.47	0.0%
Utilities	0.39	0.0%
Wet Prairie	0.06	0.0%



Little Manatee River - KM 0.0 to 19.9
Distribution of Man-Made Shoreline
Man-Made Shoreline (meters)
0
1000
2000
3000
4000
5000
6000
7000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Kilometers of Shoreline per 1.0 KM Segment
Segment Total (km)
Cumulative Total (km)
Segment Total (km)
Cumulative Total (km)
River Kilometer
0
2
4
6
8
10
12
14
16
18
20
40
60
80
100
120
140
160
1
3
5
7
9
11
13
15
17
19


Little Manatee River - KM 0.0 to 19.3
Kilometers of Shoreline per 1 Km Segment
Shoreline Length (km)
Cumulative Length (km)
Segment (km)
0
2
4
6
8
10
12
14
16
20
40
60
80
100
120
140
160
1
3
5
7
9
11
13
15
17
18
19

December 13, 2021

Request and questions about Little Manatee River EFF modeling

Hello Kym and Doug,

I have request for a report, selected model output, and have a few questions about the Environmental Favorability Function (EFF) modeling results presented in the minimum flows report for the Little Manatee River. If the District could address these requests when it is convenient, it would be greatly appreciated.

The references for report I am asking for is below, taken from page 186 in the minimum flows report.

Wessel, M. 2011. Defining the Fish-Flow Relationship in Support of Establishing Minimum Flows and Levels for Southwest Florida Tidal Rivers: Building on the Toolbox of Analytical Techniques. Report prepared by Janicki Environmental Inc. for the Southwest Florida Management District

I would also like to receive output from the Environmental Favorability Function modeling that was done for fish species in the lower river. In particular, I am requesting daily output for the amount of favorable habitat for the fish species listed on pages 146 to 149 of the minimum flows report, except for Sheepshead, for the baseline and the 15, 20, 25 and 30% flow reduction scenarios. If it saves time, my request could be limited to the Sailfin Molly, Naked and Clown Gobies, Eastern Mosquitofish, Rainwater Killifish, small gobies and Common Snook. I would also like to receive the flows at the USGS streamflow gage near Wimauma for these flow scenarios for the years 2015 to 2019, the results for which are presented on pages 146 to 149.

The questions I have are about the EFF analyses are listed below.

1. Figure 6-11 on page 147 in the minimum flow report shows average percent reductions in favorable habitat for 10 species. How were the average percent change values calculated for each flow reduction scenario. Were simple arithmetic averages of favorable habitat calculated from all days for the baseline scenario and each flow reduction scenario, then the average for the flow reduction scenario divided by the baseline average value, or was some other method used?

Similarly, in Tables 6-5 to 6-7, were the percent reduction in favorable habitat values calculated as averages for each flow reduction scenario as described above, within flow blocks, or was some other method used to calculate the percent reduction values?

2. The report about nekton in the river collected by the FFWCC that was prepared for the District (MacDonald et al., 2007) divided the stages of many species into size classes for certain analyses. For the species that were assessed for the EFF modeling, were all size classes combined for the modeling of flow reduction effects?

The following questions pertain to the habitat factor that is included in the logistic regression equation that is shown on page 129 of the minimum flows report with the intercept adjustment on page 130. Information on the EFF model is also presented in the report included as Appendix E the minimum flows report, which is draft minimum flows analysis submitted by Janicki Environmental (JEI) in June 2018. The questions below pertain to Appendix E. If these factors are no longer applicable or have been updated, please let me know.

3. On page 4-21, Appendix E says that for the refined model, the habitat levels were collapsed to the following categories: mangroves, emergent (marshes), structure and freshwater habitats, with tree, terrestrial grasses, and bare sand group as a single category. Are these the categories that remained in the final EFF model used to determine the minimum flows?

Also, this page shows a map of the dominant shore types assigned by FFWCC as part of their seine collections. Were the shoreline classifications assigned by FFWCC categories used as the source data to create the collapsed shore habitat types used in the EFF modeling, or was some other source used to determine the shore habitat types?

The map of page 4-21 of Appendix E shows the distribution of dominant shore types identified FFWCC as part of their sampling. It is interesting to note that the map shows 'freshwater" shore types that are located fairly far downstream, sometimes in the mesohaline reach of the river. I wonder what the FFWCC was using to classify the shore type. Were they looking at the vegetation on the upland next to the shoreline? For fish sampling, I would suggest that the shore type should be classified based on habitats and vegetation within the inter-tidal range of the river, but I don't really know what FFWCC used to classify shore types. Does the District or JEI have any information on that?

Also, the FFWCC sampling generally did not extend upstream of approximately kilometer 14. Again, what source data was used to assign habitat types, was something other that data for FFWCC data used? What was applied upstream of kilometer 14?

In general, how was favorable shore habitat determined and applied in the EFF model? I am assuming that shore type was what used to determine shore habitat. Is that correct? Was a separate analysis conducted on the frequency of occurrence of fish species in various shore habitats conducted to determine favorable shore habitats, then the quantity of those shore habitats in various river reaches applied in the EFF modeling? Or, did the EFF modeling itself derive what the favorable shore habitats were for each species? More explanation of how favorable shore habitats were determined and applied in the model would be helpful.

For example, could a species have more than one favorable shore habitat? From looking at the map on page 4-21, I would think that combined emergent marsh and freshwater would make sense.

The figure on page 4-25 for favorable habitat predictions for the striped mojarra (*Eugerre plumieiri*) using the EFDC and the LOESS model is interesting. Does it incorporate both the salinity predictions and favorable habitat factors or is it just based on salinity? On this date (December 6, 2003), it appears that salinity distribution had much to do with favorable habitat being upstream of approximately kilometer 10, as the flow at the gage on that date was 53 cfs.

I would assume on a day with higher flow, the favorable habitat would extend farther downstream. If that were the case, does the EFF analysis also incorporate data from within the bayous and Ruskin Inlet? Page 169 in MacDonald et al. (2007) shows that the striped mojarra had higher geometric mean abundance values in the bayous than in the river channel during that period of data collection (1996-2006).

Thanks for whatever information you can provide to these questions. I expect you are very busy with the holidays approaching, so whenever you can address these if fine, with after Christmas or sometime thereafter being fine.

Thanks again and Happy Holidays!

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

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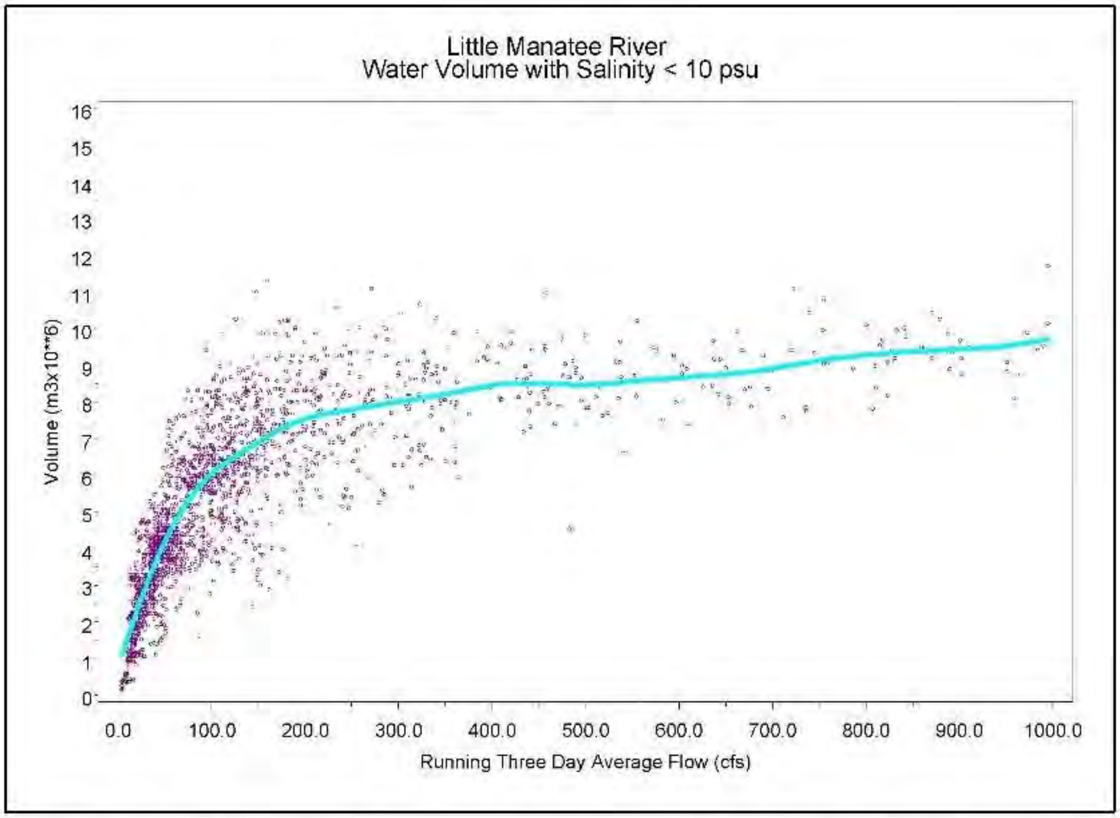
ABSTRACT: The Southwest Florida Water Management District has implemented a management approach for unimpounded rivers that limits withdrawals to a percentage of streamflow at the time of withdrawal. The natural flow regime of the contributing river is considered to be the baseline for assessing the 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.

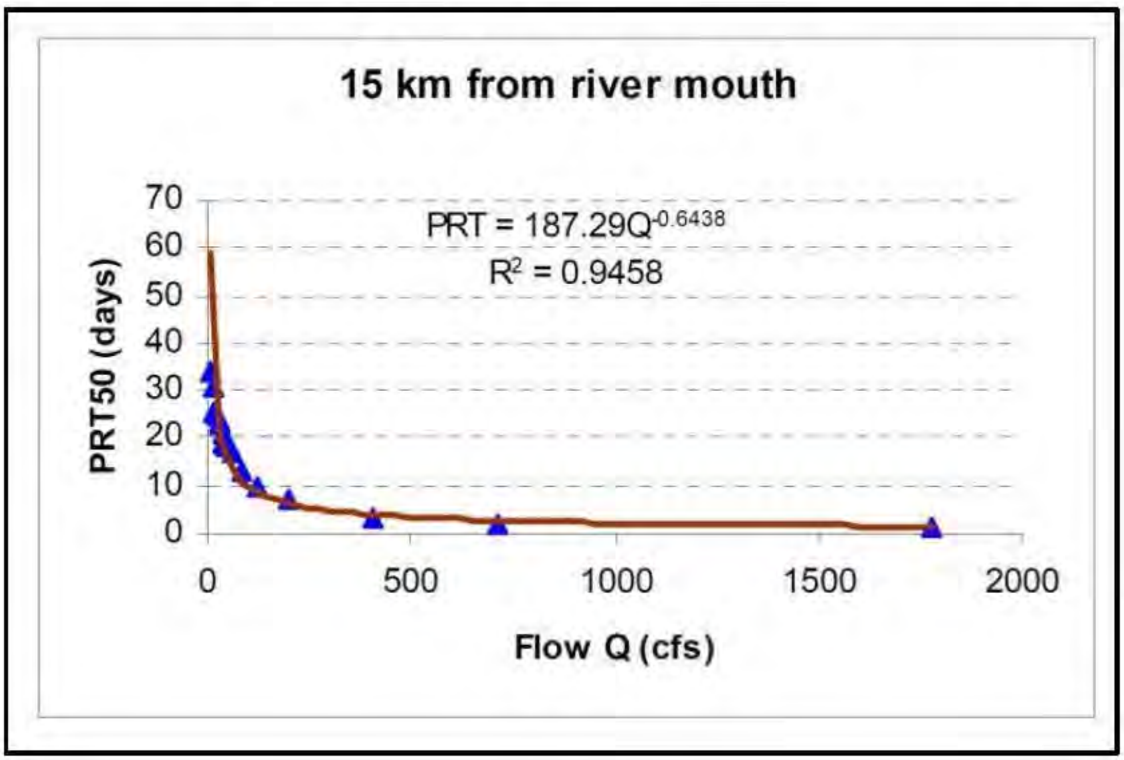
Introduction

Stream ecologists have emphasized the importance of natural flow regimes for maintaining the

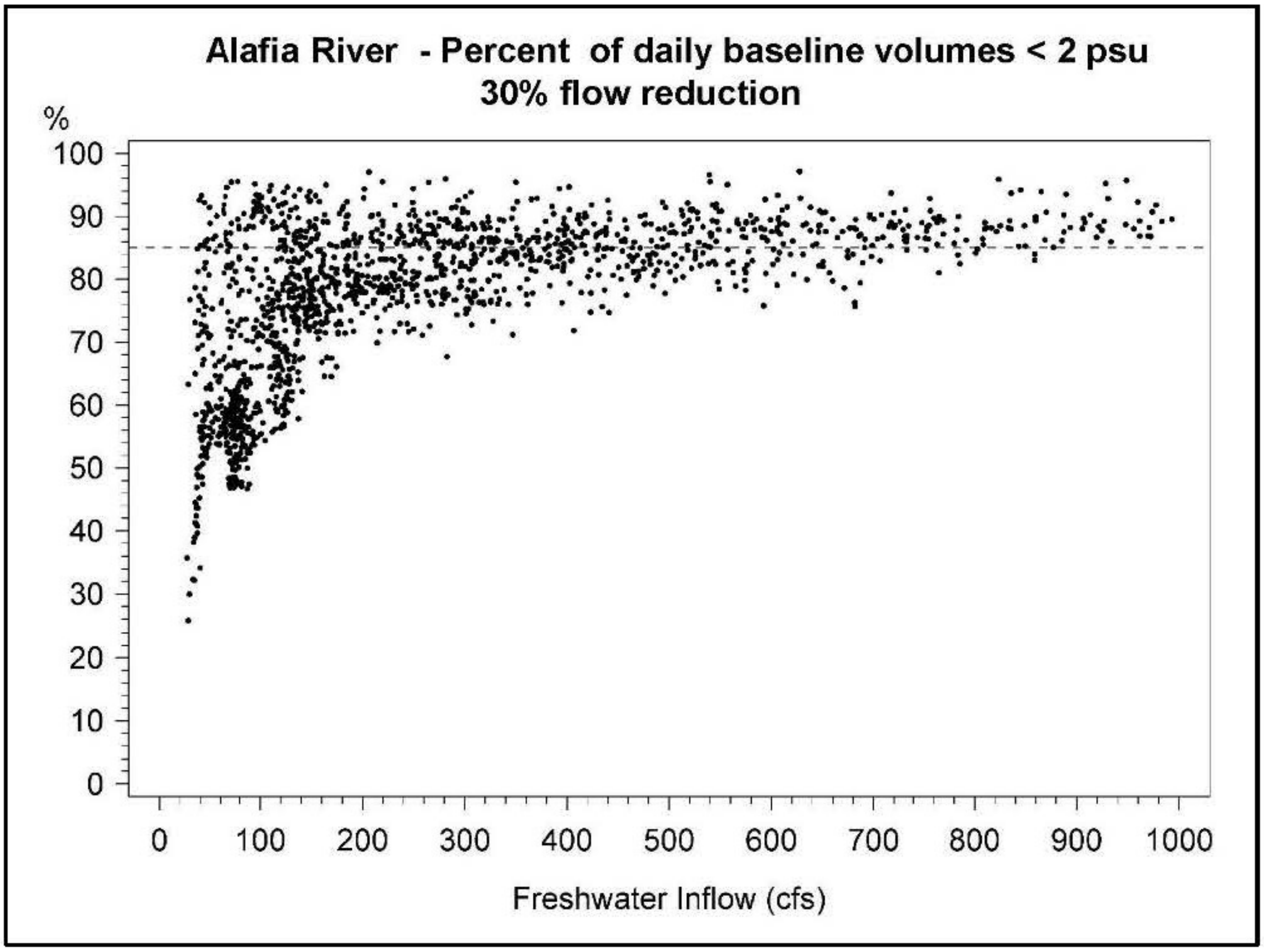
ceding freshwater inflow terms calculated over 2-mo or 3-mo intervals, indicating that the seasonality of inflow can have a significant effect on fish



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

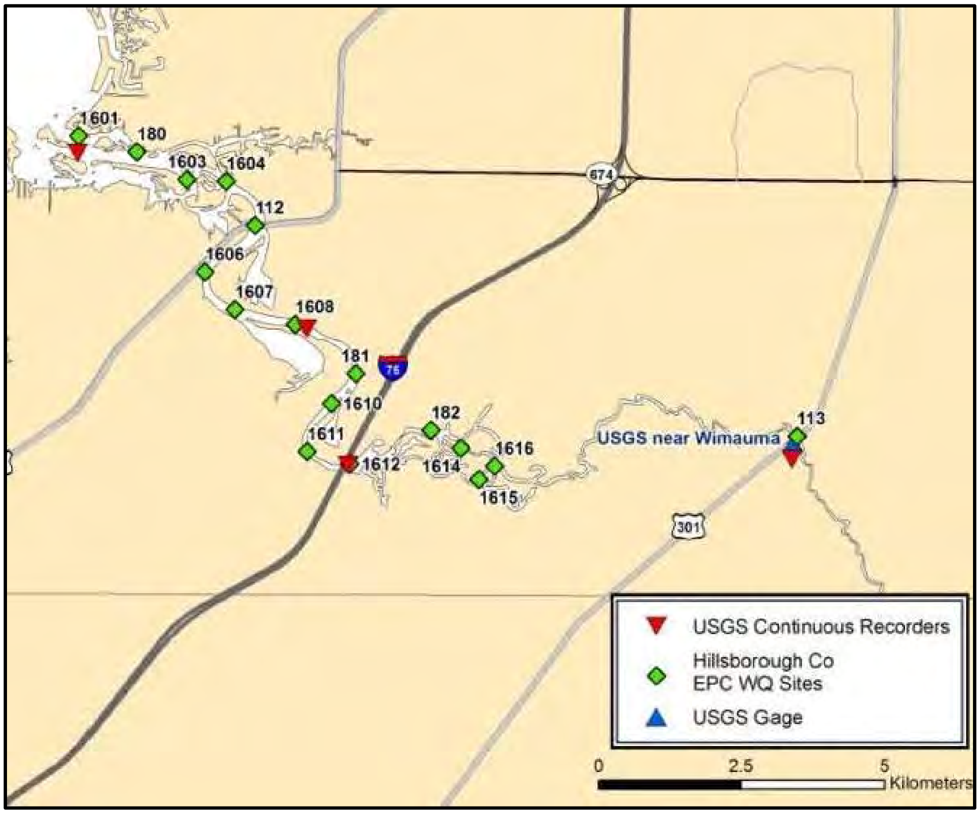


Figure A. USGS salinity recorders and EPCHC vertical profile stations in the lower river.

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

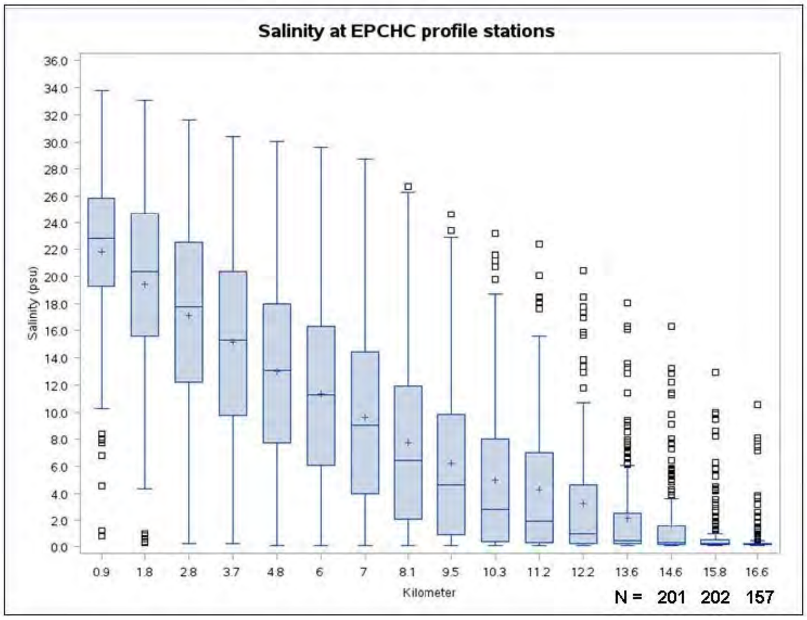


Figure C. Box plot of mean water column salinity values for vertical profiles measured in the lower river by the EPCHC from 12/14/2000 to 10/2/2006 and 01/26/2009 to 08/17/2001. N values for three upstream stations are the number of dates each station was sampled.

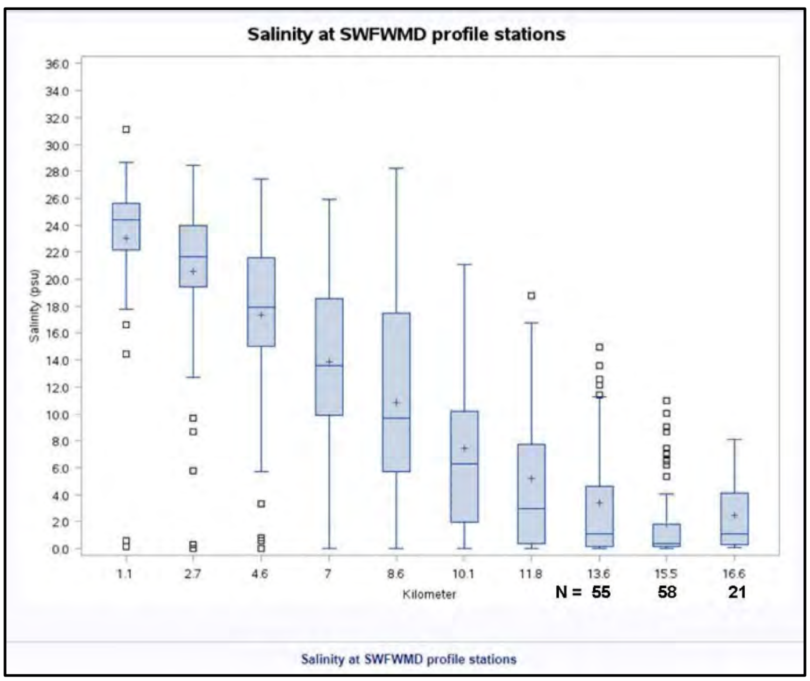


Figure D. Box plot of mean water column salinity values for vertical profiles measured in the lower river by the SWFWMD from 1985 to 1989. N values for three upstream stations are the number of dates each station was sampled.

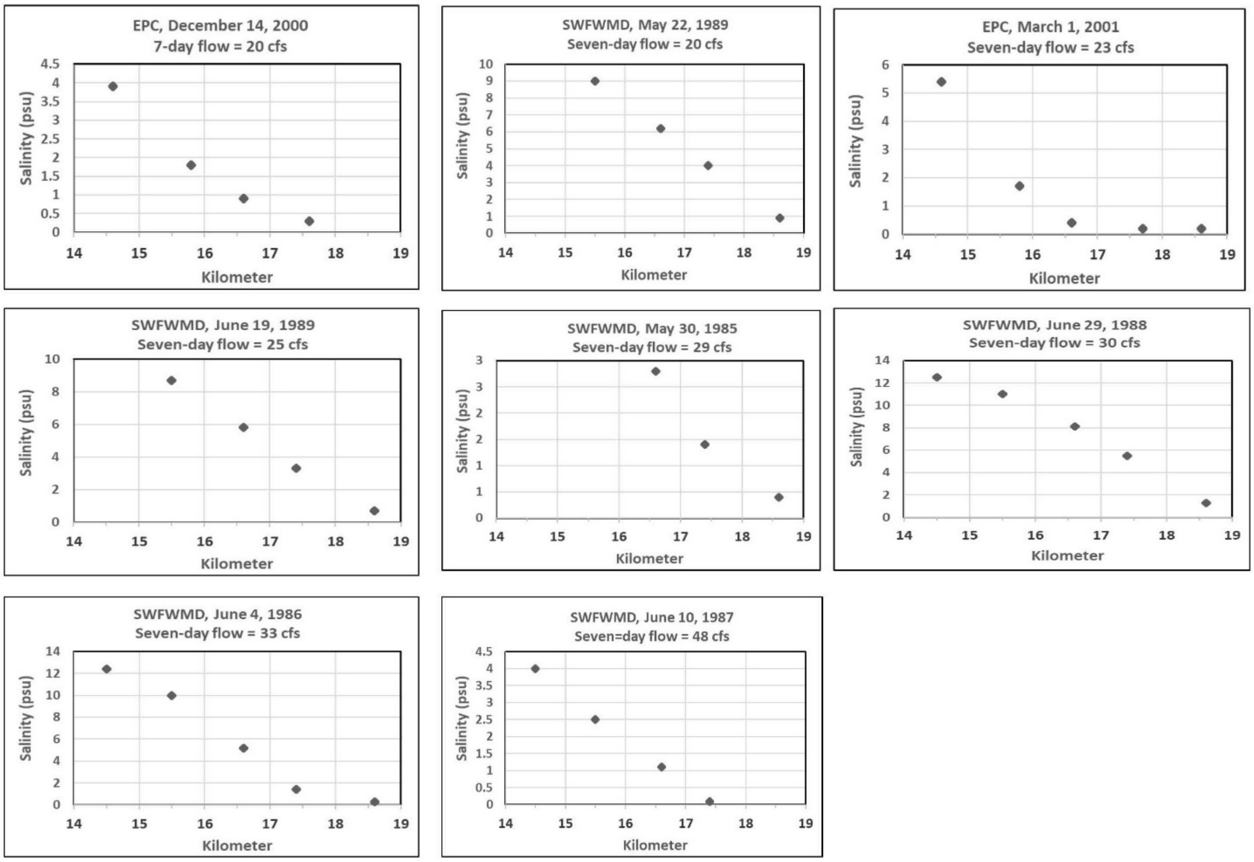


Figure E. Mean salinity values at stations in the upper reaches of the lower river on days when sampling by the EPCHC or the SWFWMD extended upstream of kilometer 16.6

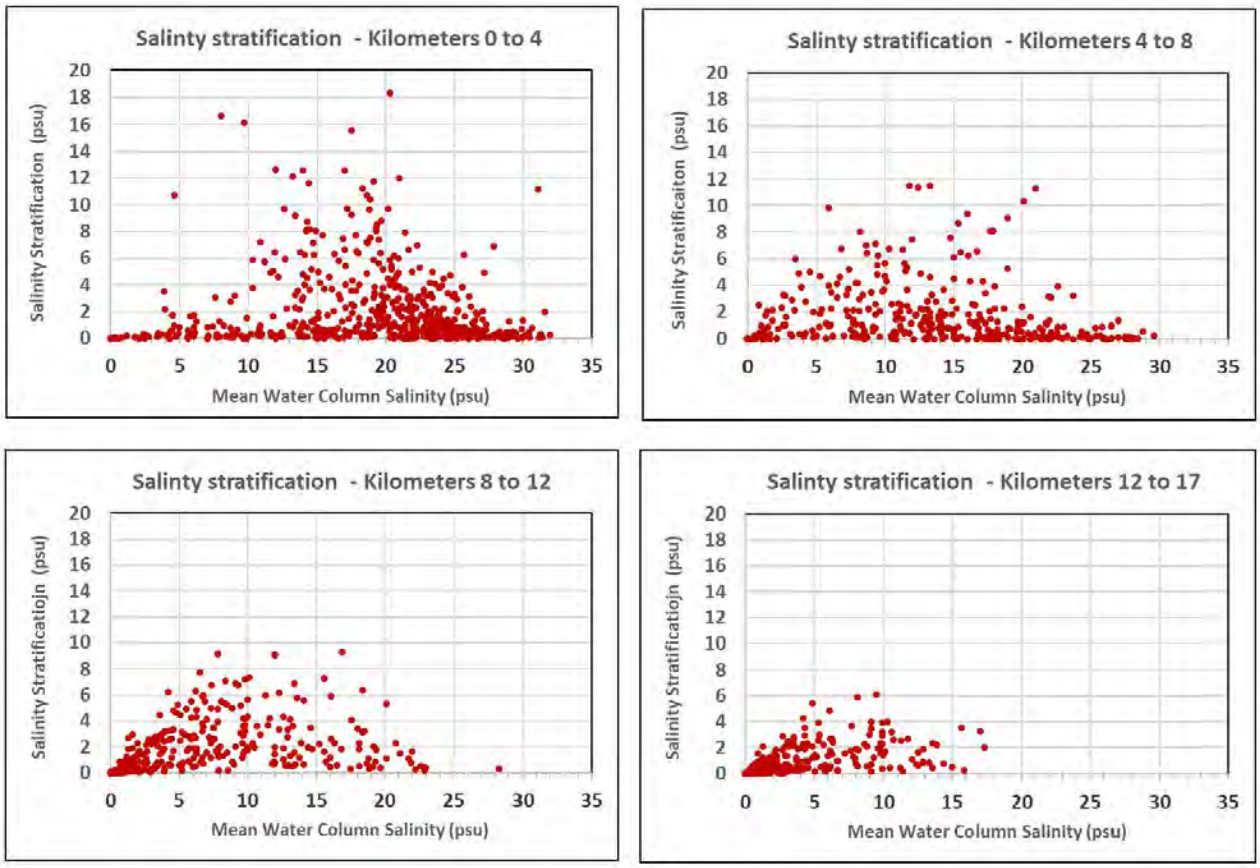


Figure F. Salinity stratification in four reaches of the lower river vs. mean water column salinity for stations that were two meters deep or greater. Stratification was calculated by subtracting the surface salinity value from the bottom salinity value.

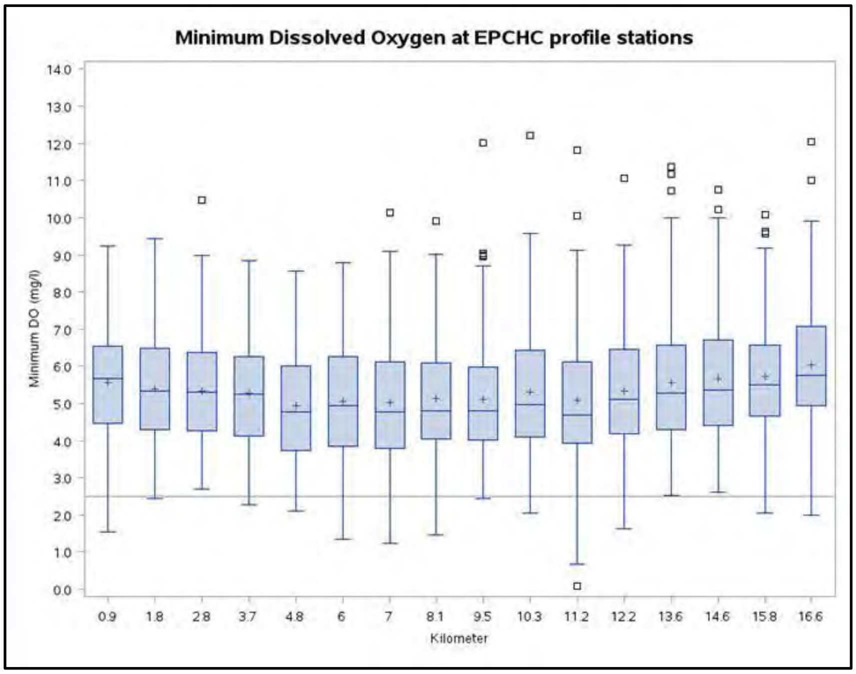


Figure G. Box plot of minimum dissolved oxygen concentrations a stations in the lower river monitored by the EPCHC. Whiskers are 1.5 times sssssssss.

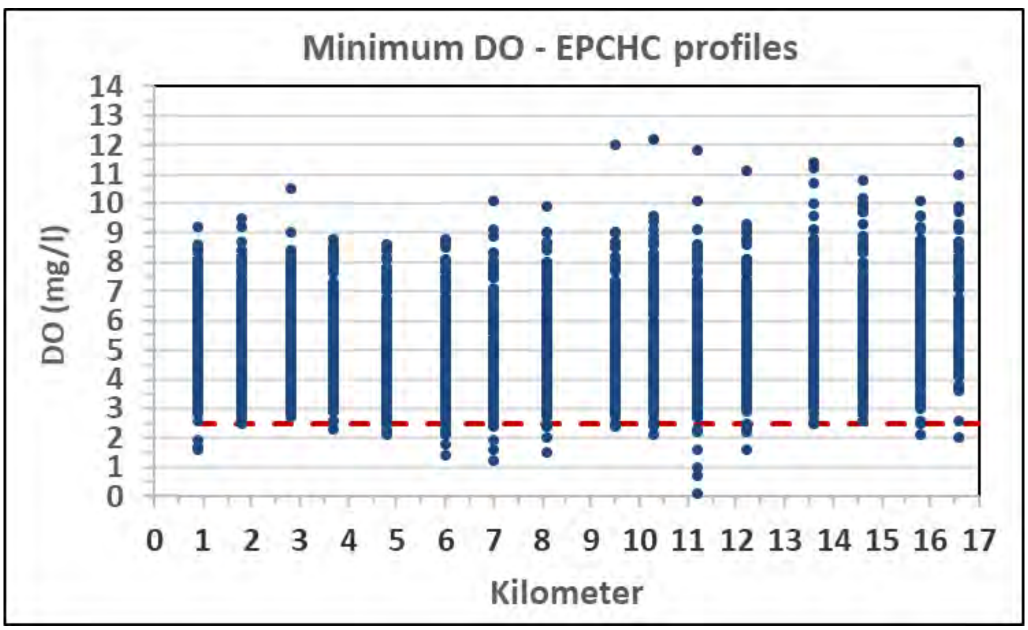


Figure G. Minimum dissolved oxygen concentrations at EPCHC vertical profile stations.

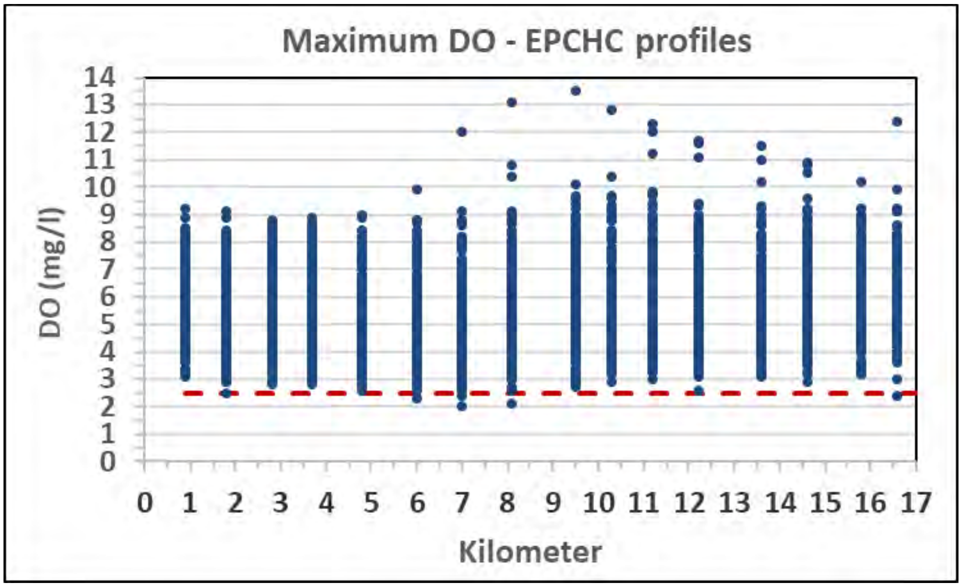


Figure H. Maximum dissolved oxygen concentrations at EPCHC vertical profile stations.

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*	2,126	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	Bleniid	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

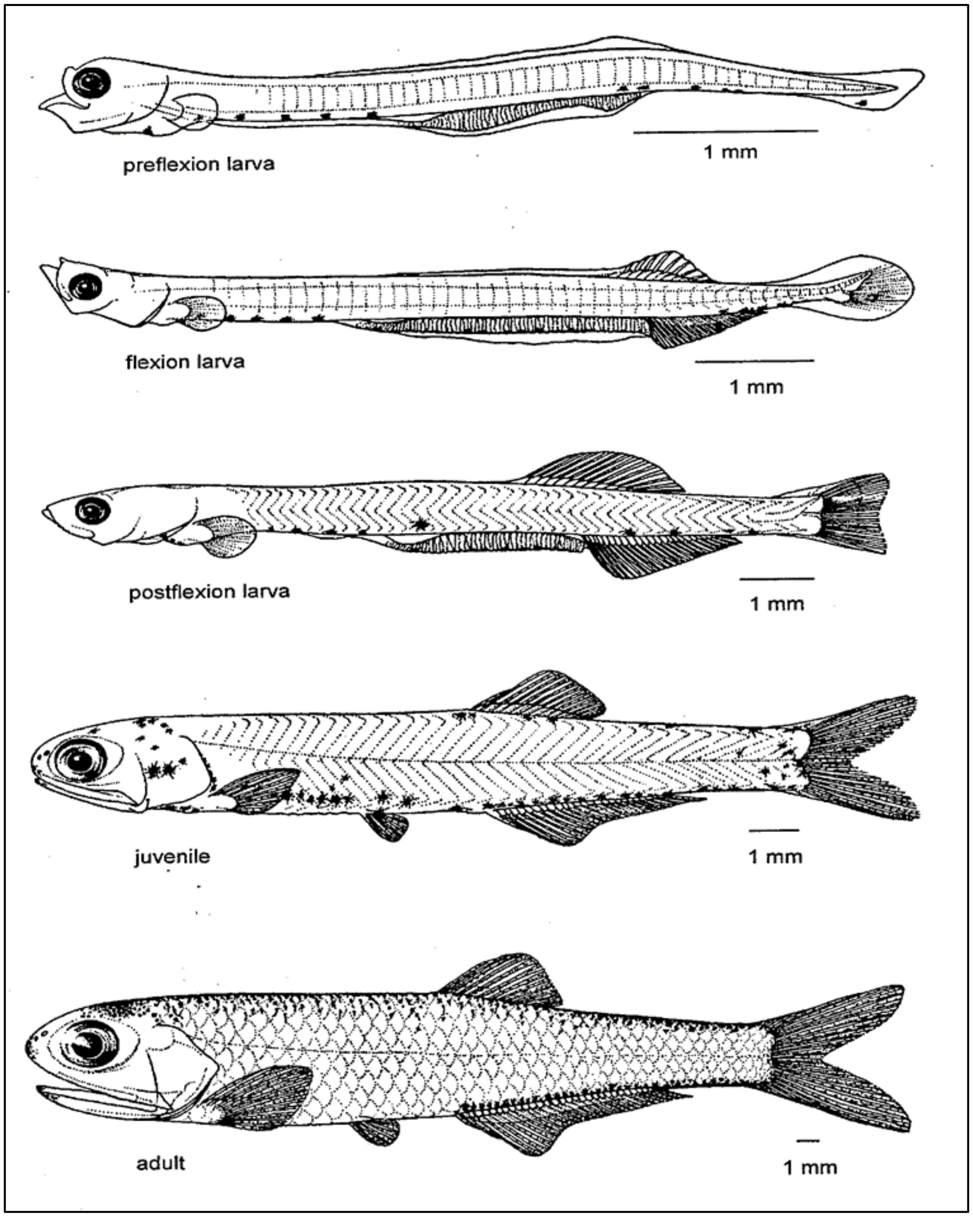


Figure I. Development stages of the bay anchovy (*Anchoa mitchilli*) collected from the Lower Little Manatee River and Tampa Bay, measuring 4.6, 7.0, 10,5, 16 and 31 mm standard length.

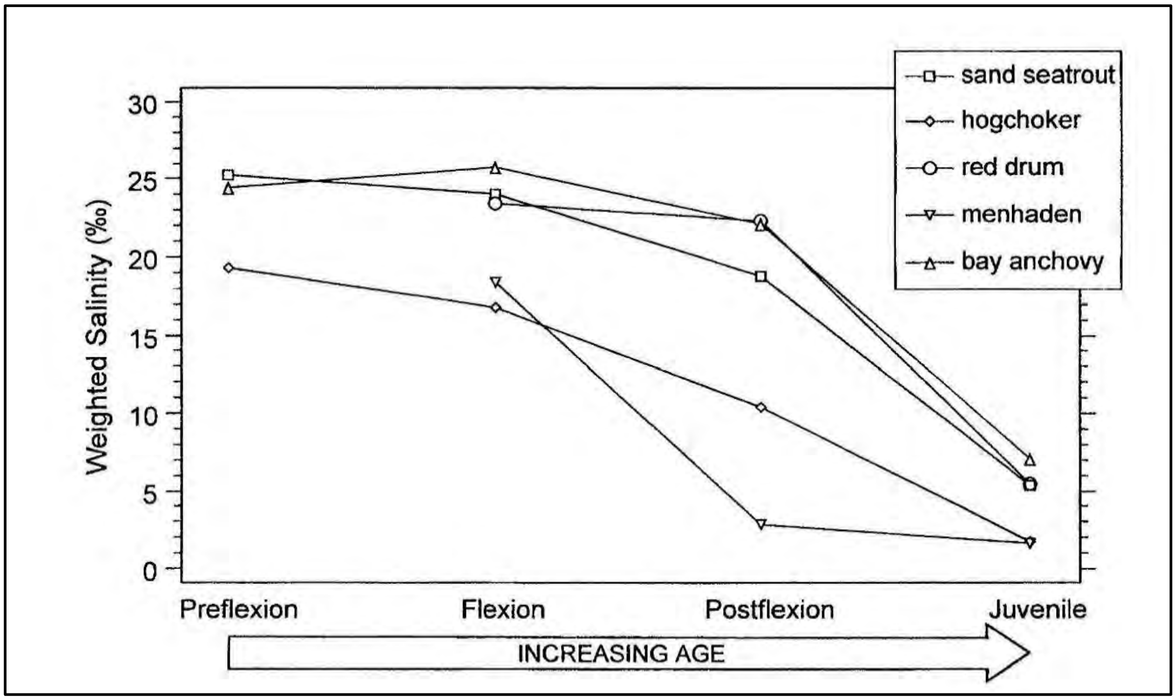
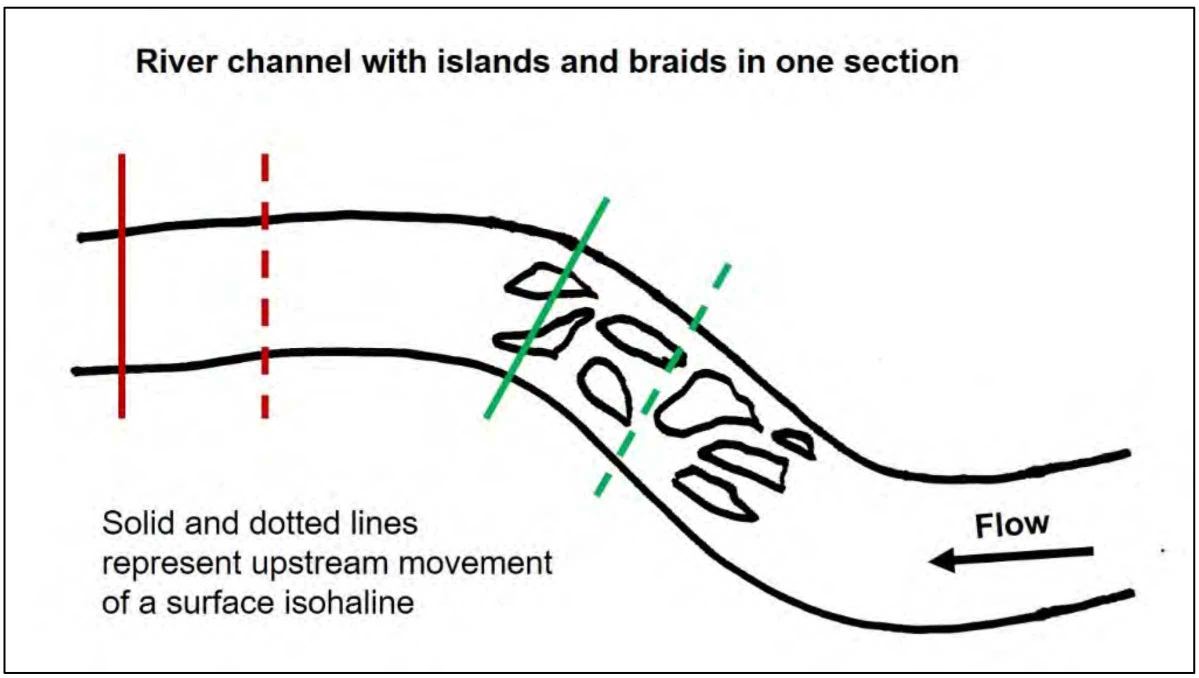


Figure J. Examples of decreasing mean salinity at capture with fish development. See Figure I for illustrations of these stages for the bay anchovy (*Anchoa mitchilli*).

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.

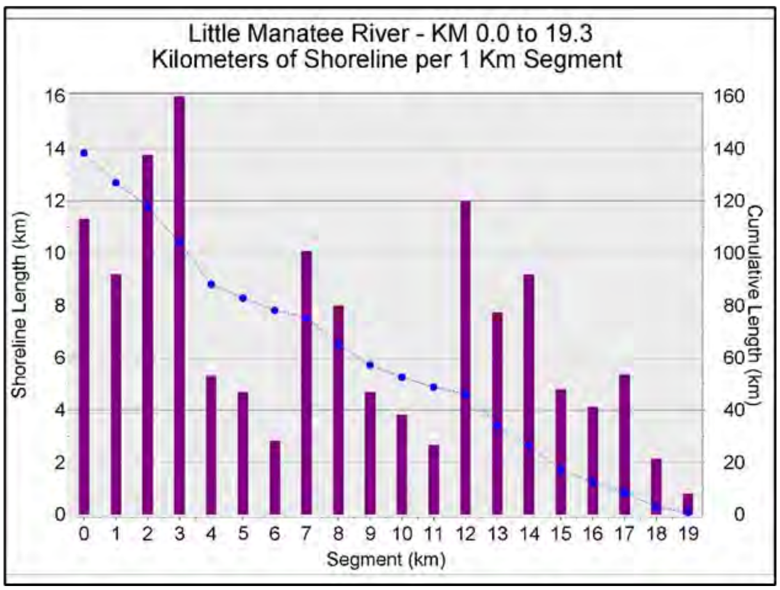
Conversely, there will be a much greater reduction in shoreline length associated with the green lines as there is a much greater quantity of shoreline length in that zone. The differences in these changes will also be reflected in percent reductions in total area and shoreline length upstream of these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

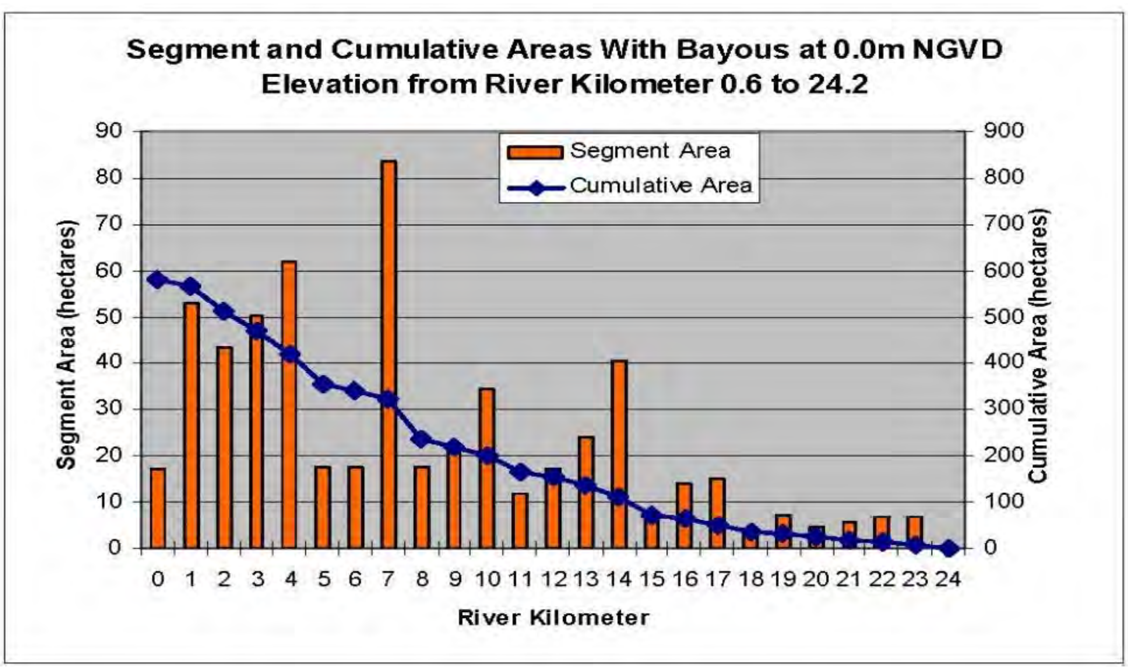


See next page for graphs from the Little Manatee

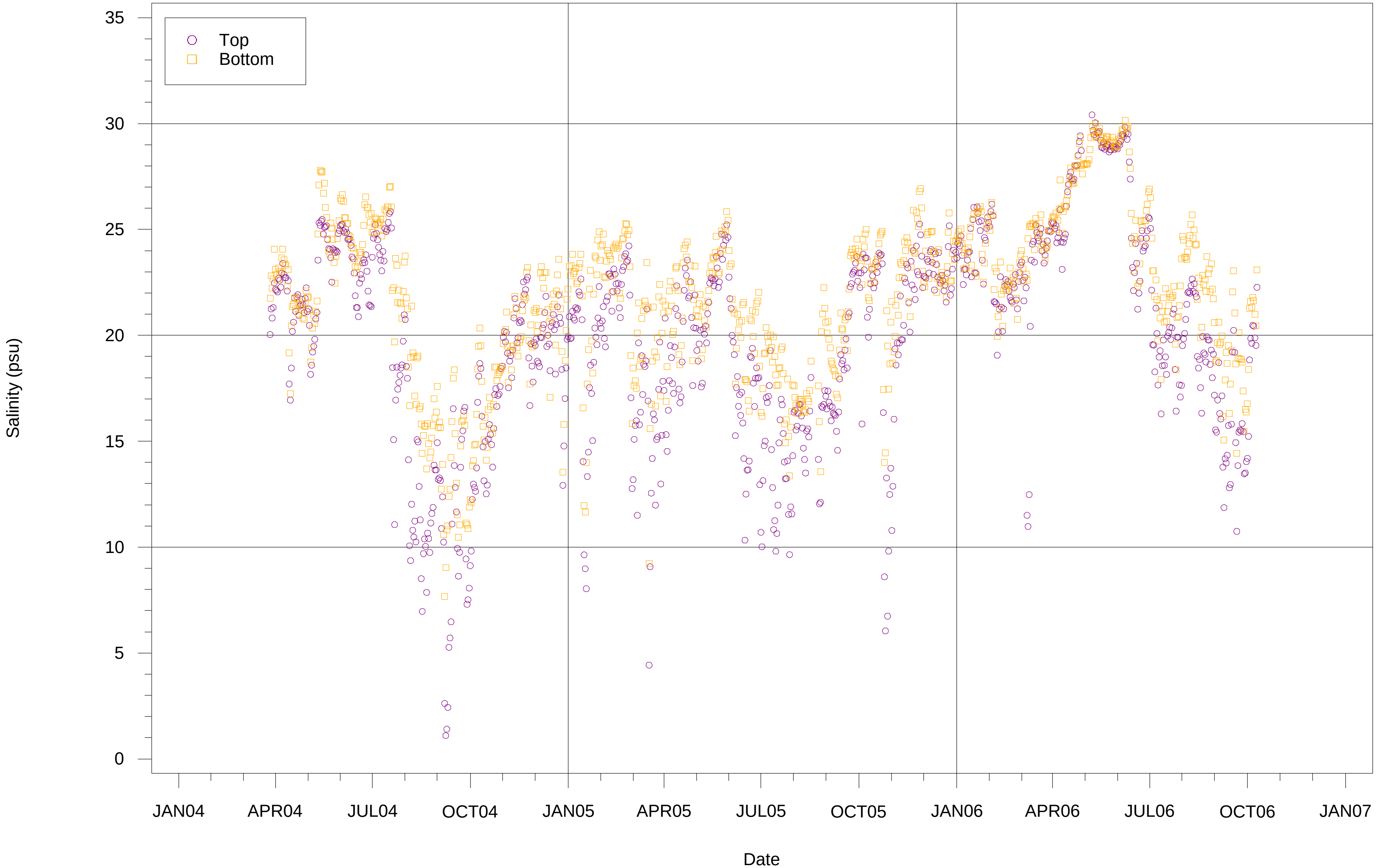
The amounts of shoreline and area can vary considerably within different river reaches. As shown below, the length of shoreline in one-kilometer segments in the Little Manatee River can vary greatly, ranging between approximately 2.4 kilometers per one kilometer of channel length to 12 to 16 kilometers 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.

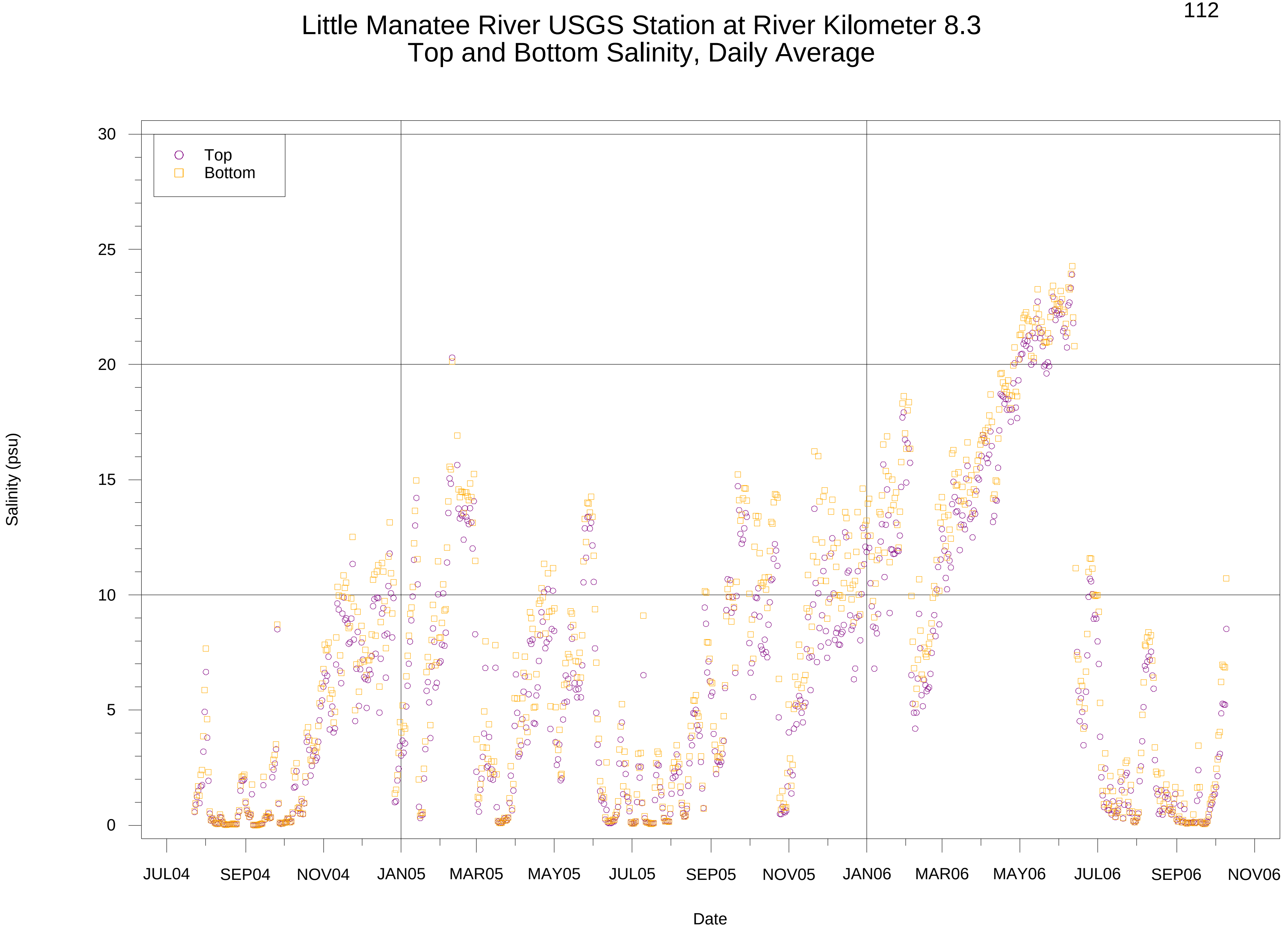
The Little Manatee has extensive oligohaline and freshwater marshes in the braided zone upstream of Interstate 75 near kilometer 12 that are susceptible to the effects of increased salinity. As such, the quantification of changes in shoreline length below a given salinity concentration (2 or 4 psu) are 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.



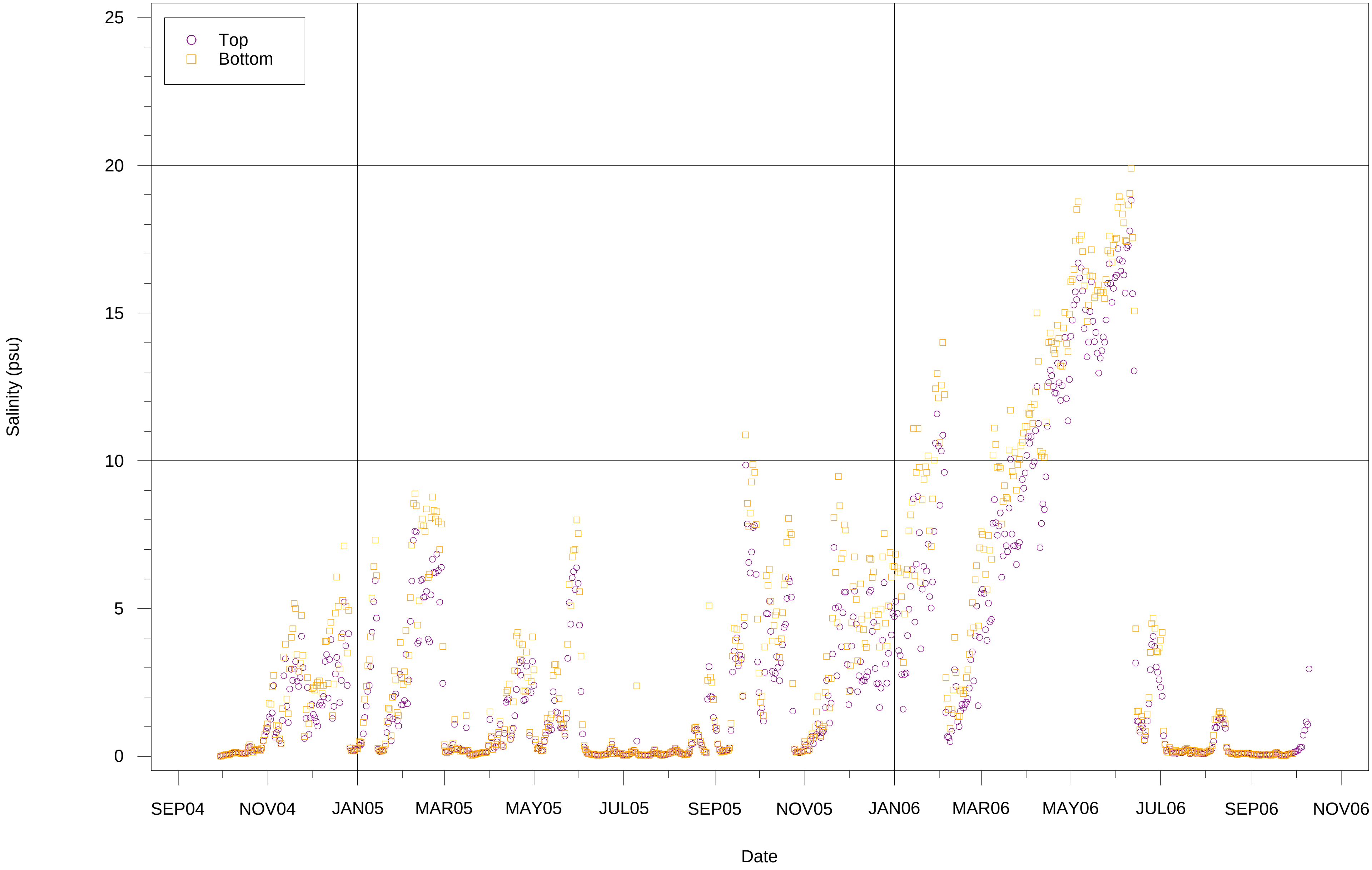


Little Manatee River USGS Station at River Kilometer 0.8
Top and Bottom Salinity, Daily Average




Little Manatee River USGS Station at River Kilometer 8.3
Top and Bottom Salinity, Daily Average
Top
Bottom
Salinity (psu)
0
5
10
15
20
25
30
Date
JUL04
SEP04
NOV04
JAN05
MAR05
MAY05
JUL05
SEP05
NOV05
JAN06
MAR06
MAY06
JUL06
SEP06
NOV06

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



September 7, 2022

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.

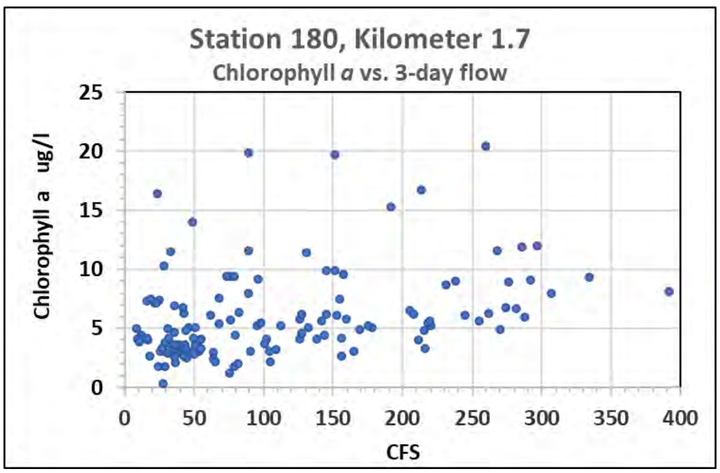
These studies have shown that the spatial distribution of chlorophyll *a* concentrations in tidal rivers is strongly affected by a number of factors, including nutrient loading, light penetration, and residence time. In turn, all of these factors are strongly affected by the rate and volume of freshwater 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.

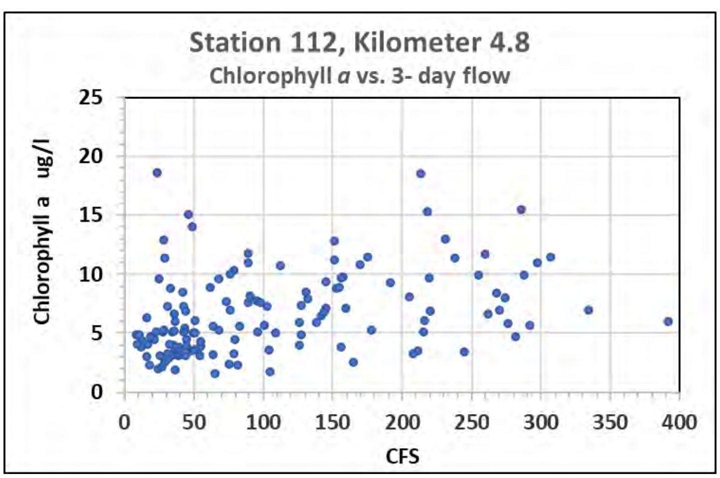
Table 2. Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers, adapted from Vargo et al. (2004).

		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.



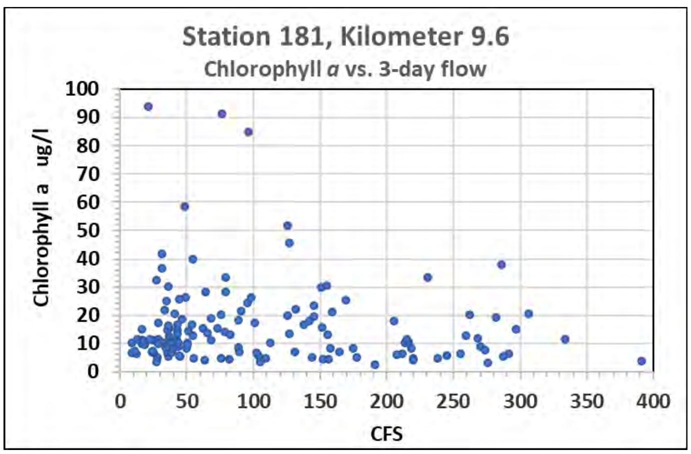


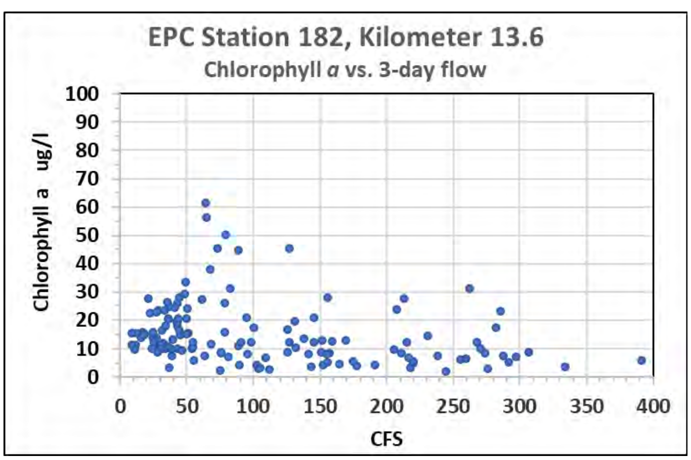
Figures 1 and 2. Chlorophyll *a* concentrations at EPCHC stations at kilometers 1.7 and 4.8 in the Lower Little Manatee River vs. the preceding three-day average flow at the US 301 gage.

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.

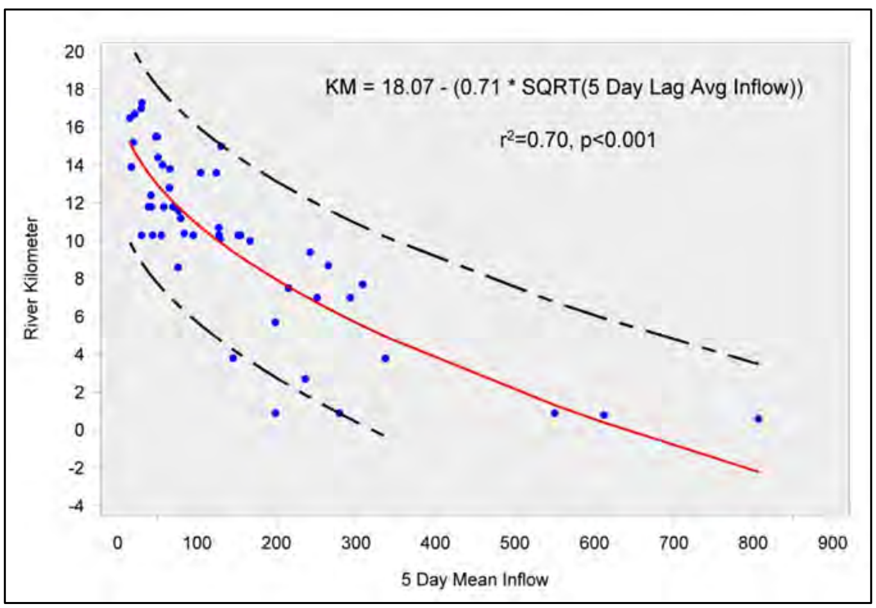


Figure 5. Scatter plot and regression of the location of maximum chlorophyll *a* concentrations measured among four moving salinity-based stations in the Lower Little Manatee River vs. the preceding five-day average inflow for each sampling date.

* **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.

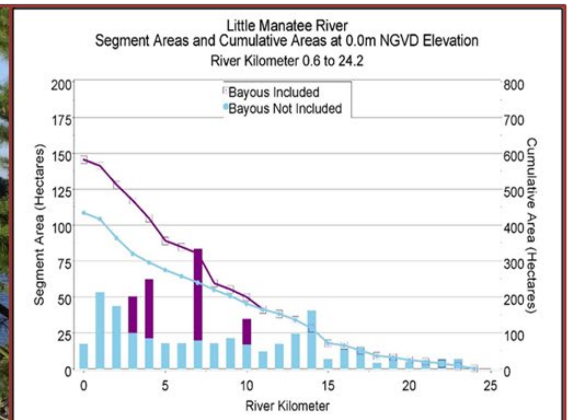
Preliminarily, it appears that a switch to a higher withdrawal percentage in the range of 150 to 200 cfs would be a more appropriate high flow threshold to protect the resources of the lower river that are associated with phytoplankton production. A flow rate of 150 cfs corrected for withdrawals by the 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.

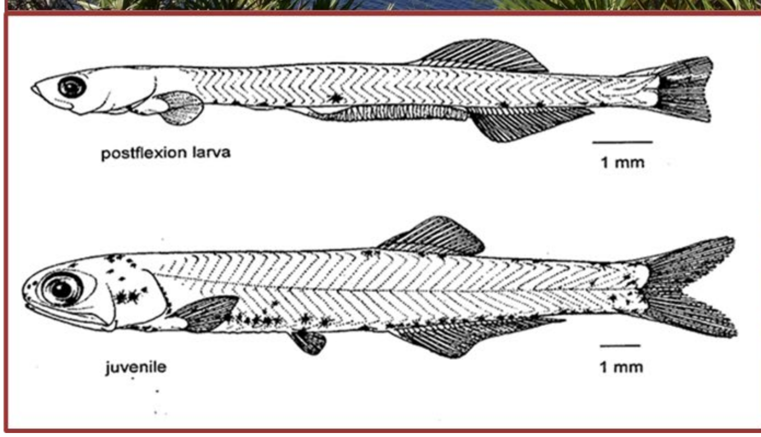
When considering what are appropriate flow-based thresholds, it is important to consider what would be the resulting actual flows in the river after the withdrawals allowed by the minimum flow rule. For example, if 30% withdrawals are allowed above the high flow threshold, a baseline flow of 150 cfs 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.

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 fish habitat modeling 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 5 to 7 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.

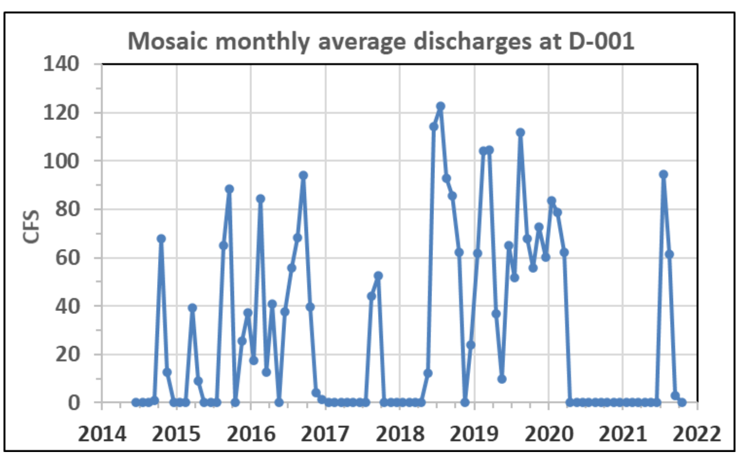
- Text resumes on next page –

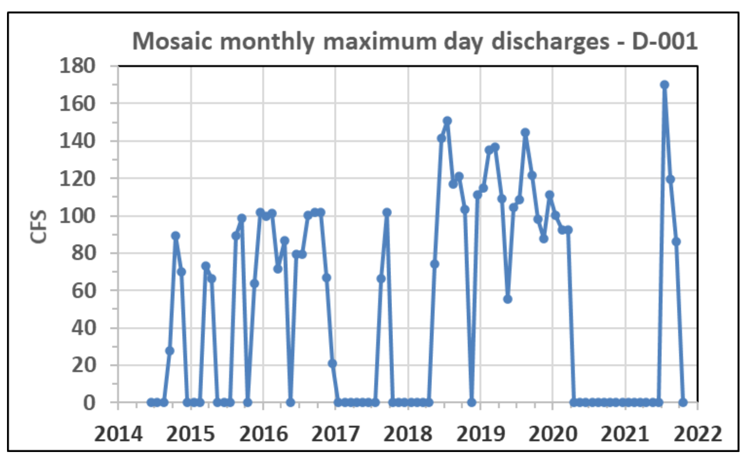
1. Recent point source discharges from the Mosaic Company Four Corners mine and status of phosphate mining in the Little Manatee River watershed.

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.

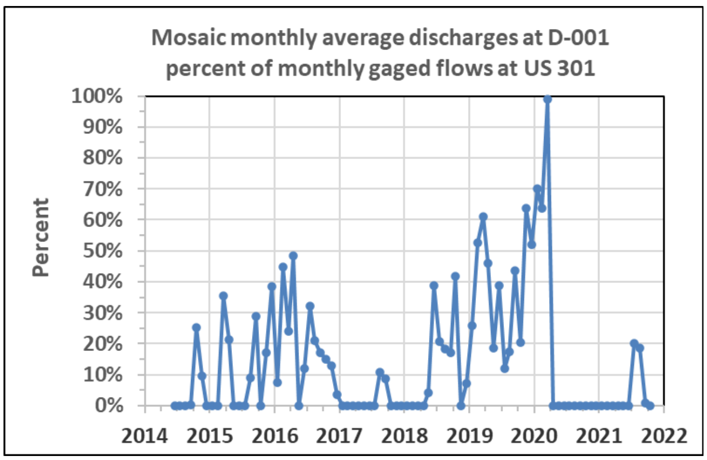


Figure 3. Percentage of average monthly gaged flows at the Little Manatee River at US 301 near Wimauma comprised of average monthly discharges at Mosaic Site D-001

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.

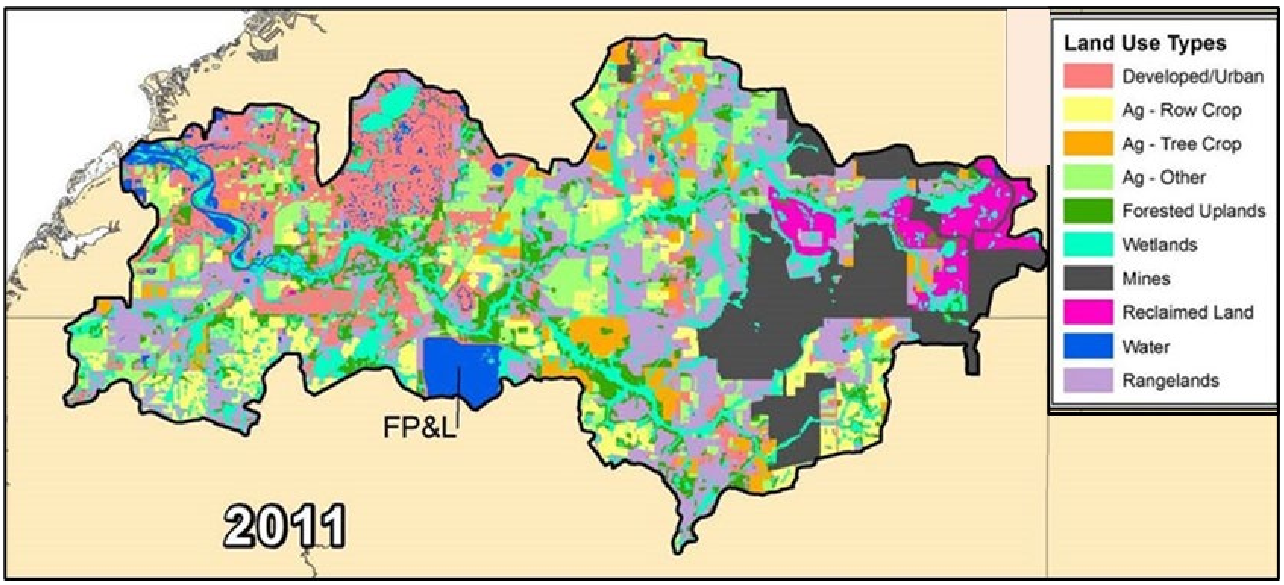


Figure 4. Land/Use cover map in the Little Manatee River Watershed for 2011, adapted from Figure 2-5 in JEI (2018a, Appendix C) and Figure 2-6 in JEI (2018b, Appendix E).

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.

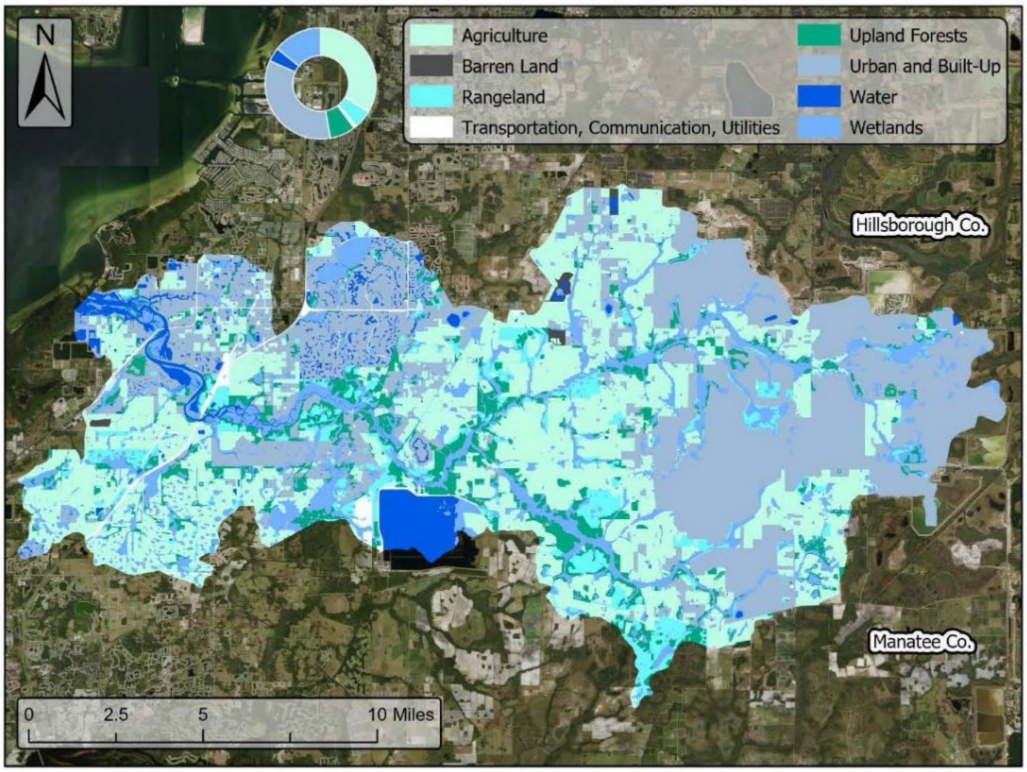


Figure 5. The 2017 Florida Land Use, Cover and Forms Classification System (Level 1) of the Little Manatee River watershed (SWFWMD 2019).   Reprinted from 2021 draft minimum flows report.

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 2, 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 2, the P50 for 2015-2019 was 105 cfs compared to range of 61 to 81 cfs in Table 2, the P75 for 2015-2019 was 243 cfs compared to a range of 145 to 167 cfs in Table 2, and the P90 for 2015 – 2019 below was 516 cfs compared to a range of 375 to 387 cfs in Table 2.

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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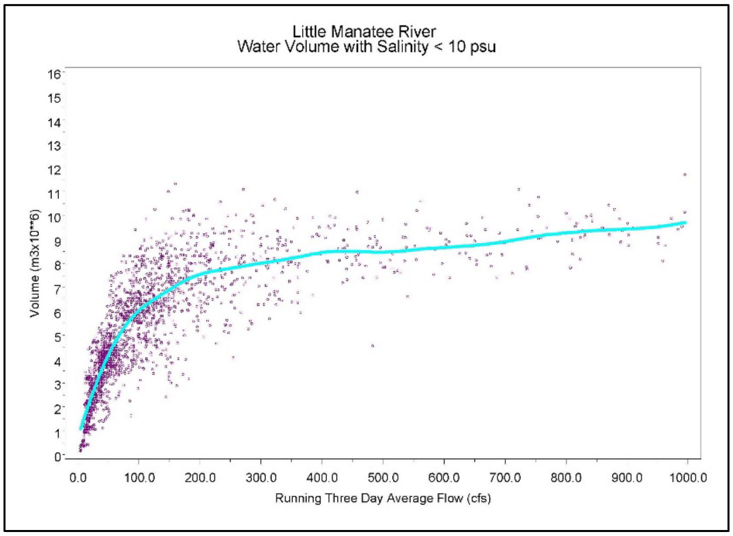


Figure 6. Water volume less than 10 psu salinity in the Lower Little Manatee River as a function of preceding three-day freshwater inflow as predicted by the EFDC model for the lower river.

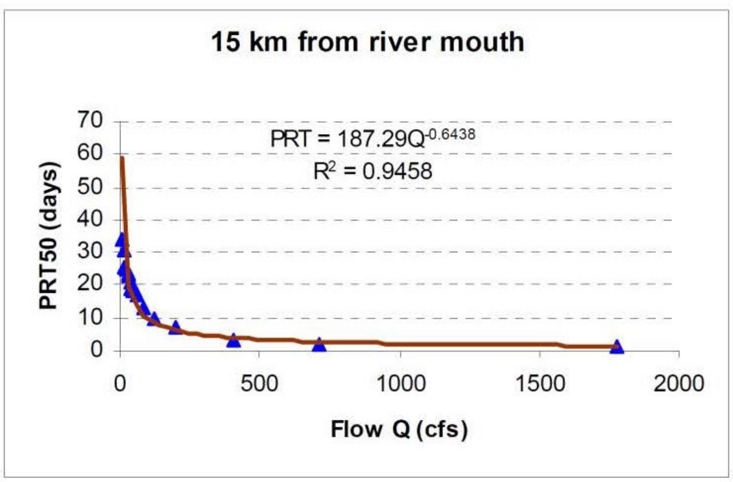


Figure 7. Pulse residence time versus freshwater inflow at a site 15 kilometers upstream from the mouth of the Little Manatee River, adapted from Figure 3-14 in JEI (2018b).

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.

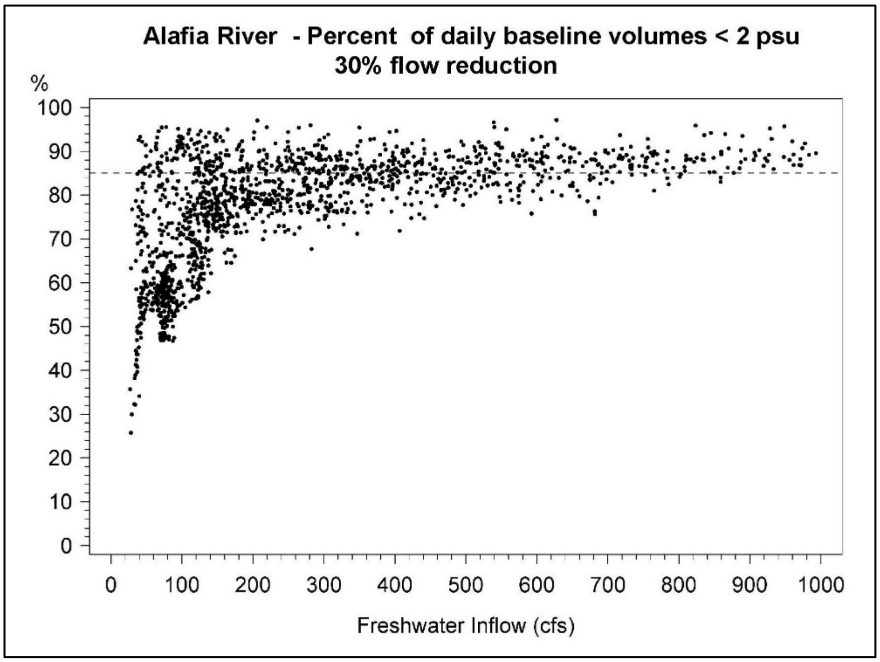


Figure 8. Percent of water volume less than 2 psu salinity relative to baseline for daily flow reductions of 30 percent vs. the rate of daily baseline flow for the Lower Alafia River with a reference line at 85 percent remaining habitat, equivalent to a 15% reduction in volume.

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.

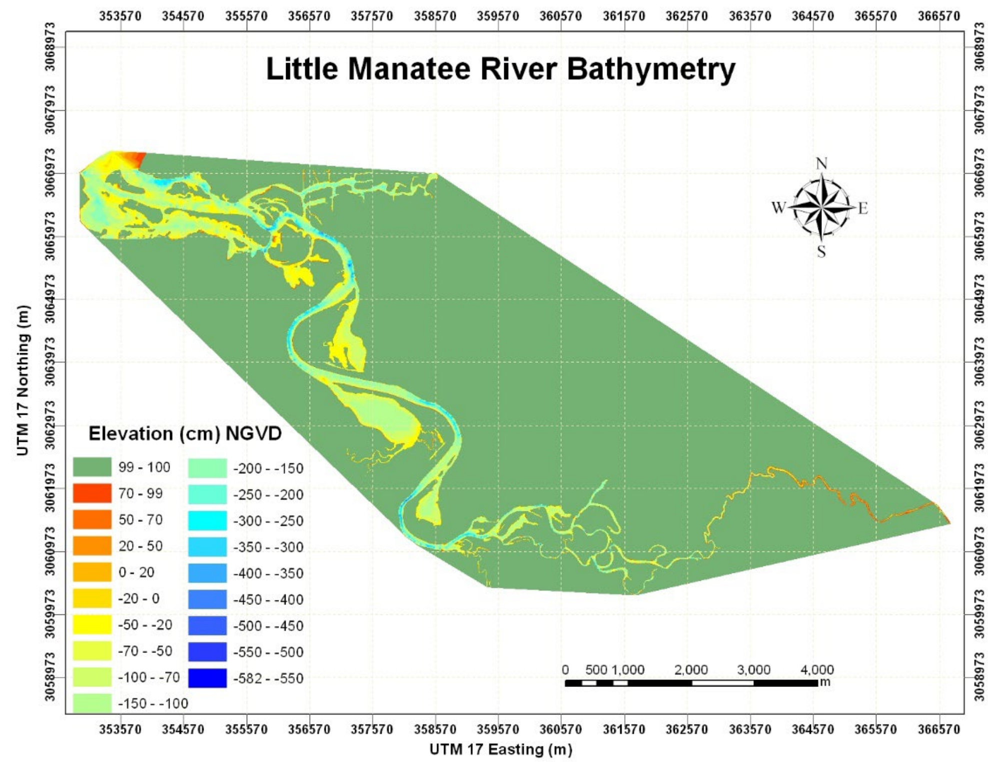
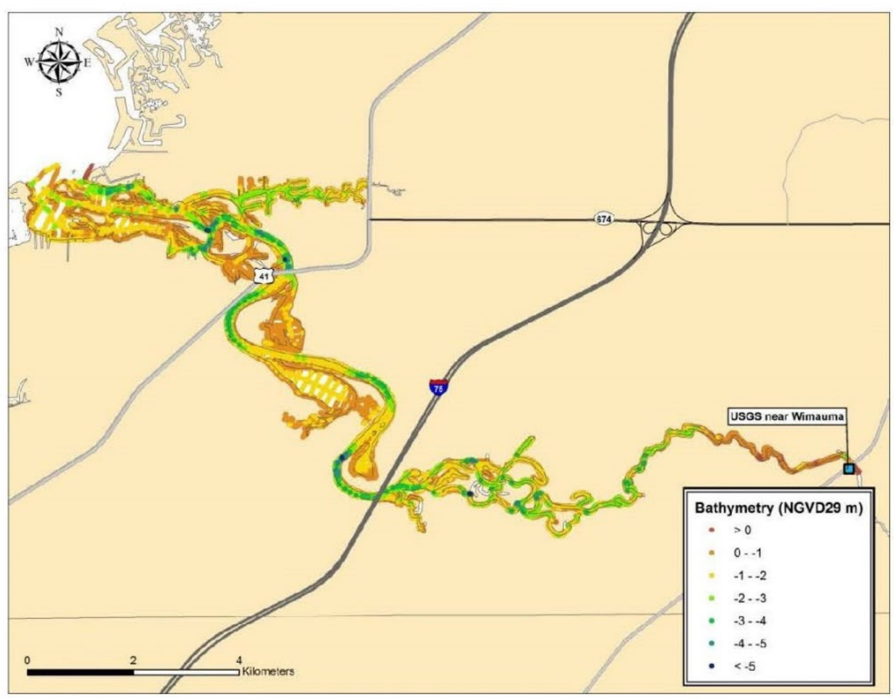


Figure 9. Bathymetric map of Little Manatee River generated from data from Wang (2006)



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.

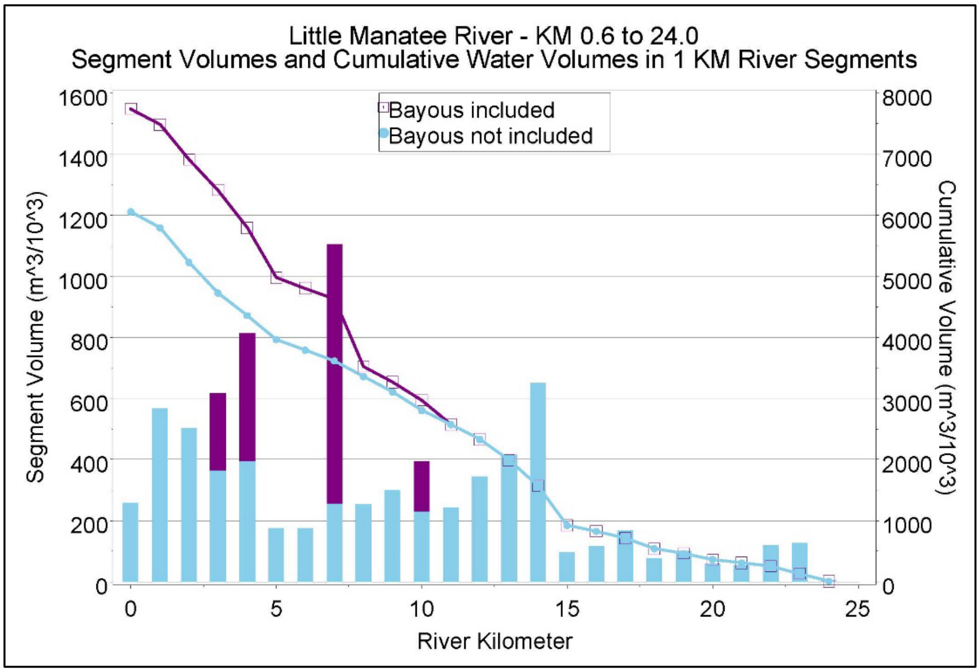


Figure 11. Volume of the Lower Little Manatee River in one-kilometer segments and cumulative volume increasing toward the river mouth from km 24 to km 0.6.

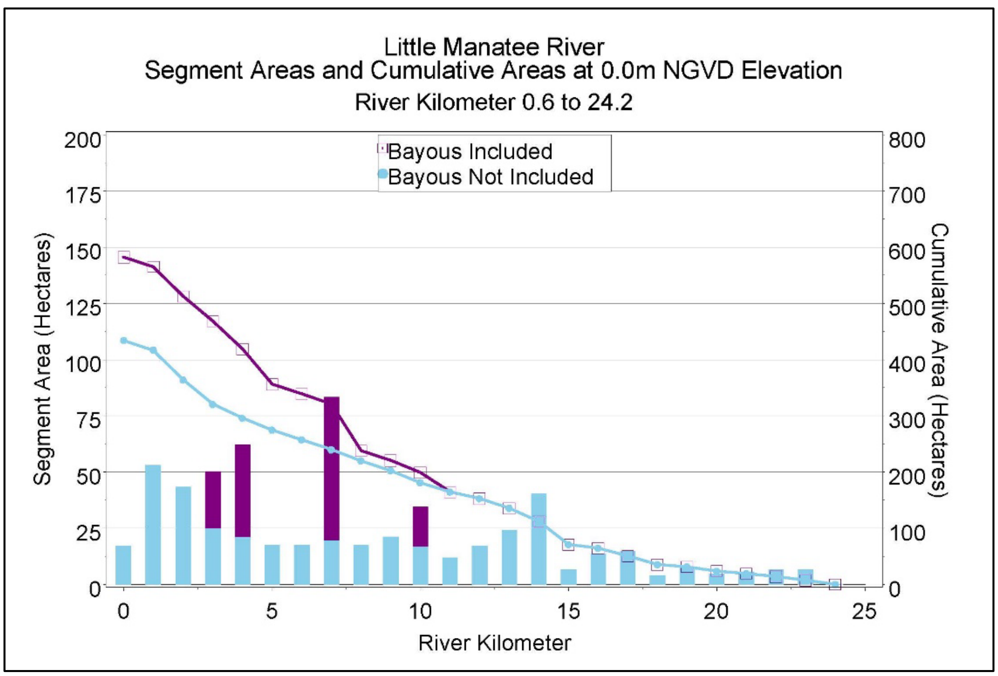


Figure 12. Area of the Lower Little Manatee River at an elevation of 0.0 meters NGVD1929 in one-kilometer segments and cumulative area increasing toward the river mouth from km 24 to km 0.6.

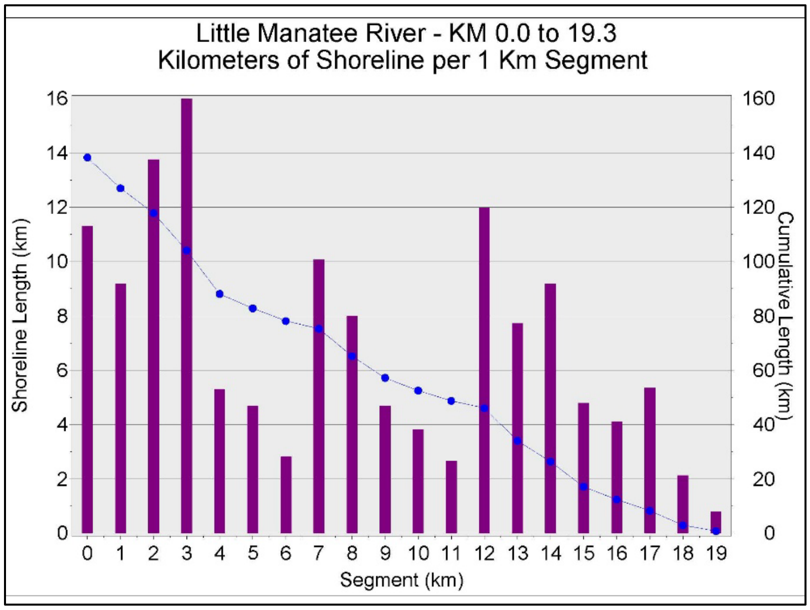


Figure 13. Shoreline lengths along the Lower Little Manatee River in one kilometer segments and cumulative shoreline length increasing toward the river mouth from km 19 to km 0.6

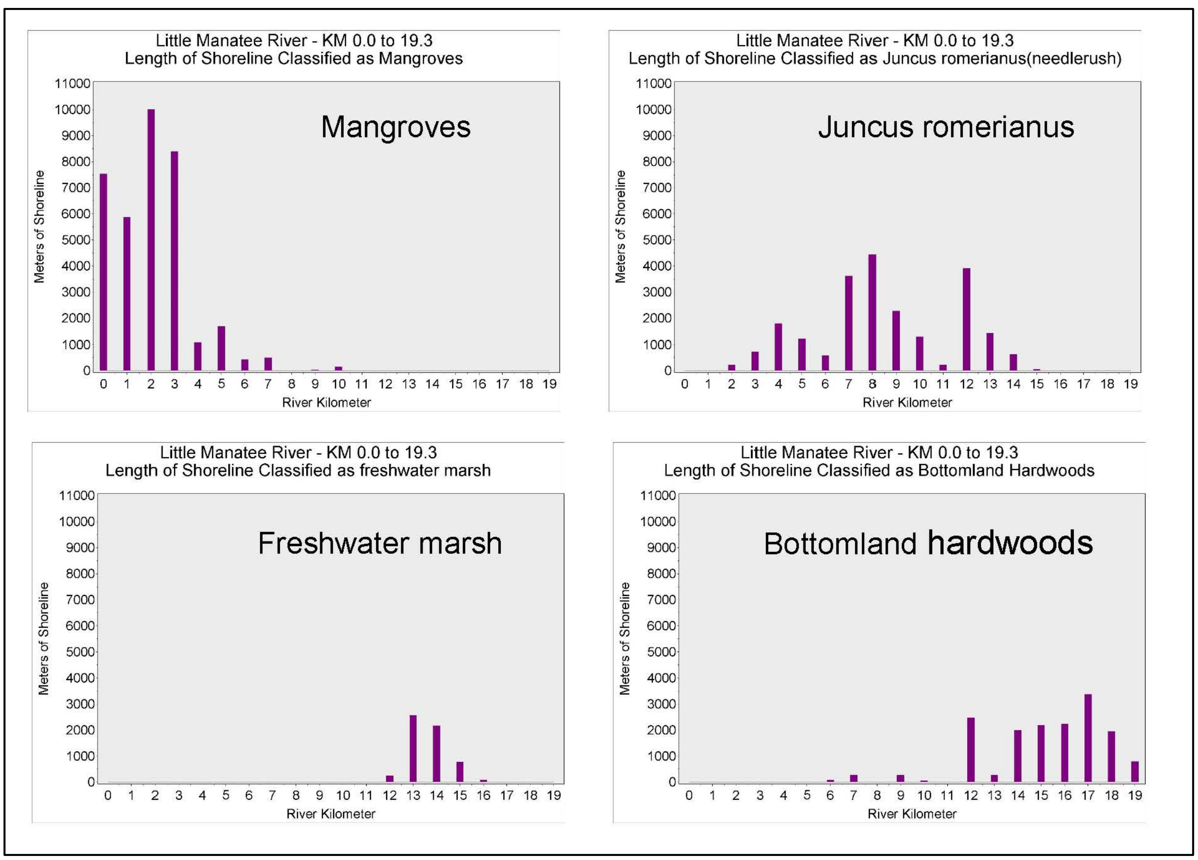


Figure 14. Shoreline lengths of mangroves, needle rush (*Juncus romerianus)*, freshwater marsh and bottomland hardwoods along the Little Manatee River from km 0.0 to km 19

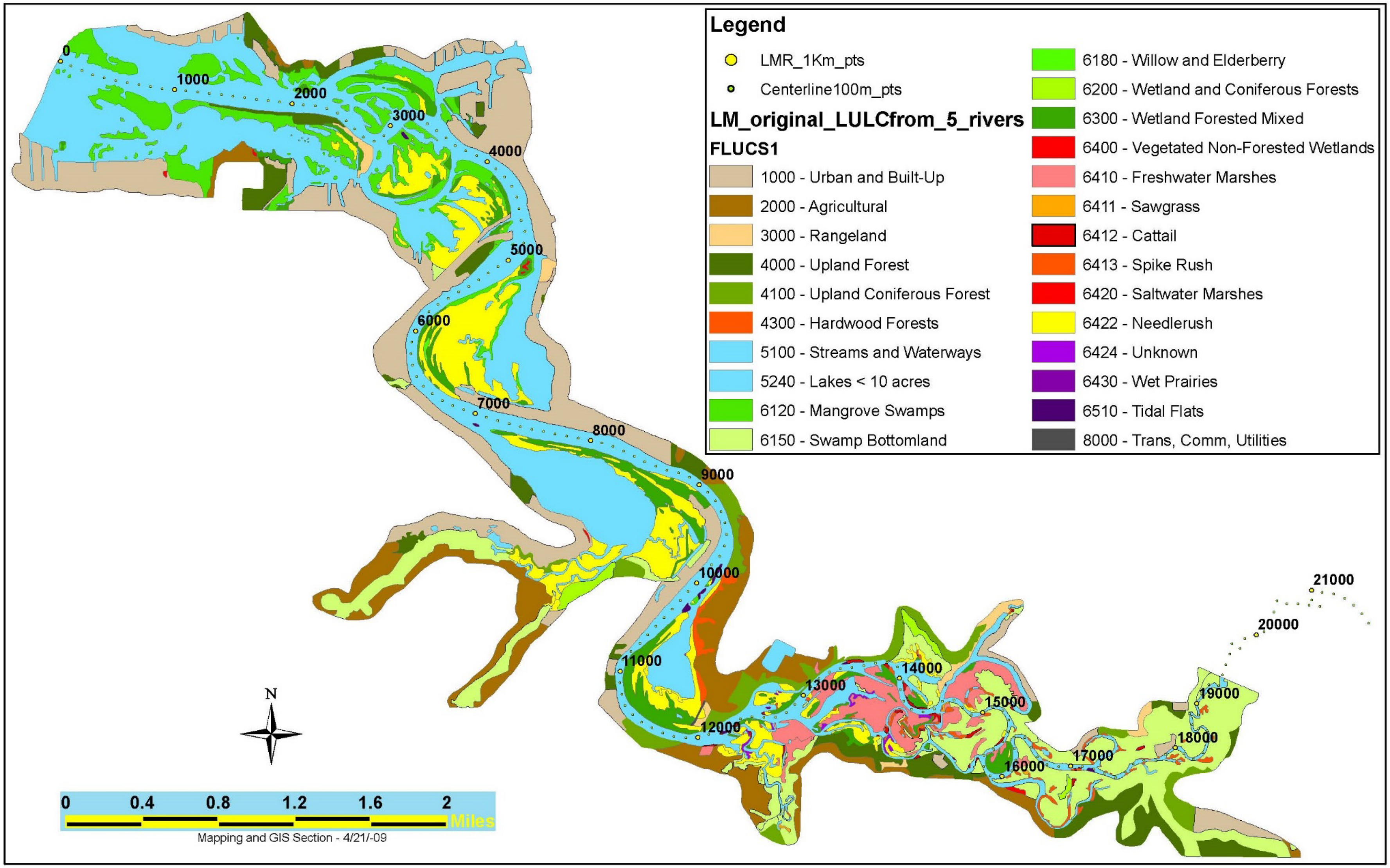


Figure 15. The distribution of major vegetation communities along the Lower Little Manatee River mapped by the Florida Marine Research Institute (1997).

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.

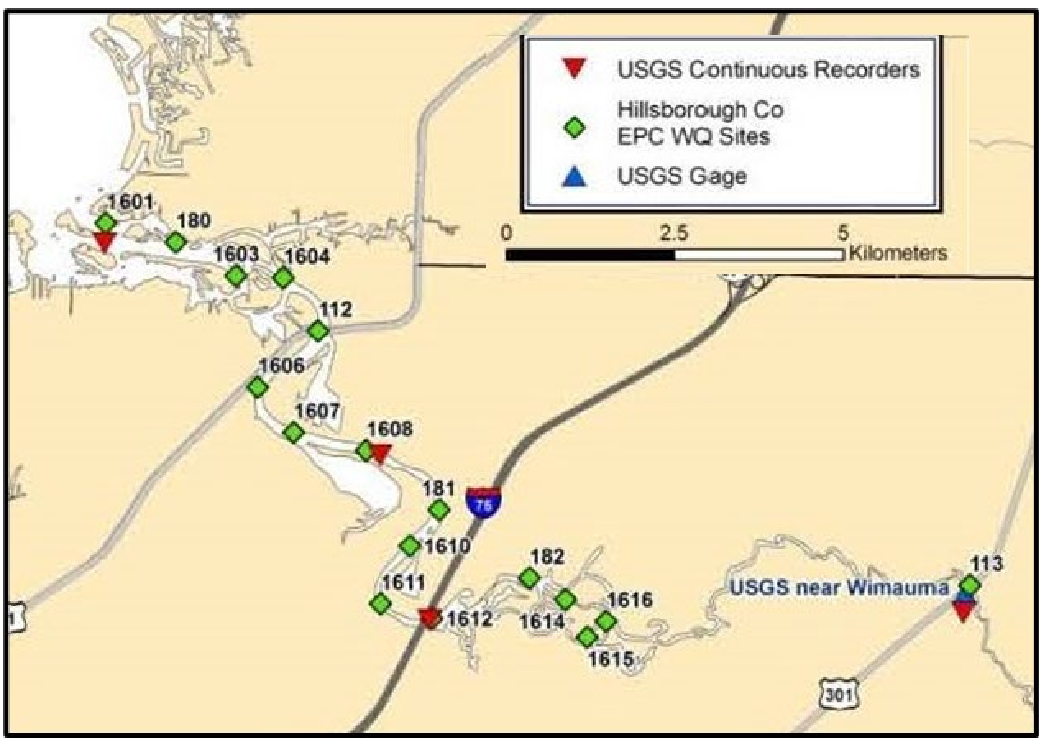


Figure 16. Location of vertical profile stations monitored in the lower river by the EPCHC, adapted from the first draft minimum flows report for the lower river (JEI 2018b).

*** 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.

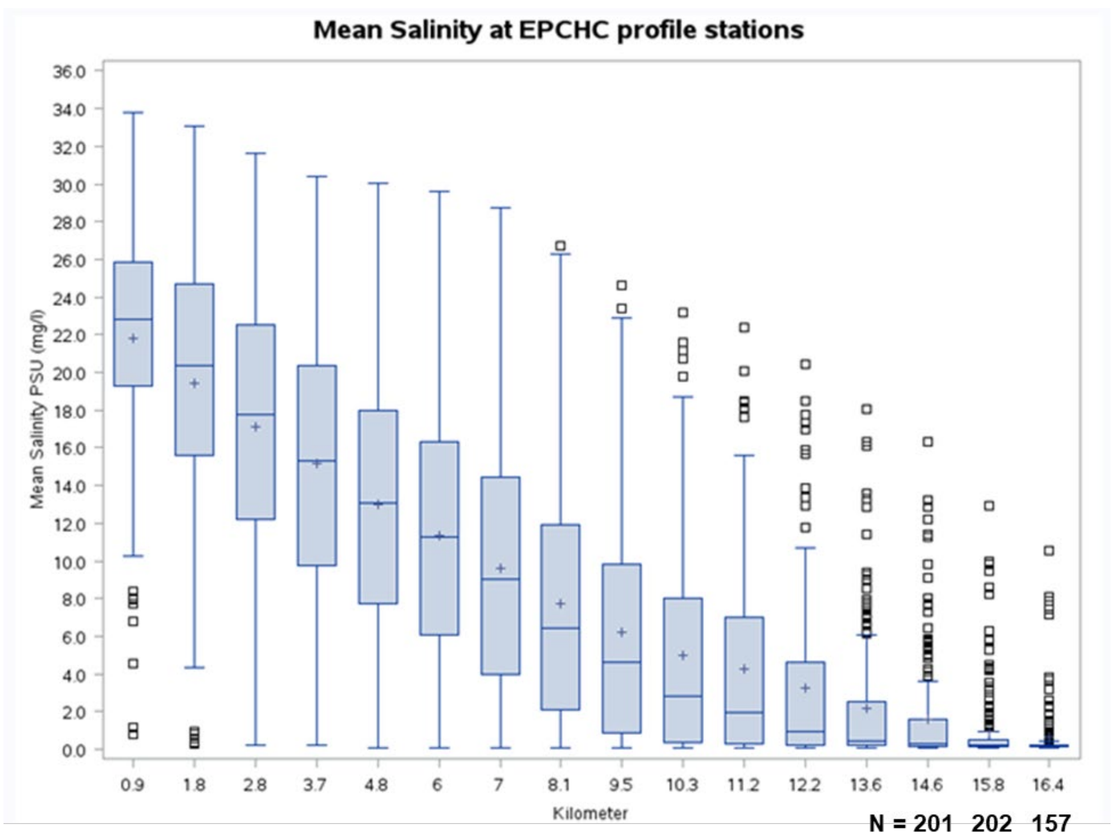


Figure 17. Box plot of mean water column salinity values at EPCHC vertical profile stations. The + symbols are means, the horizontal lines the medians, with the whiskers extending to 1.5 times the inter-quartile range. Outliers are shown for above the whiskers, but not below as freshwater outliers (<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.

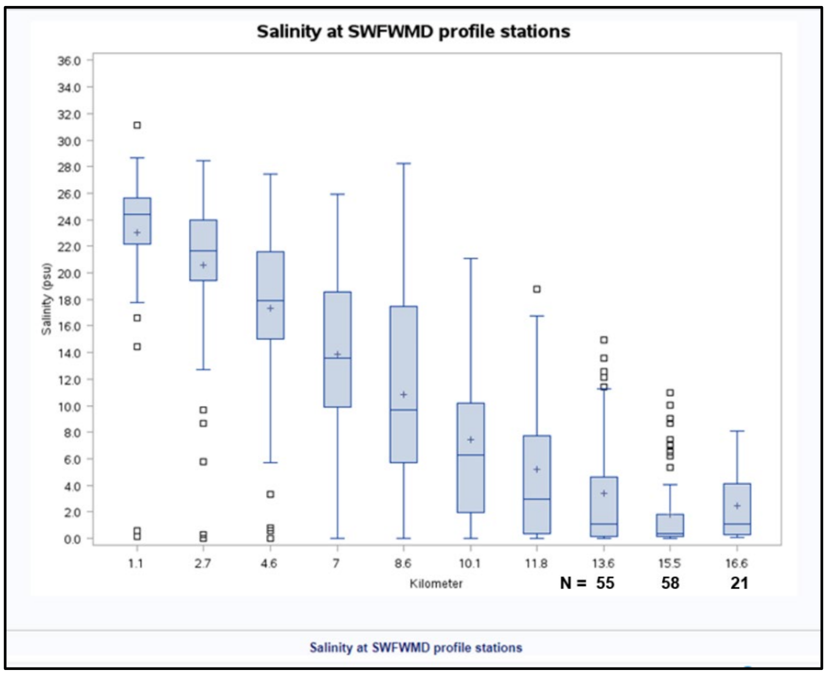


Figure 18. Box plot of mean water column salinity values at SWFWMD vertical profile stations.

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

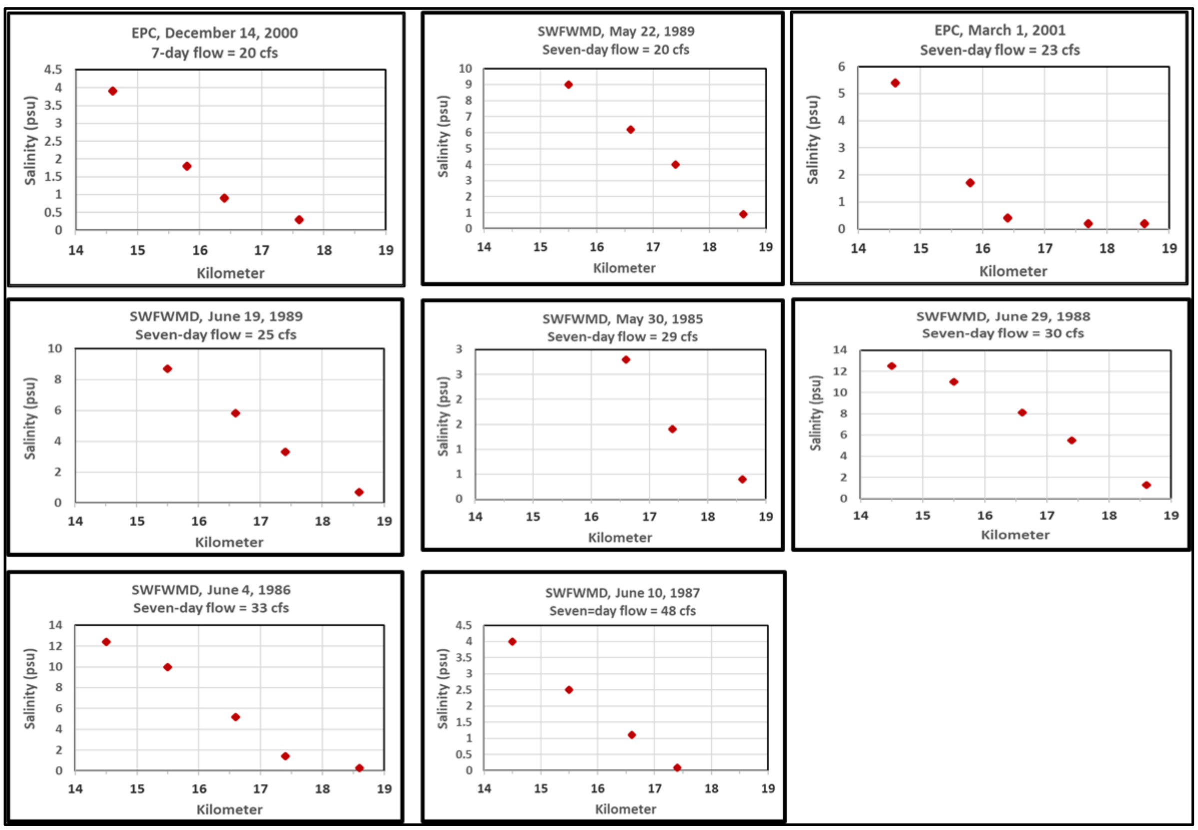


Figure 19. Mean water column salinity at upper stations in the lower river when sampling extended upstream of kilometer 16.6 by either the EPCHC or the District. The preceding seven-day average flow for each sampling date is listed on graphs.

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.

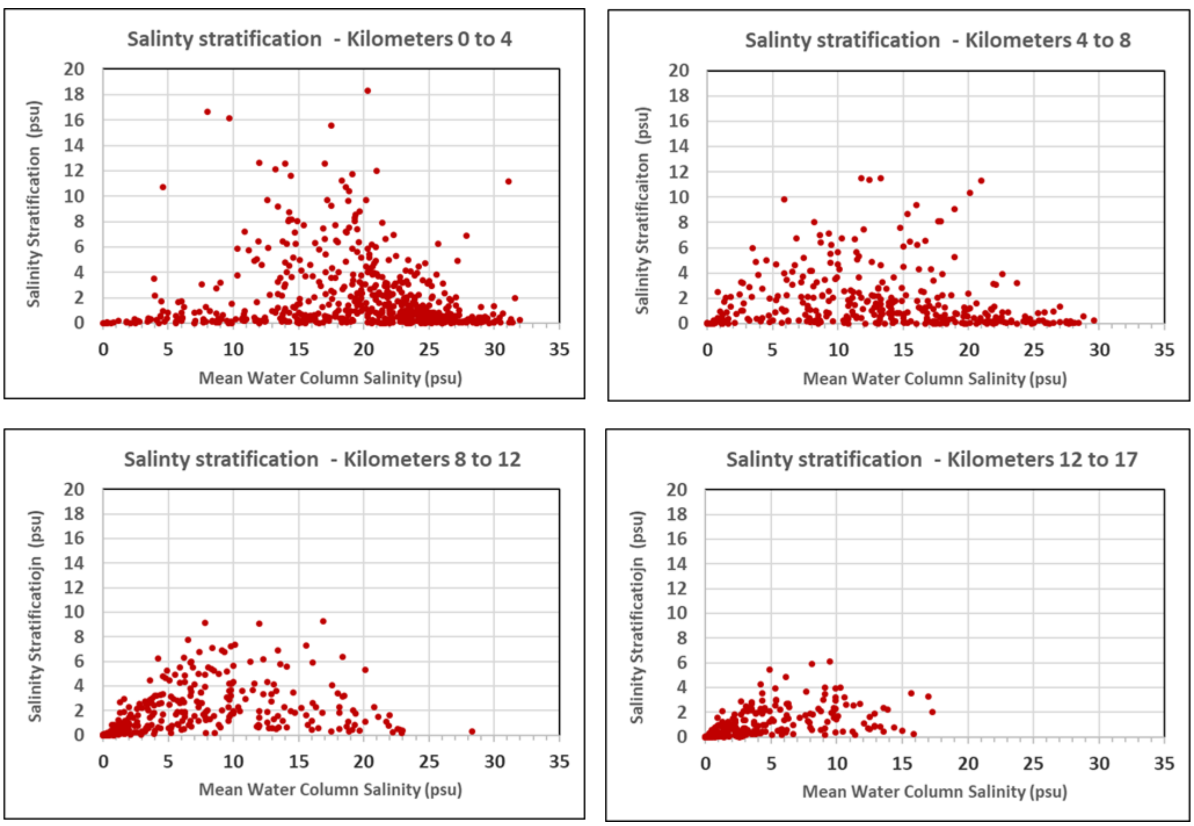


Figure 20. Salinity stratification (bottom minus surface) vs. mean water column salinity in four reaches of the Lower Little Manatee River as measured in vertical profiles taken by the EPCHC and SWFWMD.

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.

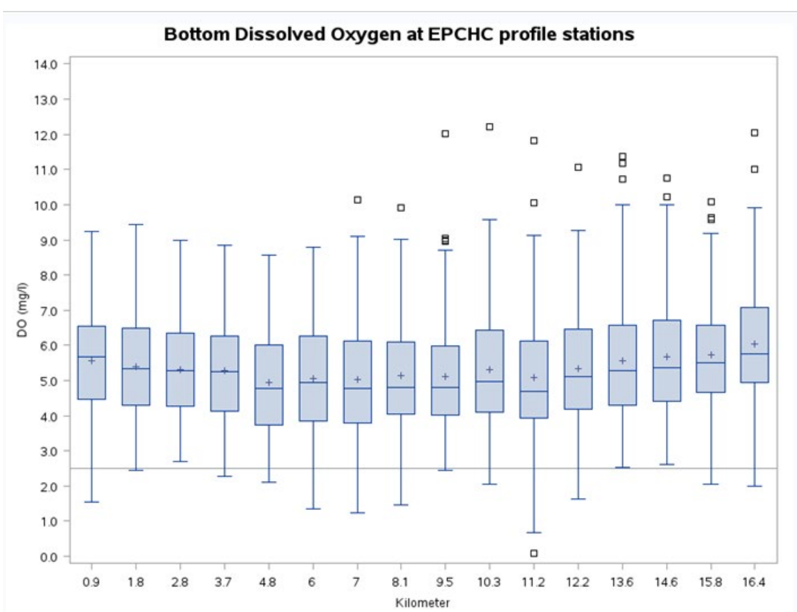


Figure 21. Box plot of bottom DO concentrations at EPCHC vertical profile stations, using same plotting conventions as Figure 17 on page 25.

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.

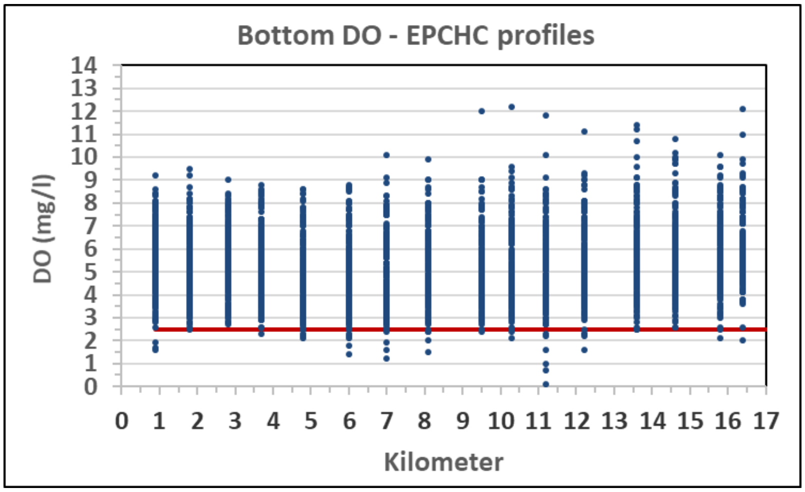


Figure 22. Individual bottom DO concentrations at EPCHC vertical profile stations

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.

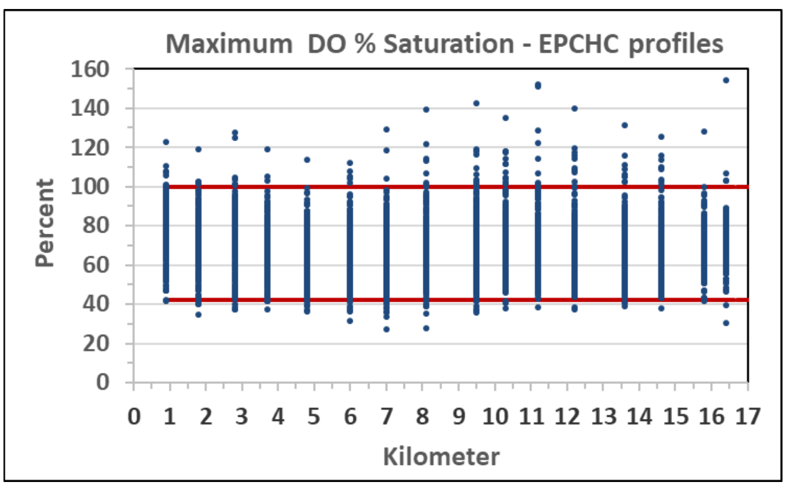


Figure 23. Maximum values of DO percent saturation at EPCHC vertical profile stations.

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.

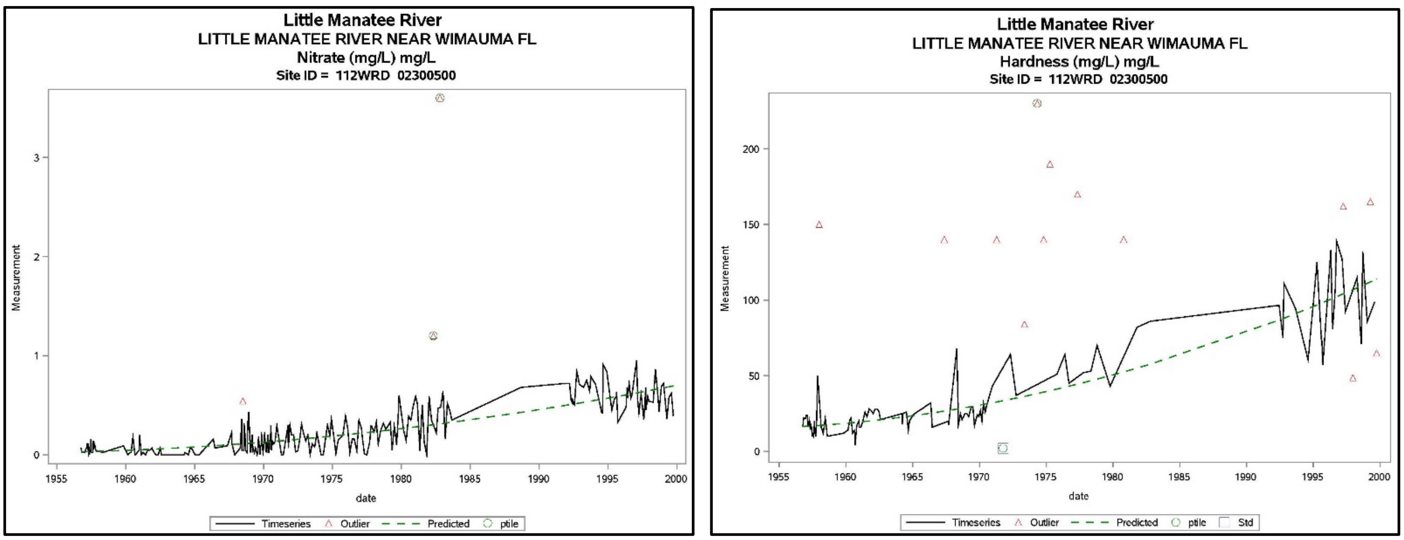


Figure 24. Concentrations of nitrate nitrogen and hardness, both as mg/l, for the USGS gage at US 301 Little Manatee River near Wimauma starting in the 1956 through 1999. Graphs taken from Appendix D-1 to the draft minimum flows report.

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.

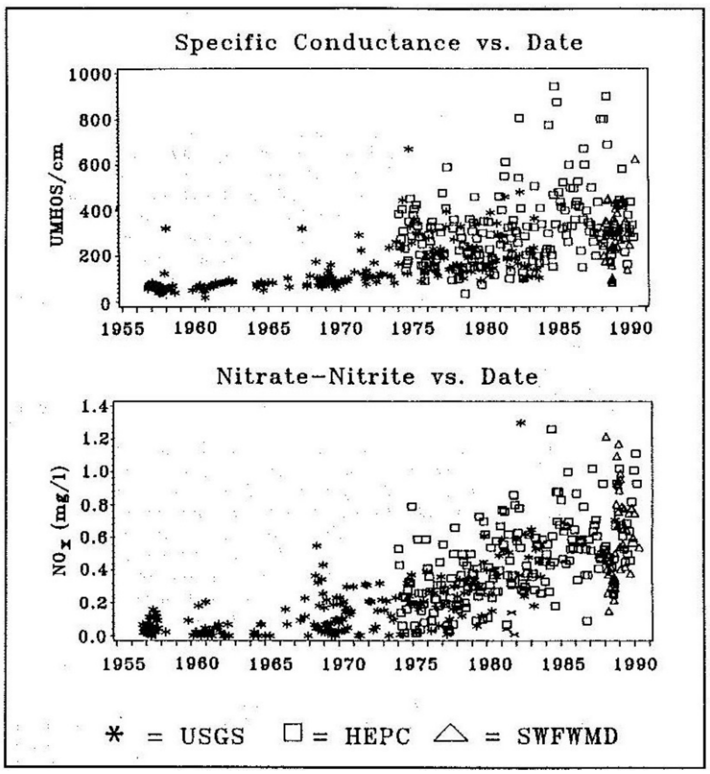


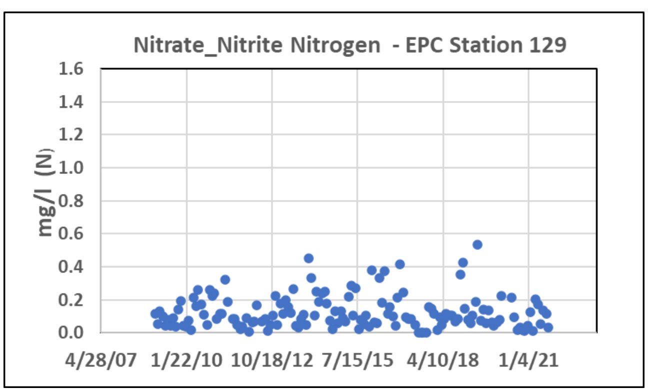
Figure 25. Time series plots of specific conductance and nitrate + nitrite nitrogen (as mg/l N) at the Little Manatee River near Wimauma at US 301 gage for 1956 through 1990 from three data sources: the USGS; the EPHCH (HEPC) and the District (SWFWMD). Reprinted from Flannery et al. (1991).

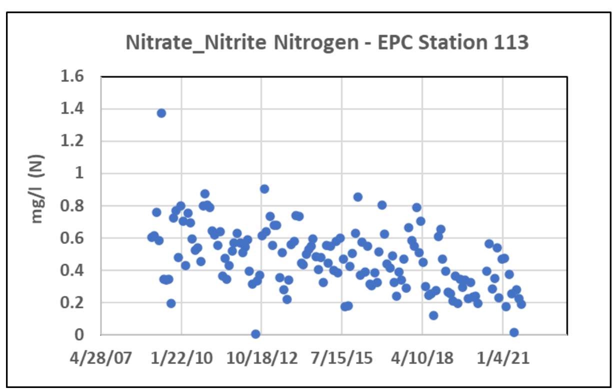
The comparison of constituent concentrations and flux rates from the watershed in this project was also informative. During the study, the most upstream site on the river at the site of the USGS gage near Ft. Lonesome was somewhat of a control site, as phosphate mining was largely inactive during the 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

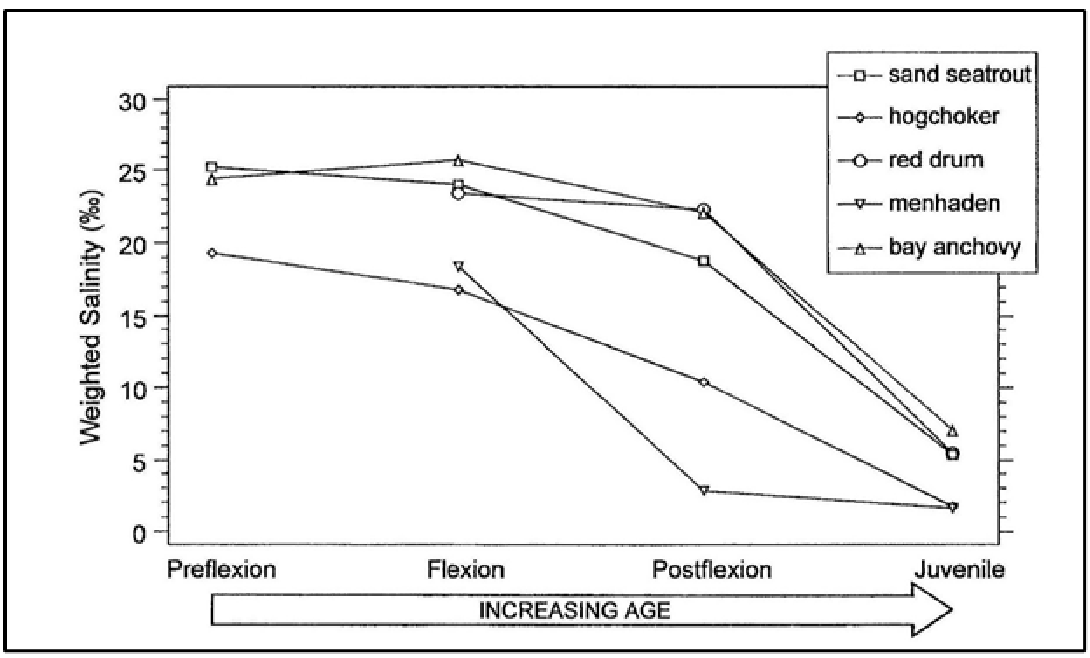


Figure 28. Decreasing mean salinity at capture with fish development for five species in the Little Manatee River

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	Bleniid	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.

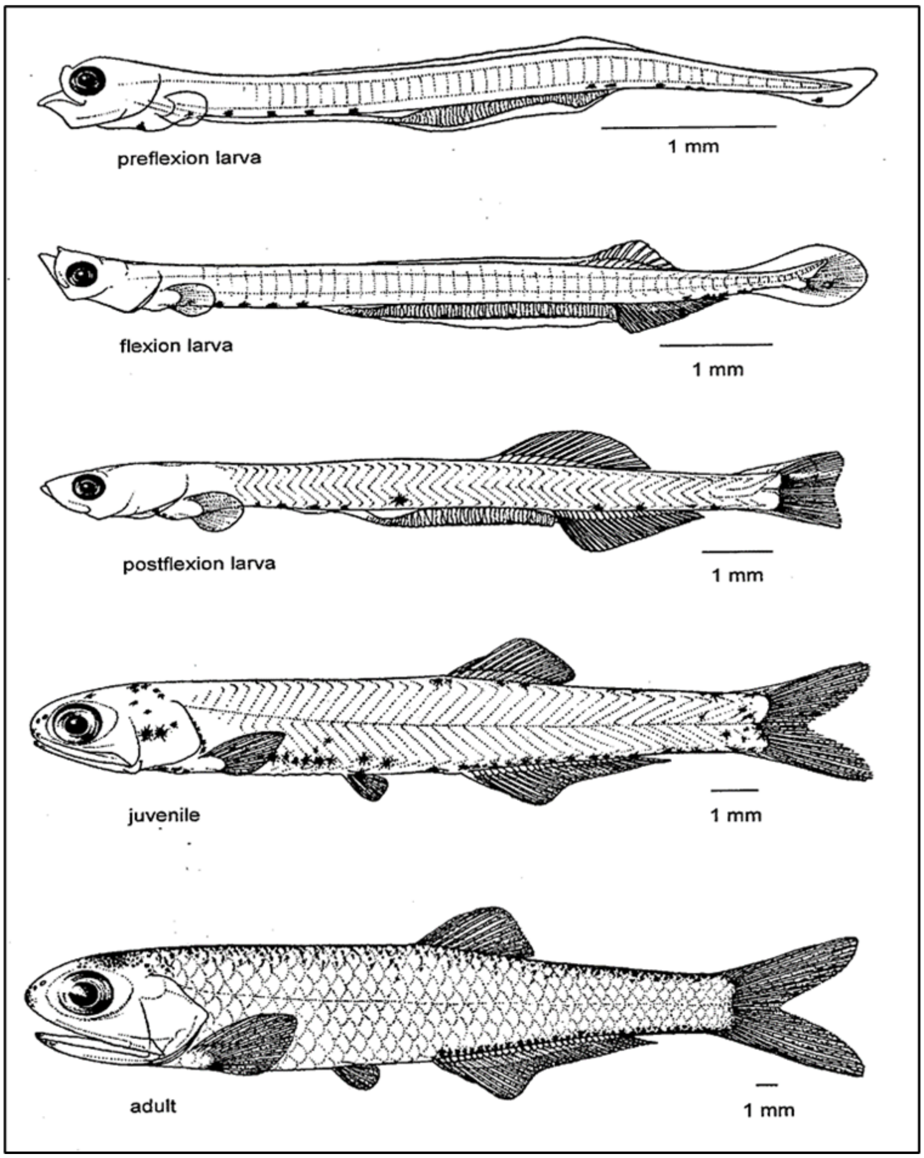


Figure 29. Development stages of the bay anchovy (*Anchoa mitchilli*) collected from the Lower Little Manatee River and Tampa Bay, measuring 4.6, 7.0, 10,5, 16 and 31 mm standard length. Reprinted from Peebles and Flannery (1992).

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 30 on the following page with text for new topic beginning on page 48

Sciaenops ocellatus (Red drum), Seines

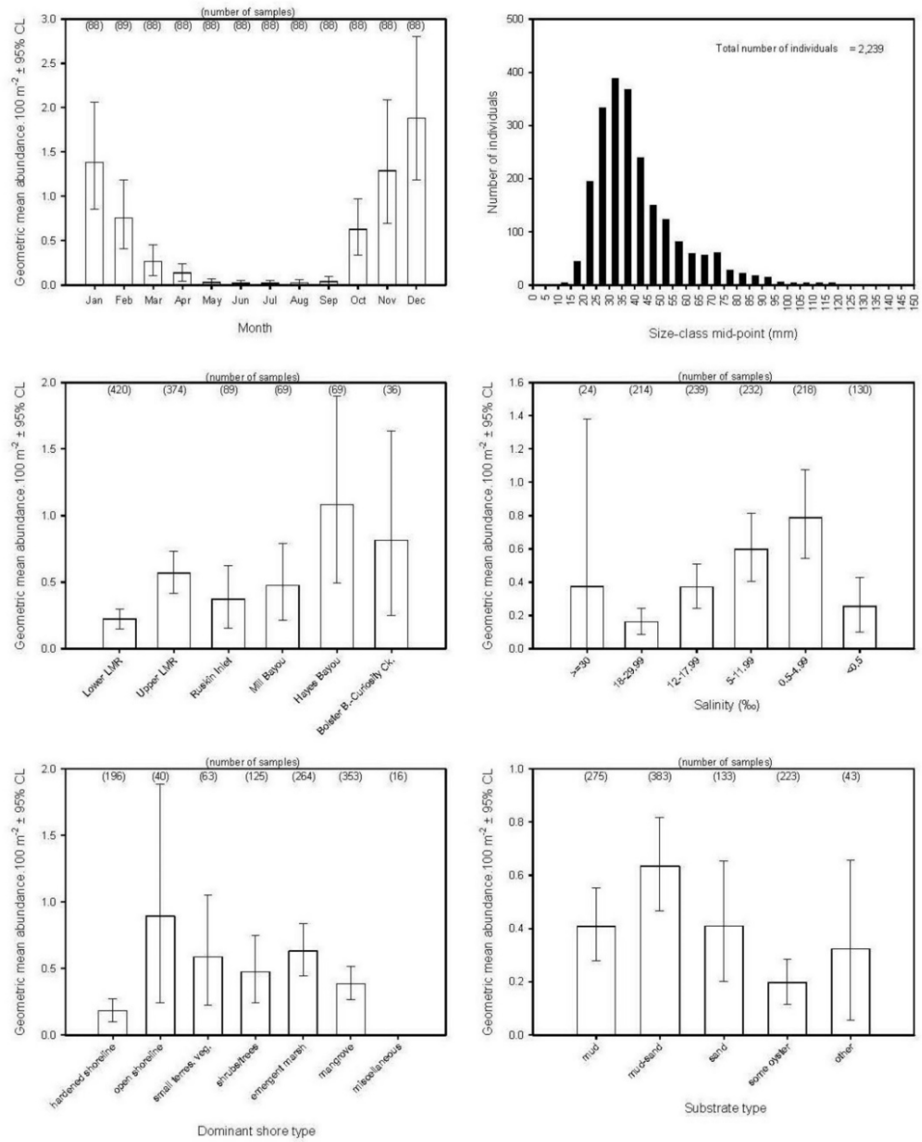


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

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.

Literature Cited on the following page

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From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Chris Zajac; Randy Smith
Subject:	Two files for occaisional possible reference during this afternoon"s meeting
Date:	Friday, June 30, 2023 7:51:18 AM
Attachments:	Little Manatee River supplementary analyses - DRAFT - Sid Flannery, Jan 24, 2022.pdf DRAFT - Combined files sent to SWFWMD regarding Little Manatee River minimum flows.pdf

Good morning Kym, Doug, Chris and Randy,

Attached are two documents that comprise the combined comments, graphs, and tables I have submitted to the District regarding my review of the minimum flows report for the Little Manatee River.
The point in sending this to you now is that at a few times in today's meeting, I may want to refer to a page in either of these documents to refer to a graph, table or text to aid our discussion.

The first document is the supplemental analyses report I submitted in January 2022 which has page numbers at the bottom. The second document is a compendium of various files I have submitted to the District which has page numbers in the upper right.

I can imagine how hard staff has been working on this report and I appreciate you taking time to meet with me this afternoon.

Sid

Text, tables, and graphics provided by Sid Flannery to the Southwest Florida Water Management District regarding review of the first draft Minimum Flows Report for the Little Manatee River (SWFWMD, 2021)

Content and Organization

This document complies various text, tables and graphics provided to the Southwest Florida Water Management District (the District) as part of a review of the draft minimum flows report for the Little Manatee River that was published in September 2021. These files were submitted to the District between Oct 2021 and September 2022. A revised draft minimum flows report for the Little Manatee River that addresses many of the topics identified in these files was published by the District in June 2023.

Other information not included

This document does not contain email correspondence with the District and miscellaneous files associated with that correspondence. Most notably, it also does not include analyses, results and discussion presented in an interpretive document provided to the District in January 2022 titled *Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows for the Little Manatee River (Flannery 2022)*, which can be provided upon request. Several technical points raised in that document were also addressed by the District in the revised draft minimum flow report.

This document also does not include a letter submitted to the District by the Florida Fish and Wildlife Conservation Commission (FFWCC) in April 2022 regarding nekton populations in the Little Manatee River and a review of the first draft minimum flows report. Similarly, many of the points raised by the FFWCC were also addressed in the revised draft minimum flows report for the Little Manatee River that was published in June 2023.

Next steps

Although the District has done a commendable job of addressing many of the topics identified in both the aforementioned Supplemental Analysis report those described on the following pages in this document, I believe there are some topics that still need further attention.

Prepared by

Sid Flannery, retired, formerly Chief Environmental Scientist with the Southwest Florida Water Management District

June 28, 2023

Public comments by Sid Flannery at the Little Manatee River minimum flows peer review meeting on 10/5/21 (not completed at the meeting due to time constraints)

Below is a transcript of the complete comments I had hoped to give at the peer review panel meeting on October 5, 2021, but ran short on time. I have added two paragraphs about the work by Dr. Gabriel Vargo and have supplied one additional slide I would like sent to the peer review panel with this document. The other two slides that were shown at the meeting are also submitted and all three slides are shown at the end of this document.

I encourage readers to review the information about Dr. Vargo's work and the important topic of separate flow thresholds for freshwater and estuarine sections of the river that starts on page 3, which I did not have time to cover in my public comments at the meeting.

My name is Sid Flannery, and as I introduced myself earlier, I am a retired Chief Environmental Scientist with the District's minimum flows program, where I worked many years on the hydrobiological flow relationships of the Little Manatee River. I managed nine different consultant research or analysis projects for the river and have probably spent 50 plus field days on the lower portions of the Little Manatee.

I want to first acknowledge how hard and conscientiously District staff works on the minimum flows reports, for they are under a very challenging schedule for the adoption of the minimum flow rules.

I quickly read through the minimum flows report for the Little Manatee, and based on further review, I will submit a series of questions and comments to the District. I will request that these questions and comments be provided to the peer review panel via the minimum flows web-board.

Today, I want to briefly discuss two aspects of the minimum flows report, the first of which I think is pretty easy to address, and the second which may require some new analyses.

The first topic is the report does not cite nor describe some important earlier technical reports that were prepared for the District about the Little Manatee River which provide very useful information regarding its ecological relationships with freshwater flows. I think these reports need to be cited and briefly summarized in the District report. Importantly, I don't think that concise summaries of these reports will change the recommended minimum flows and it should be fairly easy to incorporate them in the format of the District report. Inclusion of this material will improve the public and the technical community's understanding of the freshwater flow relationships of the Little Manatee River, and therefore better support the recommended minimum flows.

I have got two slides I want to show you in this regard *(a third slide has been added since I spoke).*

On page 70, the District report shows a land cover map for the lower, tidal reach of the Little Manatee River using the Florida Land Use, Cover, and Forms Classification System, also known

as FLUCCS. However, there is much better information available for the river, for in the 1990's the District contracted the State of Florida Marine Research Institute to do detailed mapping of vegetation communities in five tidal rivers, including the Little Manatee.

This slide (at end of this document) shows the vegetation communities that were mapped as part of that project. Note that compared to the FLUCCS codes shown in the District report, the low salinity plant communities are identified with much greater resolution, including *Typha*, *Cladium*, *Acrostichum*, freshwater marshes and other communities. It is worth noting that on the Little Manatee and other tidal rivers, the District has rightly emphasized the protection of low salinity zones, such a < 2 psu salinity. This is particularly relevant on the Little Manatee for it has a highly braided zone above kilometer 12, which has a very high degree of shoreline length per river kilometer. This zone of the river is one of the real unique areas in southwest Florida and its health is closely linked to the minimum flows. This is the map that needs to be used in the District report and work that produced it needs to be cited.

Also, in 1988 and 1989, the District received grants from the Florida Department of Environmental Protection to examine the linkages between the Little Manatee River watershed and its receiving estuary. That project included a two-year study of ichthyoplankton communities in the tidal reach of the river, which involved the early life stages of estuarine fishes. This was conducted by Dr. Ernst Peebles of the University of South Florida College of Marine Science and it is briefly described on page 99 in the District report, followed by a table of the 30 most abundant fish life stages captured during the study. It should be noted this study also quantified the abundance of many invertebrates caught in the plankton net that are important fish food organisms.

There are other valuable findings from this project that could also be briefly summarized in the District report. The next slide is from that project. I think If there is one slide that best supports the District's minimum flows program for tidal rivers, this is it. It shows mean salinity at capture for the immature life stages for five species of fish in the Little Manatee, with age increasing toward the right. The first three are larval stages, as many important estuarine dependent species spawn in the bay or gulf or near the mouths of rivers.

As these fishes grow to juveniles and develop stronger swimming ability, they move into low salinity waters. This, about as effectively as anything, justifies the use of the low salinity habitats as a parameter for establishing minimum flows. There are some other aspects of the ichthyoplankton report for the Little Manatee that are valuable, but at a minimum this graphic needs to go into the District report.

There are four other papers or reports (one a group of three related reports) that need to be cited and summarized in the District report. Of particular significance is important primary production work done by Dr. Gabriel Vargo of the University of South Florida College of Marine Science.

On page 56, the District report shows yearly mean chlorophyll *a* concentrations at five stations in the Little Manatee monitored by the Environmental Protection Commission of Hillsborough

County, including four in the estuarine reach of the river. The report states the spatial pattern shown between these stations is typical of tidal rivers. Well not exactly, the Little Manatee is unusual in that regard and there are reasons for it. The table below, which is also submitted as a slide, is adapted from a report that Dr. Vargo prepared for the District that compares chlorophyll and phytoplankton relationships in the Little Manatee, Alafia, and Peace Rivers.

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.

		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

The Alafia and Peace have the more typical pattern of high chlorophyll *a* concentrations at the 6 and 12 psu zones, while the Little Manatee frequently has its highest values near the freshwater/brackish water interface. This is likely due to comparatively longer residence times in the braided reach of the river which allows phytoplankton blooms to develop. The effects of changes on freshwater inflows on excessive phytoplankton blooms can be an important factor to consider in minimum flows analyses, as was done for the Lower Alafia. I think we are okay on the Little Manatee in that regard, but the three reports that Dr. Vargo prepared for the District need to be cited and briefly summarized in the minimum flows report.*

The citation and summaries of these and a few other reports can be very brief, one or two paragraphs with a figure or table. These concise and informative summaries will improve the public and technical community's understanding of the freshwater inflow relationships of the Little Manatee River and better support the technical justification of the minimum flows.

Assessment of separate thresholds for flow-based blocks for the freshwater and estuarine sections of the Little Manatee River

I want to change topics now and discuss the use of flow-based blocks in the District report. I strongly support the use of flow-based blocks, but they probably should be identified separately for the freshwater and estuarine reaches of the river. For most rivers, the District has previously produced separate reports for the freshwater and estuarine reaches of each river using different analytical methods, such as for the Alafia, Peace and Myakka Rivers. For many

* **The District report cites a paper by Vargo et al. (1991) in the Proceedings of the BASIS 2 Symposium, but the reports for the District provide other valuable findings with the third report completed after BASIS 2.**

years the District used a seasonal block approach for the freshwater rivers, with three seasonal blocks corresponding to low, medium, and high flows. For example, if it was February, you assumed flows were in the medium range and you applied the minimum flow percentages for that time of year.

On page 103 the District report makes a good case that this method has serious limitations, for flows in any season can be above or below the expected seasonal flow range for prolonged periods of time. A much simpler and more direct way to avoid this is to use flow-based blocks, in which minimum flow percentages are defined for different flow ranges, an approach which the District has recommended for the Little Manatee, which I strongly support.

Flow based minimum flows have previously been determined by the District for estuarine rivers, such as the Lower Pithlachascotee and the Lower Peace. In these rivers, the relationships of variables to freshwater inflow within the estuary were examined to determine ranges of flows where different percent withdrawal limits should be applied. Combined with a low flow cutoff, this is a very effective way to largely preserve natural flow characteristics, protect the estuary from significant harm, and make water proportionately more available as flows increase.

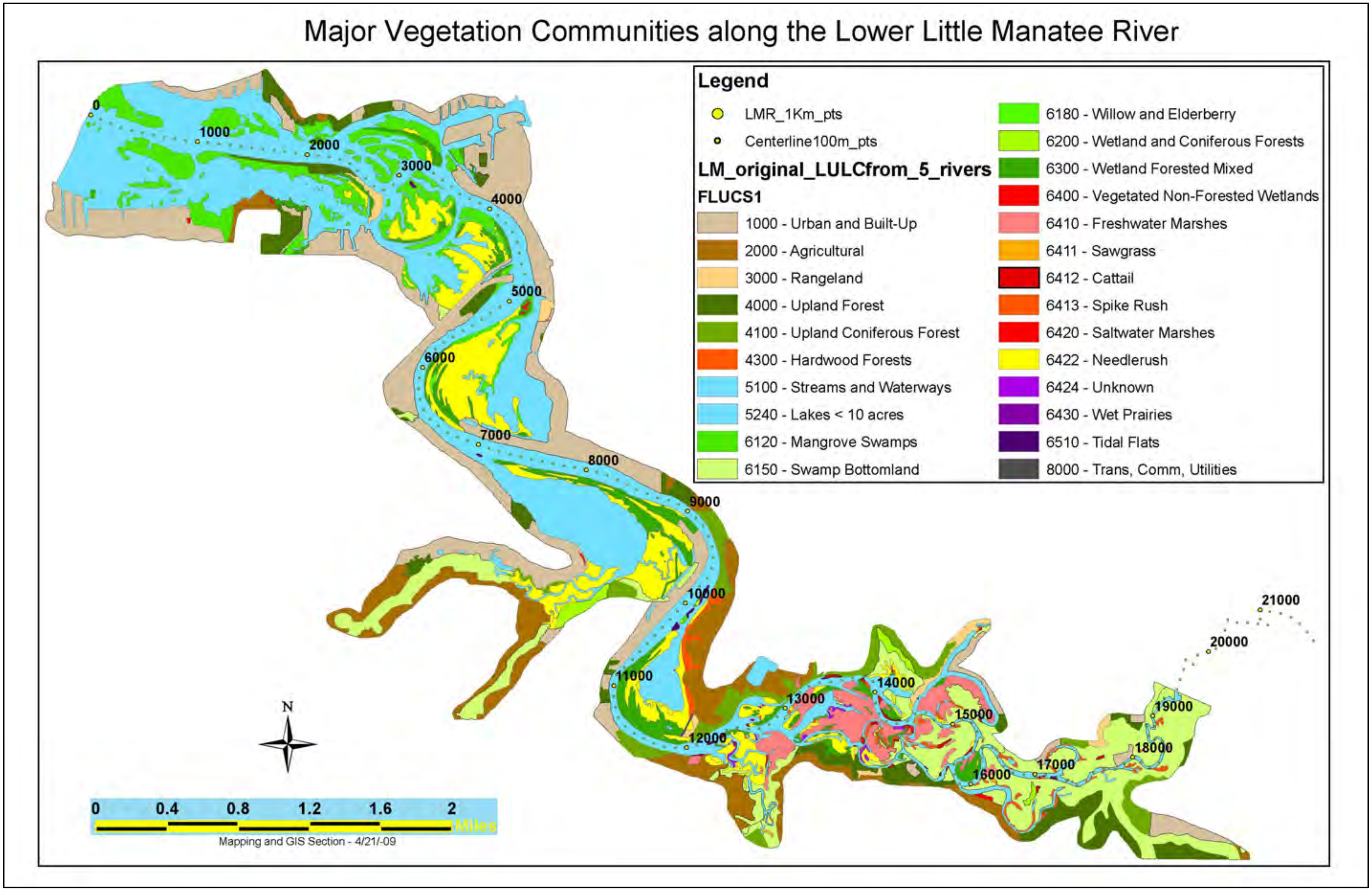
The problem with the Little Manatee River report is that flow thresholds of 35 and 72 cfs were based solely on environmental analyses of the freshwater reach of the river. These flow thresholds are then applied to the estuarine reach of lower river as well. This is a first, as the District has never done this before, and it is probably not the best approach.

As was done for the Lower Pithlachascotee and Lower Peace Rivers, the response of key variables in the estuary to freshwater inflows should be examined separately for a series of flow ranges. Flow thresholds can then be identified to switch percent allowable flow reductions. Practical and ecologically effective flow thresholds for the estuarine portion of the Little Manatee might be similar to the flow thresholds identified for the freshwater reach, but you don’t know until you analyze the data in that manner.

If necessary, the application of separate thresholds for flow-based blocks for the freshwater and estuarine reaches of a rivers is very feasible from a management perspective and can easily be applied, especially on a small river like the Little Manatee.

I recommend the District conduct further analyses to examine the response of low salinity zones and the environmental favorability functions for fishes in the lower river to freshwater inflow, and determine if separate thresholds for flow-based blocks in the estuarine section of the Little Manatee River are needed. The Lower Little Manatee River is an Outstanding Florida Water, an Aquatic Preserve, and is the jewel of tidal rivers flowing to Tampa Bay. It warrants a high degree of protection and the best analyses possible.

Three slides begin on the following page


Major Vegetation Communities along the Lower Little Manatee River
Legend
LMR_1Km_pts
Centerline100m_pts
LM_original_LULCfrom_5_rivers
FLUCS1
1000 - Urban and Built-Up
2000 - Agricultural
3000 - Rangeland
4000 - Upland Forest
4100 - Upland Coniferous Forest
4300 - Hardwood Forests
5100 - Streams and Waterways
5240 - Lakes < 10 acres
6120 - Mangrove Swamps
6150 - Swamp Bottomland
6180 - Willow and Elderberry
6200 - Wetland and Coniferous Forests
6300 - Wetland Forested Mixed
6400 - Vegetated Non-Forested Wetlands
6410 - Freshwater Marshes
6411 - Sawgrass
6412 - Cattail
6413 - Spike Rush
6420 - Saltwater Marshes
6422 - Needlerush
6424 - Unknown
6430 - Wet Prairies
6510 - Tidal Flats
8000 - Trans, Comm, Utilities
0
1000
2000
3000
4000
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7000
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Mapping and GIS Section - 4/21/-09

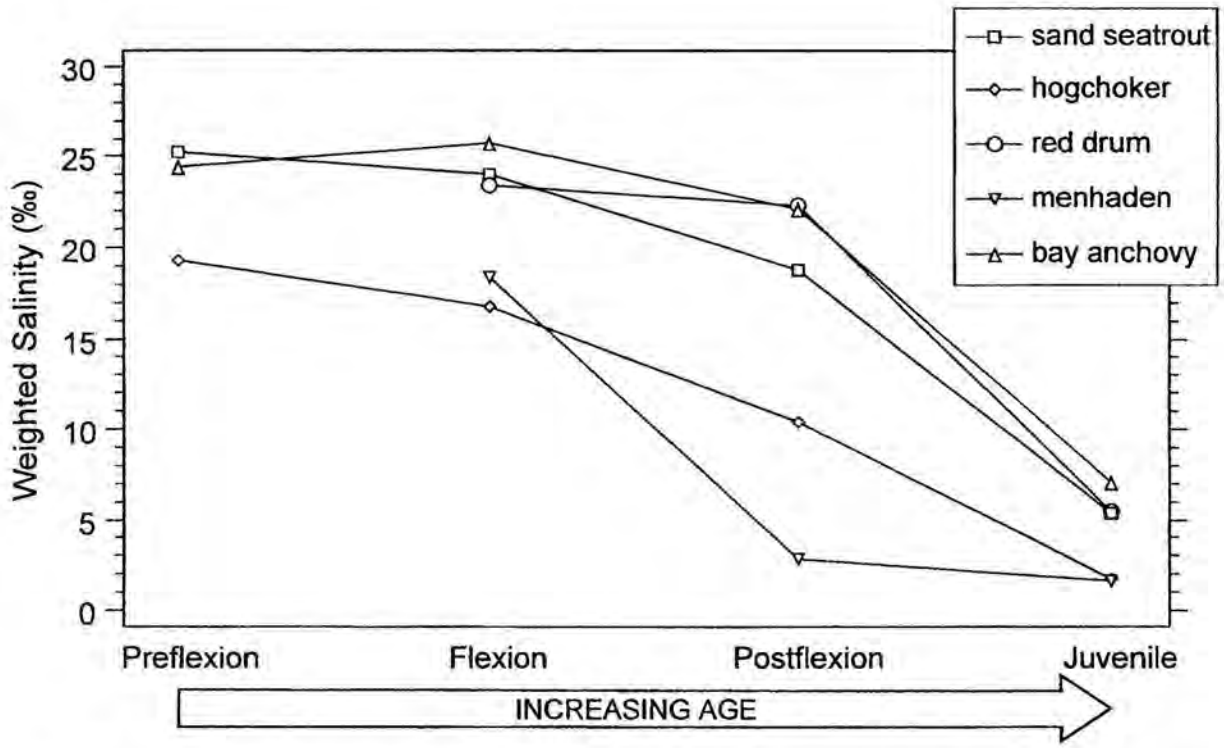


Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

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.

		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

Technical review of the description and analysis of the freshwater flow regime of the Little Manatee River presented in the 2021 SWFWMD minimum flows report

Submitted by Sid Flannery, October 14, 2021

The comments contained in this document pertain to the characterization of the freshwater flow regime of the Little Manatee River presented in the current draft minimum flows report for the river. Some of the comments pertain to the discussion of factors that can affect those flows such as land and water use, climate, and permitted surface water withdrawals and discharges. In a week or two, I will submit additional comments related to the response of various biological and water quality variables in the estuarine portion of the river to freshwater inflow.

In the meantime, the comments below are intended to clarify and enhance the material presented in the District's draft minimum flows report so that readers have a better understanding of the flow regime of the Little Manatee River and how it is related to the ecological characteristics of the river and the potential effects of the proposed minimum flows.

The primary consultant, Janicki Environmental Inc. (JEI), has a done a very good job in justifying the use of flow-based blocks, which I strongly support. Also, the method they developed to adjust the gaged flows to develop a baseline flow record is very good and better than the method presented in the first minimum flow report (Hood et al. 2011).

I realize the District wants to produce minimum flows reports that are concise, but for some topics (e.g., the Florida Power and Light withdrawals), I think the hydrologic characterizations presented in the first minimum flows report are more informative than the material presented in the current report. I suggest the review panel read pages 4-1 and 4-6 to 4-32 to in the first minimum flows report. That report is provided as Appendix A with the current minimum flow report, and possibly in some cases the current report could say something like "See Appendix A for further details on …..". In that regard, I preface some my suggested edits with "At a minimum" and suggest the current report make reference to material presented in the first report. I don't think that is the best solution, but the District could go that route on some items to direct readers to the first minimum flows report for more information on a certain topic.

Organization

In several other minimum flows reports including the Lower Alafia, the Pithlachascotee and the Lower Myakka, the section on the baseline flow adjustment was in the same chapter as the hydrologic characterization, which flowed nicely as the baseline adjustment was described after the presentation of historic trends in rainfall, flows, and anthropogenic factors.

On the other hand, in the current report rainfall and flows are discussed in Chapter 2, while the flow blocks and generation of the baseline flow record are in Chapter 5, as was done for the Lower Peace River minimum flows report. I found this a bit hard to follow, but it is workable and suitable the District did it that way. However, for understanding the potential ecological changes that can result from applying the percent-of-flow method, it is helpful to see some other basic

hydrologic data reductions such as a bar graph of average monthly flows and a flow duration curve of baseline and observed flows. Some suggestions in that regard are presented below, along with other edits to the parts of the report that deal the freshwater flow regime of the river. Another day I will submit comments pertaining to the estuarine results presented in the report.

Suggested edits

Page (P) 18, Lines (L) 4 to 5. This sentence could shortened and slightly revised to read "Compared to other rivers in the region, flow in the Little Manatee watershed has a relatively high mean runoff rate normalized by contributing area. See page 4-10 in the previous minimum flows report (Apppendix A), where average areal based runoff rates for the Little Manatee are listed along with values for five other rivers."

Regarding the second half of this same sentence on page 18, I don't think the Little Manatee has a moderate to high baseflow fraction compared to other rivers such as the Hillsborough, Alafia and Withlacoochee, which all receive some springflow and other flow from the upper Floridan aquifer.

For example, from the minimum flows report for the Lower Alafia River, which is located about 14 miles north of the Little Manatee, the 10th percentile flow of the Alafia is 16.2% of its mean flow. If flows from Lithia and Buckhorn Springs are added to the gaged flows, the 10th percentile flow for the Alafia is 21.9% of its mean flow. In contrast, the 10th percentile flow for gaged flows on Little Manatee for 1996 to 2019 period (24 cfs) listed on page 144 in the current report is 14.4% of the mean flow (167 cfs) for that period.

Keep in mind the baseflow in the gaged record of the Little Manatee has been supplemented by excess agriculture irrigation water and the mean flow I just cited was not corrected for withdrawals from Florida Power and Light. So, the baseflow fraction for natural flows corrected for agricultural flows and FP&L withdrawals would be even lower. Therefore, I would not characterize the Little Manatee has having a moderate to high baseflow fraction. Simply drop that part of the sentence, which will agree better with the statement two sentences later about flows in the river having spiky behavior and low relatively low surface storage, which is accurate.

P28 – 30. I have reservations about over postulating about the effects of the Atlantic Multidecadal Oscillation (AMO). In the more recent warm AMO period (Figure 2-12), which is supposed to result in more rainfall, some of the worst multi-year droughts in the region occurred, including the year 2000 and early 2001 and an eight-year period from 2006 to 2013 when yearly rainfall was below normal for seven years (Figure 2-14). The report says there is not a lot of surface or surficial aquifer storage in the Little Manatee River basin and it responds quickly to rainfall events. In that regard, the time series graph of moving 20 -year average rainfall does not have as much to do with variations in flows the Little Manatee River as it might with rivers with more surface and groundwater storage like Pithlachascotee or the Withlacoochee. A moving average yearly rainfall hydrograph of shorter length would be more appropriate for comparison to flow trends in the Little Manatee. The previous minimum flows report used a moving three-year average rainfall hydrograph (Figure 4-4 on page 4-6).

P38 Section 2.5 (Little Manatee River Flow History) This section of the current report starts off describing the effect of agriculture on past flows, then follows with two short paragraphs and four hydrographs about the gaged flow record, then turns to a discussion of groundwater flow modeling. I suggest it would be better to start of with a description of the flow record and present the hydrographs and discuss the temporal patterns shown in them, then switch to possible causative factors including the groundwater modeling discussion.

P39. Figure 2-24. This figure plots average yearly flows on a semi-log scale with a fitted polynomial trend line. The range of yearly flows appears to be from about 40 to 400 cfs, which should plot fine on an arithmetic scale and would give the readers a better sense of the natural variation in yearly flows. If the polynomial trend was fitted to log transformed data, the current hydrograph could also be shown, but I think would be helpful to also show the flows on an arithmetic scale (see page 4-1 in the previous minimum flow report).

Monthly flows are plotted on a semi-log scale in Figure 2-25, which is helpful as there is much greater range in values. The report says there appears to be no significant long-term trend in monthly flows, but the occurrence of low monthly flows prior to the mid-1970s seems apparent, which is supported by other findings presented in the report. The report does suggest there appears to be a slight increasing trend in dry season flows (October to May), but not wet season flows. As with Figure 2-24, the time series plots of yearly average dry and set season flows on an arithmetic scale would be valuable.

Though the data end in the year 2010, there are very informative hydrographs and trend tests presented in previous minimum flows report by Hood et al. 2011. Having worked in estuarine ecology, I think the eight-month October to May dry season discussed in the current report is too broad for some ecological applications, and examining trends in other flow parameters can be meaningful from a resource management perspective. On pages 4-22 to 4-29, the previous minimum flows report showed some interesting results for trend tests and hydrographs for various yearly percentile flows, which clearly show a rise in values for the yearly 10th, 25th, and 50th percentile flows starting in the mid-1970s. As concluded in the current report, the previous report found no significant change in the higher flows. However, trend tests on monthly flows showed an increase for the dry season months of November, December, April and May. The previous report also showed hydrographs and trend results for moving average flows for various durations from 3 to 120 days, which clearly showed significant increases in their yearly minimum values (e.g, the lowest 60-day moving average flow within each year).

Frankly, I think it would be valuable to repeat such graphical and trend analyses for key flow parameters in the current report and see what the updated results look like, but will defer to the District. However, at a minimum, the current report should at least refer to some of the findings in the previous report, acknowledging the flow data end in 2010.

In the discussion of the effects of agriculture on flows in the river, the current District report should cite and briefly mention the paper by Flannery et al. (1991). I am not saying this to see my name in lights, but rather this was a very large effort that was funded by grants the District received from the Florida Department of Environmental Protection that involved the District, the University of South Florida, the USGS, and land use mapping specialists from the Florida Marine Research Institute. The USGS installed three new streamflow gages in the watershed and baseflow and runoff rates were compared from six sub-basins. Extensive water quality monitoring was conducted and nutrient loading rates were compared from these sub-basins. Water quality sampling of 21 sites was also conducted in May 1988 and May 1990, which showed where mineralized water of groundwater origin was entering the river.

The current report can qualify that these data were collected when the quantities of excess agricultural water entering the river was near maximum. On page 4-31, the previous District report has a very short paragraph about this study, and in a previous section described that since that report was produced there have been improvements in agricultural water use practices and a reduction in excess irrigation water entering the streams. The current District report provides a good summary of changes in land use and water use efficiency and the plot of residuals from the baseline flow analysis (Figure 5-2 on page 105) is very effective. Overall, the findings of the watershed assessment in the late 1980s supports the District's findings and that paper (Flannery et al. 1991) should be cited and quickly summarized in a short paragraph in the current report. A pdf of that paper is submitted along with this review.

Florida Power and Light

Because they utilize an off-stream reservoir and have long used withdrawal schedules linked flow rates, the FP&L facility has been an example of progressive water resource management. Along with the Peace and Alafia Rivers, ecological results and management applications from the Little Manatee River are featured in the 2002 journal article about the percent-of-flow method (Flannery et al, 2002), which is also submitted with this review.

Having said that, the withdrawal schedule that FP&L now uses will have to be revised to comply with the proposed minimum flows, and the description of their withdrawal schedule in the previous minimum flows report is much more informative than the discussion in the current report. In particular, the frequency that the emergency withdrawal schedule has been used and the quantities that were withdrawn from the river is well described in the previous minimum flows report. Again, the District could update and enhance the discussion of the FP&L withdrawals in the current report, or at a minimum, refer to the previous report (Appendix A) which provides a history of the changes in the diversion schedule and the frequency of use for the emergency schedule, acknowledging those data end in 2009.

At a minimum, the District needs to support their statement on page 44 that FP&L withdrawals have been less in recent years. The previous report listed an average water withdrawal by FP&L of 9.1 cfs for the 1976-2009 period, pointing out that includes the initial filling of the

reservoir. The previous report also mentioned this average withdrawal rate was largely driven by the diversion of high flows, as no withdrawals occurred on 71 percent of the days during that period. The District could easily characterize diversions by FPL during recent years, and at an absolute minimum, report an average diversion value for 2010 to 2020.

I was very involved in the re-evaluation and the revision of the FP&L withdrawal schedule, and toward the end of this peer review process, will offer some thoughts on further revision of their schedule to comply with the minimum flows. As a sneak preview, I think it would ecologically counter-productive to restrict FP&L to the 13% and 11% allowable freshwater flow reductions at flows in block 3. Reasons will be presented later, but if the final percent allowable reduction for estuarine minimum flows is greater at high flows, that is what FP&L should be regulated on. Tentative for now, but should be the way to go.

Mosaic land use and diversions

On page 44, the current report has a short paragraph about the permitted discharge by Mosaic Company for their phosphate mining operations and cites a report from 2012 (FDEP, 2012) to support the statement that the discharge has been limited for several years. Clearly, any characterization of discharges from the D-001 outfall needs to be updated.

As with FP&L, a good description of Mosaic's land use and hydrographs and characterization of the discharges for 1996 to 2009 is provided in the previous District report (pages 4-18 to 4-22). That report described why it would be difficult to create a baseline flow record adjusted for these discharges, so that was not done as part of that study. On page 4-20, the previous report shows an excellent map that showed the status of various categories of the Mosaic Company's lands (e.g., mined, reclaimed, preserved) and described the status of these land use categories and the percentages of the river watershed they represented.

In Section 2.2, the current District report generally characterizes extractive land covers, but provides no information on the status of those lands, such as what is currently and previously mined, reclaimed, preserved, or other. The land use maps that are shown have Extractive land use included as part of Urban and Built-Up, but Table 2-1 has the acreages of Extractive separately quantified over time. The previous District report states that Mosaic owns 26% of the Little Manatee River watershed. Given that a quarter of the watershed is owned by a phosphate mining company, it would improve the current District report to provide a more comprehensive update on the status of Mosaic's land holdings and the projections for future mining.

The District could cite the section on phosphate mining in the previous minimum flows report, but qualify that those results and projections are out of date and may no longer apply. At a minimum, the District needs to access the discharge records for the D-001 outfall and present an updated hydrograph and statistics for those discharges.

Nitrogen trends

In Section 3.3.2 (pages 54-56) the current report presents information on concentrations and trends for various forms of nitrogen measured by the Environmental Protection Commission of Hillsborough County (EPCHC). With the exception of organic nitrogen at freshwater station 113 at the Highway 301 bridge, concentrations were either decreasing or showed no trend. These results are encouraging, and it is good that the tidal section of the Little Manatee River has very little hypoxia (low dissolved oxygen concentrations). With regard to chlorophyll *a*, concentrations generally do not indicate impairment, but as will be discussed in the next review I submit, there are periodically very high chlorophyll *a* concentrations in the upper reaches of the tidal river and the potential effects of flow reductions need to be examined further. But that is for another day.

For now, I think it would be useful for the minimum flows to very briefly point out while that nitrogen concentrations have generally been either decreasing or non-trending in recent years, water in the Little Manatee River is nitrogen enriched compared to decades prior to the 1970s. Historical data presented as part of the late 1980s watershed assessment (Flannery et al. 1991) found that nitrate-nitrite concentrations have increased greatly since the mid-1970s, which corresponds to the increase in agricultural land use. The previous minimum flows report also reported an increase in nitrate-nitrite concentrations measured by the USGS, but the data ended in 1999 (pages 5-4 and 5-5). Increases in specific conductance, which are shown in Figure 12 in Flannery et al. (1991) and Figure 4-23 in the previous minimum flows report, show this same temporal trend, indicating the effect of agricultural land and water use on the river.

Also, during the 1988-1989 study period, the phosphate mining operations were largely inactive and the Ft. Lonesome station in the river upper river sub-basin served somewhat as a control site. Nitrogen concentrations and loading rates from that sub-basin were much less than from downstream sub-basins where there was much more agriculture. The point of this is the current minimum flows report could have one or two sentences that say that although nitrogen has been non-trending or decreasing in recent years, historical data indicate the the river is nitrogen enriched compared to before the 1970s (Flannery et al. 1991, Hood et al. 2011)

P 103 – **Excess flows and adjustment of the baseline flow record**.

The consultant (JEI) did a very nice job on the method for adjusting the gaged flows to develop a baseline flow record, which was an improvement over the method used in the previous District report. However, it is interesting the previous peer review panel did not criticize the method for adjusting the baseline record in the first minimum flows report, but they waxed at length about the use of benchmark flow periods. Regardless, the current method for adjusting the gaged flow to come up with baseline flows is very useful and the plot of residuals and the LOESS curve plotted in Figure 5-2 (page 105) is very informative. Also, with regard to benchmark flows issue, that is handled well in Section 6.5 in the current report in which the estuarine fish habitat analyses were conducted over four different multi-year periods.

Figure 5-3 on page 106 in the current District report is interesting in that there are large increases in excess flows during July to September, when irrigation rates are small or not occurring. This likely occurs because the excess irrigation raises water levels in the surficial aquifer, which can persist into the wet season and increase runoff potential. Also, the change from more natural land covers to agriculture can result in greater runoff from rainfall events.

In Figure 5-3 (page 106) the current District report cites the Lower Myakka River minimum flows report (Flannery et al. 2007). However, all the work on the excess flows was done by Interflow Engineering, which was presented and cited in the District's Lower Myakka River report. The current Little Manatee report should cite their work, such as Interflow Engineering LLC (2008 or 2009). Panel member Dr. Loper who conducted that work, can review the District's Lower Myakka minimum flows report and conclude which of the three references for Interflow Engineering cited therein should be used.

Also, the caption for the figure should say agricultural excess flows in the Myakka River, because Interflow also simulated total excess flows from all land use changes. In that regard, since it was based on overall rainfall runoff relationships, the baseline corrections done by Janicki Environmental are for total excess flows, though I suspect the predominant source of the excess flows results from agricultural land and water use.

A few basic graphics of a table to describe the flow regime of the Little Manatee River

The current report could benefit from presenting a few simple graphics and a table to describe the basic streamflow characteristics of the Little Manatee River. Such hydrologic information is important for not only understanding the seasonal and flow duration characteristics of the river, but also for understanding how application of the minimum flows will affect the ecology the river.

A plot of average monthly flows needs to be included to characterize the seasonal flow characteristics of the river. Two figures from page 4-12 in the previous minimum flows report are presented on the following page. This should be updated for the current report. Obviously, the yellow line in the second figure mimics the average monthly flows in the top graphic, but it is helpful to demonstrate how flows are lagged with regard to seasonal rainfall during some months of the year.

Also, as previously described, the Little Manatee River has a relatively high rate of basin runoff, a spikey response to rainfall events, and a relatively low rate of baseflow. These flow characteristics are manifested in the graphs on the following page where the difference in average monthly flows between the spring dry season and late summer flows is among the highest in the region. As will be described later in this review, the springtime dry season is especially important to the ecology of the freshwater river and the estuary and flow reductions must be managed very carefully during that time of year.

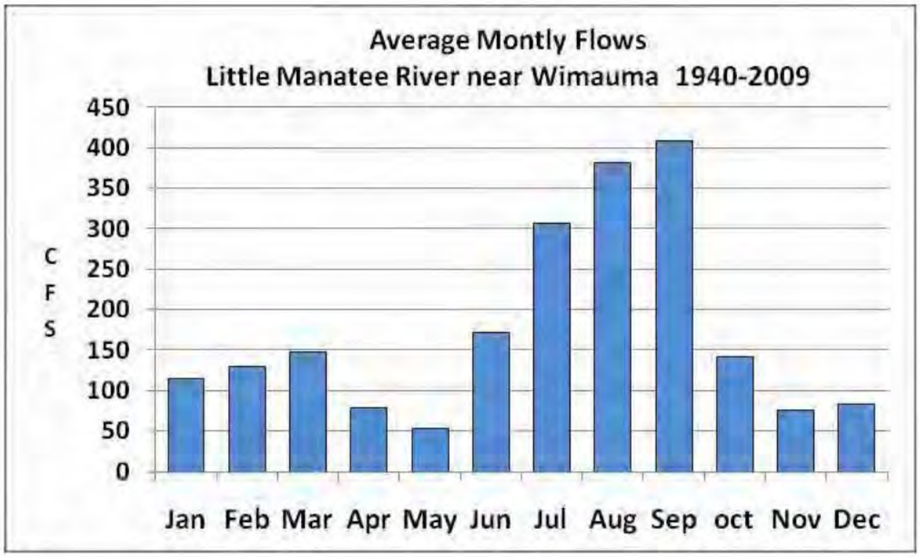


Figure 4-9. Average monthly rates of flow for the Little Manatee River near Wimauma for the years 1940-2009.

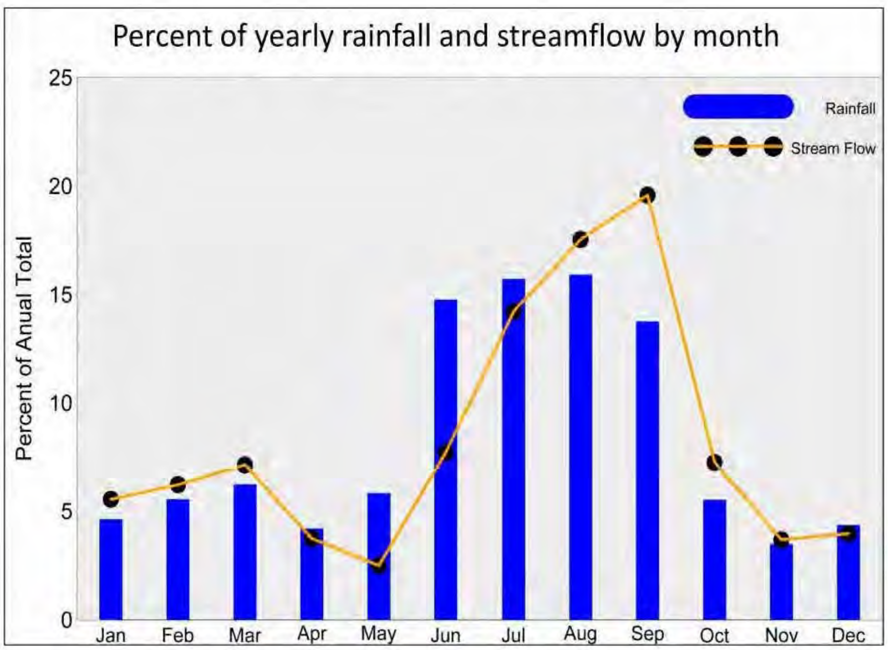


Figure 4-10. The percentage of yearly rainfall and streamflow by month for the Little Manatee River watershed and the LMR Wimauma gage.

4-12

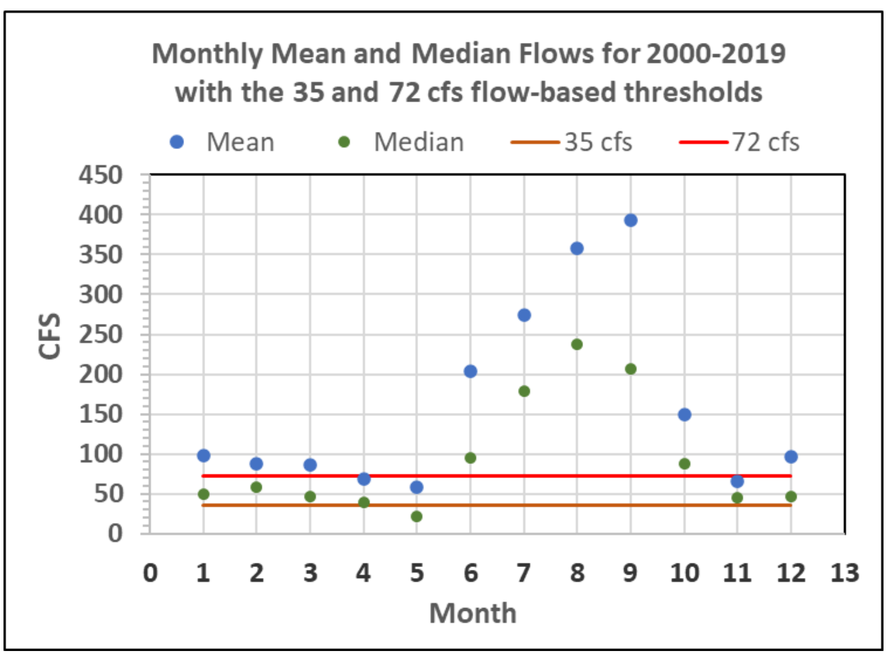
Figures 4-9 and 4-10 from the previous minimum flows report (Hood et al., 2011)

Also, in application of the percent-of-flow method it is very important to understand the seasonal flow duration characteristics of the river, particularly how often the different flow-based blocks will be in effect. In the second paragraph on page 103 the current report states "For reference, 35 cfs is the 34th non-exceedance percentile and 72 cfs is the 60th non-exceedance percentile." This is one of the most important findings in the report, and in general, the amounts of time that flows will be within the various flow-based blocks needs more description and emphasis in the report.

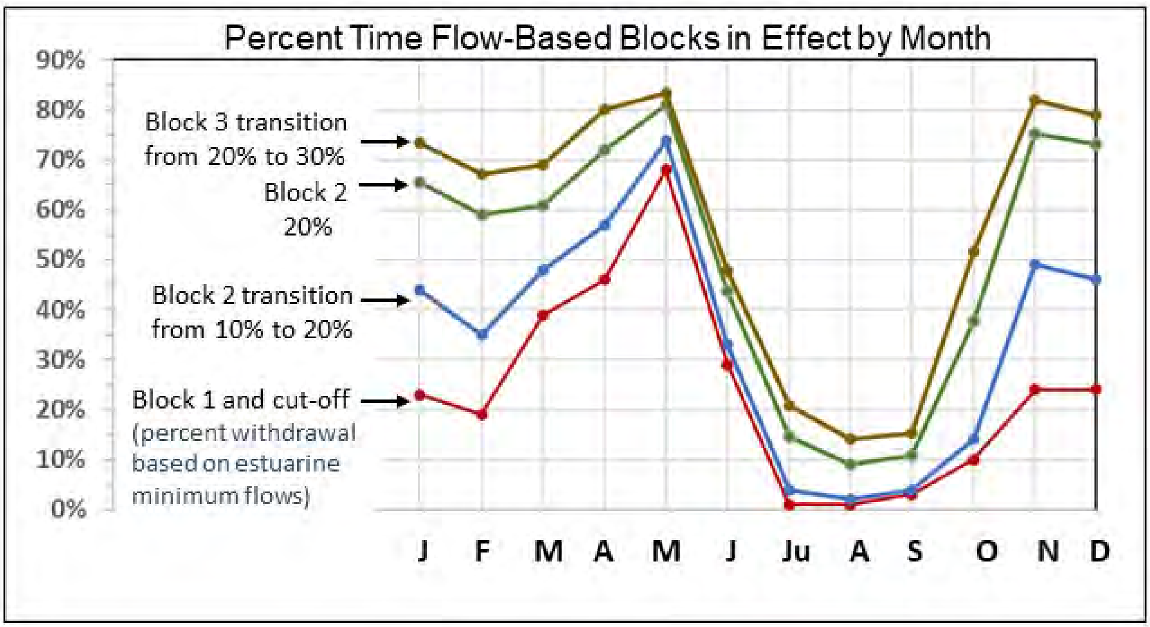
As part of such a description, it would be also helpful to see present a flow duration curve (cumulative distribution function) for the baseline and uncorrected flows for the 1976 to recent period. Both data sets should include corrections for FP&L withdrawals from the river. Also, various percentiles from these two flow records could listed in in a table, as in Table 2 in the first peer review report (Appendix B) or Table 4-2 (page 4-11) in the previous minimum flows report. The current report does show a flow duration curve and some percentile flows for the unadjusted flows at the USGS streamflow gage for four different time periods, but a similar table for baseline and observed flows together would be helpful.

Also, this critical hydrologic information is included in the Sections 5 and 6 of the report. It is probably too late now, but reorganization of the report to put the hydrologic characterization, including the adjustment for baseline flows, in Chapter 2 would be helpful, from where it could be referred to as needed later in the report.

Although flow durations for the entire period of analysis are important, it also useful to see how the flow-based blocks correspond to different seasons in the year. The 35 cfs threshold between blocks 1 and 2 and the 72 cfs threshold between blocks 2 and 3 are show in the figure below along with the average and median flows for each month for a recent 20-year period. It is apparent there are very large differences between months in how frequently flows in the river will be within the different flow-based flows, which has important implications for the ecological effects of the minimum flows.



The figure below shows how often the flow-based blocks would be in effect on a monthly basis. Note that lines are included for the transition between blocks 1 and 2 and between blocks 2 and 3. This is because the full percentage flow reduction for a given block cannot be achieved until flows get to a certain flow rate. For example, using the proposed minimum flows for the estuarine lower river, a 30% flow reduction at 77 cfs in block 3 would result in less flow than a 20% flow reduction at 70 cfs in block 2. Therefore, minimum flows rules typically provide for a transition range between blocks. This operations plan is feasible and is how water user permits for withdrawals from rivers using the percent-of-flow method are currently managed, as the utilities know for each rate of daily flow the amount they can withdraw.



The region below each line is the percent of time that flow reduction, or a lesser flow reduction, will be in effect. For example, in January flows are less than the block 1 cutoff 35 cfs threshold 23 percent of the time. Flows are in the block 2 transition 21 percent of the time, which is the difference between the blue and red lines (44% and 23%, respectively). Full block 2 flow reductions for January will be in effect of 22 percent of the time (66% minus 44%). Flows are fully in block three above the brown line, or 100 percent minus the value of the brown line, which would be 27% of the time (100% – 73%) for January.

Given the large differences in seasonal flows, it is striking how often the different flow blocks will be in effect in the various months. On average, flows are below the 35 cfs low flow cutoff 68% of the time in May, but only 3% of the time in September. Conversely, flows are in block 3 for 85% of the time in September. However, it is emphasized that these are average conditions over 20 years, and flows can be above or below a given threshold for longer periods of time in a specific year.

Seasons are still relevant

As previously described in this review and the document I submitted on October 6th, the District has gone to flow-based blocks for both the freshwater and estuarine reaches of the river. This is a first, for the District has previously used seasonal blocks for freshwater systems.

I support this approach, but emphasize the District continue to consider seasonal factors in their minimum flows analyses. I was not involved in the earlier PHABSIM evaluations of for freshwater systems, but apparently some freshwater fish species have a strong seasonal component to their reproductive cycles and habitat use patterns.

There are also strong seasonal factors in estuaries, with two figures shown below as examples. It has been repeatedly shown in tidal rivers, with and example shown for the Lower Alafia, that the number of larval fish taxa increases rapidly in the spring due to seasonal fish spawning. Based on estuarine considerations, the journal article by Flannery et al. (2002) suggested that flow reductions should be most restrictive in the spring (article submitted with this review). On the other hand, as shown below, the migration of red drum juveniles into the Little Manatee River occurs in the fall and winter (from MacDonald et al. 2007 cited in the current minimum flows report).

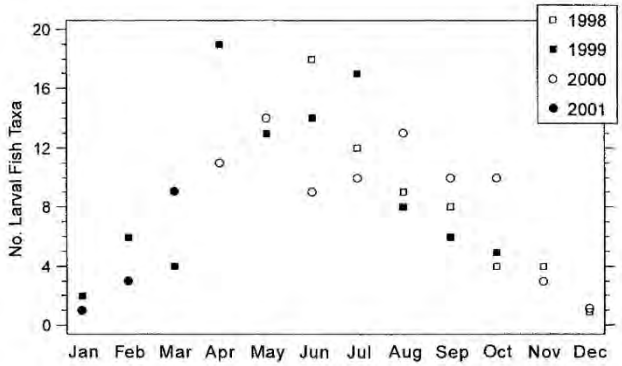
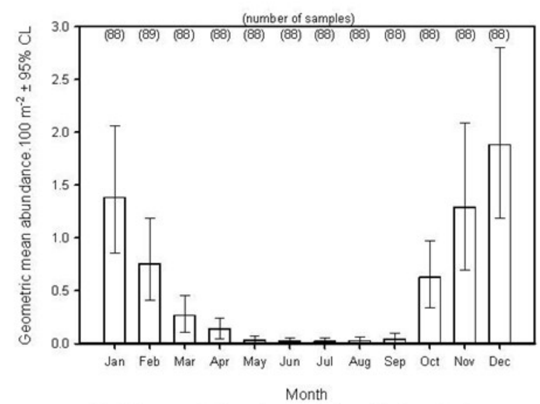


Fig. 9. The seasonal distribution of approximate larval richness in the tidal Alafia River (data from Peebles 2002a).



Red drum, all size classes (primarily juveniles)

Seasonal factors are also important for water quality in estuaries, as hypoxia is often most frequent in the summer during times of high water temperatures. Similarly, low flows and increasing water temperatures often contribute to large phytoplankton blooms in the spring.

All things considered, I think the flow-based approach proposed for the Little Manatee River is appropriate for the tidal portion of the river, in part because using the percent-of-flow method withdrawals in the springtime will be very low. However, as I recommended in the review submitted on October 6th, I strongly recommend that flow-based blocks be evaluated separately for the freshwater and estuarine sections of the river.

I also think the flow-based approach has important advantages for the freshwater section of the river, but I have not worked on the freshwater biological communities in the river and I defer to the District and the review panel. However, for both freshwater and estuarine systems, I suggest the District continue to evaluate seasonal factors and incorporate them in the minimum flows as needed.

Summary Points

- For some topics, the previous minimum flows report is very informative and the current report should refer to it, although it would be better to repeat those analyses or presentations
- It is probably too late, but the report could be reorganized to put the method for baseline flow creation and flow duration characteristics in Chapter 2 with the other hydrologic information
- The differences between seasonal low and high flows in the Little Manatee are among the highest in the region, so it should not be characterized as having moderate to high baseflow
- The discussion of the AMO has less relevance to the Little Manatee than some other rivers
- Chapter 2 should be slightly reorganized to present the flow hydrographs first, then discuss possible causative factors
- Some time series plots of flows on semi-log scale should be changed to an arithmetic scale
- Some of the trend analyses for flow parameters presented in the first minimum flows report should be repeated or as least referred to
- The report should reference the watershed assessment done by the District in the late 1980s as it was a very large effort that supports the District's current findings regarding flows in the river
- The description of Florida Power and Light's withdrawals from the river should be expanded, or at least refer to the previous District report and list an average withdrawal rate since 2010
- The description of the current status of Mosaic Company's land holdings and rates of outfall discharge should be expanded, or least refer to the previous District report and update the discharge records at the outfall
- The report should acknowledge that while water quality trends in recent years are encouraging, the Little Manatee River is nitrogen enriched compared to decades prior to the 1970s
- The report should cite Interflow Engineering regarding excess flows in the Myakka River
- The report should include some graphs of the basic hydrologic characteristics of the Little Manatee and a flow duration curve and table of percentiles for observed and baseline flows.
- The report should describe how often flows will be within the various flow blocks by month or season
- Seasons are important for biological use of both the freshwater and estuarine sections of rivers. The District should continue to evaluate seasonal relationships in their minimum flows analyses and incorporate seasonal factors in proposed minimum flow rules as necessary
- The flow-based blocks seem to work well for the Little Manatee River, in part because the resulting maximum allowable flow reductions will be small in the springtime.
- The District should establish flow-based blocks separately for the freshwater and estuarine sections of the Little Manatee River

Public comments given at second Little Manatee River minimum flows peer review meeting by Sid Flannery, Oct. 20, 2021

As I mentioned at the kickoff meeting two weeks ago, I am a retired Chief Environmental Scientist with the District's minimum flows program where I worked extensively on the Little Manatee River. I have submitted three sets of comments to the District regarding the minimum flows report. The first set of comments were posted 12 days ago, the second two days ago, and the third set today.

Regarding my second set of comments, I think the District could easily improve parts of the report that describe the streamflow characteristics of the Little Manatee to make it more understandable and comparable to the ecological characteristics of the river. For example, for understanding the ecology of the lower river estuary, a useful piece of information is a simple bar graph of average monthly flows, but one does not appear in the report

Also, for assessing both the ecological and water management aspects of minimum flows that are based on the percent-of-flow method, it is very informative to view the flow duration characteristics of a river on a seasonal and monthly basis, and how often the different flow-based blocks would be applied. I have included a couple of graphics of such values in my comments that I think you will find interesting.

My review also points out that the withdrawals by Florida Power and Light and the phosphate mining operations by the Mosaic Company, which are still ongoing, were described in much better detail in the previous minimum flows report. The District should expand the description of phosphate mining in the current minimum flows report and update the discharge records for Mosaic's point source outfall.

I also recommend the District cite, and with one short paragraph, summarize a paper that resulted from a FDEP funded watershed assessment that the District and other agencies performed in the late 1980s, as it provides valuable information that supports the hydrologic results presented in the minimum flows report.

The comments that were uploaded today discuss published biological studies I think the District should cite and briefly describe in the minimum flows report. Even though estuarine minimum flows are sometimes based on the modeling of just a few parameters, it benefits and improves minimum flows reports to describe the other ecological characteristics of a tidal river estuary that are related to freshwater inflow and minimum flows.

There are five informative reports that need to be cited the minimum flows report. For example, a zooplankton study of the lower river was conducted by the University of South Florida. Zooplankton are an important food source for young fish, and they play a critical role in the nursery function that estuaries provide for sport and commercial fisheries. Among other findings, the USF report shows plots of zooplankton density vs. salinity and the rate freshwater inflow, which are obviously relevant to minimum flows.

There are four reports that are cited in minimum flows report that could benefit from a bit more description. For example, on page 78 the report has a single sentence that says a survey of mollusks in river was performed, but does not mention any findings. In the document that was posted today, I've included a graphic from the mollusk report that clearly shows strong spatial partitioning of species along the river's salinity gradient. Also, the mollusk report describes the distribution of oyster reefs in the lower river, which comprise a key biological community whose health is related to the quantity of freshwater inflow.

So, in the document that was uploaded today, I have provided an overview of these reports and provided text, sometimes with a figure or table, the District could include in the minimum flows report to better describe the biological characteristics of the lower river that are related to salinity and freshwater inflows. These findings do not invalidate, but instead provide important justification for minimum flows. The text I have provided is fairly brief and should be fairly easy to incorporate. I also want to point out the Lower Little Manatee Rive is a State of Florida Aquatic Preserve, and it would be very helpful for the minimum flows report to cite and briefly describe valuable biological information that is available for it.

There is one section of my comments that were uploaded today that do not concern biology. Section 5.1 of those comments concerns residence time simulations that were conducted as part of the development of the EFDC hydrodynamic model of the lower river by Drs. Huang and Liu of Florida State University. That residence time work was described in the final project report by Dr. Huang and needs to be mentioned* in the minimum flows report. Residence time is directly related to rate of freshwater inflow, and as demonstrated by model simulations and analyses that Xinjian and I conducted on the Lower Alafia River, changes in residence time can affect water quality in tidal rivers.

So, that concludes my verbal comments for today. Next week I will speak to the need to develop flow thresholds for switching between low, medium, and high flow blocks separately for the freshwater and estuarine sections of the river. That topic was discussed in my first comments that were uploaded 12 days ago, so please consult that document for an overview of that topic.

* On page 125, residence time is mentioned in a sentence with two other objectives the FSU project addressed with the EFDC model, but a brief discussion of the residence time work is needed

Overview of selected technical reports about the Little Manatee River and suggested text, figures, or tables for the District's minimum flows report

Prepared by Sid Flannery, October 19, 2021

This document provides an overview of technical reports about the Lower Little Manatee River that were prepared for the District by staff from the State University System, the Florida Marine Research Institute, or Mote Marine Laboratory. I have also prepared paragraphs or single pages of text that include a figure or table that can be inserted into the minimum flows report to present findings from these reports that describe important relationships of the lower river to freshwater inflows.

These findings support the technical basis for the recommended minimum flows and provide valuable information on the physical, chemical and biological characteristics of the Little Manatee River. As described in the 2002 paper in the journal *Estuaries*, the Little Manatee was one of the three rivers on which the development of the percent-of-flow approach for minimum flows was initially based (Flannery et al. 2002). Furthermore, the tidal reach of the Little Manatee River is a State of Florida Aquatic Preserve and one of the most valued natural resources in the Tampa Bay region. As such, it would be beneficial for the report to briefly describe its biological characteristics, especially as they relate to freshwater inflows that will be affected by the proposed minimum flow rules.

1.1 Overview of Phytoplankton Reports

Dr. Gabriel Vargo of the USF College of Marine Science published two reports for the District about phytoplankton related parameters in the Little Manatee River based on just over two years of sampling from December 1987 to January 2000 (Vargo, 1989, 1991). In a separate report, he compared these data to phytoplankton related data collected from the Lower Peace and Alafia Rivers that used a similar salinity based sampling design (Vargo et al. 2004). None of these three reports are currently cited in the draft minimum flows report, but it does cite a paper that Dr. Vargo submitted to the proceedings of the BASIS 2 conference (Vargo et al. 1991).

Combined, these three reports are very informative about the relationships of different salinity zones to phytoplankton related parameters in tidal rivers, particularly the unusual characteristic of the Little Manatee in which the highest phytoplankton counts and chlorophyll *a* concentrations typically occur at the interface of fresh and brackish waters (0.5 psu), compared to other rivers where the highest phytoplankton counts and chlorophyll *a* concentrations typically occur in mesohaline waters.

In a week or so, I will present data that indicate that relationships of chlorophyll *a* to the rate of freshwater inflow and residence time in the lower river could be important to determining flow thresholds to switch between low, medium, and high minimum flow blocks for the estuarine section of the Little Manatee.

References for the three phytoplankton reports are below, including brief overviews of that work. This is followed text on page 4 that I suggest be inserted into the minimum flows report regarding the phytoplankton work on the Little Manatee River.

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

> Nutrients, chlorophyll *a*, and primary production were monitored on a bi-weekly basis for one year at four moving salinity based stations in the Little Manatee River and two fixed location stations; one near the mouth of the river in Tampa Bay and one in Ruskin Inlet, an urbanized inlet to the middle reaches of the Little Manatee River estuary. Among the salinity based stations, mean chlorophyll *a* and primary production rates were greatest at the 0.5 psu station and lowest at the 18 psu station. The Little Manatee has very low N:P rations due to high inorganic phosphorus concentrations in the river water.

Vargo, G.A. 1991. Phytoplankton studies in the Little Manatee River and Tampa Bay: Species Composition, Size Fractionated Chlorophyll, Primary Production, and Nitrogen Enrichment Studies. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> During the second year of a two-year study of phytoplankton populations in the Little Manatee River and adjacent waters of Tampa Bay, nutrients, size fractionated values for chlorophyll *a* and primary production rates were monitored monthly at a moving 12 psu salinity station in the river and a fixed location station in Tampa Bay. Phytoplankton populations were found to be nutrient sufficient or borderline nitrogen limited with respect to short-term photosynthesis, but long-term growth and biomass were clearly nitrogen limited based on bioassays of natural populations.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> Phytoplankton populations, nutrients and chlorophyll *a* concentrations were compared from similar, salinity based sampling designs in the Lower Alafia, Peace, and Little Manatee Rivers. Samples were collected on at least a monthly basis at the locations 0.5, 6, 12, and 18 psu surface salinity values in each river, with exception of the location of 20 psu being sampled in the Peace River. Mean phytoplankton counts were highest at the 12 psu station in the Alafia, the 6 psu station in the Peace, and the 0.5 psu station in the Little Manatee (see figure on next page). Phytoplankton counts were frequently an order of magnitude higher in the Alafia compared to the other rivers, presumably due to high nutrient loading from that watershed. In the figure on the next page, note separate axis for the Alafia River, which is an order of magnitude greater.

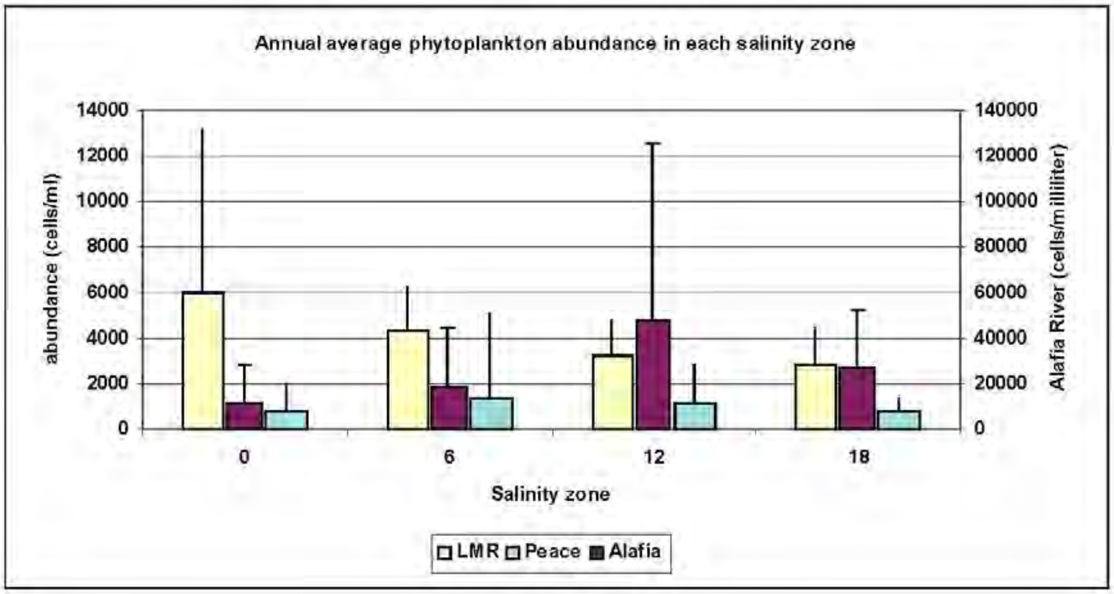


Figure X. Annual average phytoplankton abundance in the Little Manatee, Peace, and Alafia Rivers by salinity zone (20 psu for the Peace grouped with 18 psu). The Alafia is shown on a separate axis since the counts are an order of magnitude greater than the other rivers. From Vargo et al. (2004)

Mean values for chlorophyll *a* concentrations during the phytoplankton sampling periods for these rivers are listed on the following page. The much higher chlorophyll concentrations in the Alafia River are apparent, especially in mesohaline waters. Similar to the phytoplankton count data, the pattern for high chlorophyll *a* in the very low salinity zone (0.5 psu) in the Little Manatee River is again apparent, as are the high concentrations in the mesohaline zones for the Peace and Alafia. Although cell counts are higher in the mesohaline zone in the Little Manatee than in the Peace, chlorophyll *a* concentrations were higher in the Peace due to differences in the species composition of the phytoplankton between the rivers.

Comment - I think that differences in residence time for the Little Manatee contribute to it having its highest phytoplankton abundance and chlorophyll *a* concentrations at the 0.5 psu zone. The upper reaches of the Little Manatee are braided, and given the smaller rates of freshwater inflow, water moves more slowly through the tidal freshwater and oligohaline zones of the Little Manatee compared to the other rivers. All of these rivers (Peace, Alafia and Little Manatee) have residence time values that were generated from hydrodynamic model simulations.

Suggested page for phytoplankton. I think the Little Manatee minimum flows report could contain one page that ties the findings from these reports together. As an example, I have prepared three paragraphs and a table on the following page.

1.2 Phytoplankton (suggested text)

Based on just over two years of sampling spanning 1988 and 1989, the University of South Florida College of Marine Science produced two reports describing phytoplankton related parameters in the tidal reaches of the Little Manatee River and a nearby station in Tampa Bay (Vargo 1989, 1991). Data for nutrients, light penetration, chlorophyll *a*, phytoplankton species composition and primary production rates were measured at four moving salinity-based stations in the river and a fixed location station near the mouth of the river in Tampa Bay (Vargo 1989). Nutrient concentrations in the Little Manatee were characterized by very low nitrogen/phosphorus ratios (generally less than 2) due to high phosphorus concentrations in the inflowing river water. The second of these reports concluded that increased nitrogen loading could result in increased algal biomass and eutrophication in the tidal river (Vargo 1991).

In a subsequent report, (Vargo et al. 2004) compared data from the Little Manatee to phytoplankton related data collected in the Lower Peace and Alafia Rivers that were collected using a similar moving salinity-based design. The highest phytoplankton counts and chlorophyll *a* concentrations typically occurred at the interface of fresh and brackish waters (0.5 psu salinity) in the Little Manatee, whereas the highest cell counts and chlorophyll *a* concentrations typically occurred in mesohaline waters (6 and 12 psu salinity) in the Peace and Alafia (Table x). Using a separate data set for the Alafia, Vargo et al. (1991) compared chlorophyll *a* concentrations and primary production rates for the Little Manatee, the Alafia, and a nearby station in Tampa Bay.

Table X. 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

The high chlorophyll *a* concentrations at the freshwater/brackish water interface in the Little Manatee may be related to comparatively long residence times there, which were simulated as part of the development of the hydrodynamic EFDC model for the river (Huang and Liu 2007, Huang et al. 2010, 2011). These comparatively long residence times are related to the braided morphology of the river between kilometers 12 and 16, where the water slows compared to the upstream freshwater reach. These findings and data presented in this report indicate chlorophyll *a* concentrations in the upper reaches of the tidal river could be sensitive to the effects of freshwater flow reductions.

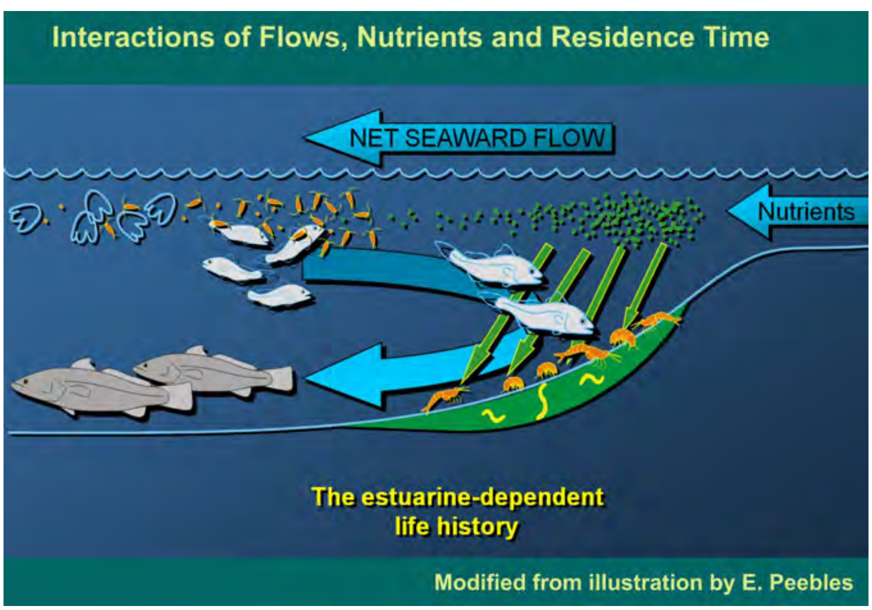
2.1 Overview – Zooplankton Report

Zooplankton were sampled in the estuarine section of the Little Manatee River during 1988 and 1989 concurrently at the same stations as the ichthyoplankton work performed by Dr. Ernst Peebles. Five stations were sampled ranging from the mouth of the river to kilometer 14.2, with another station located at a nearby site in Tampa Bay. The second of these two reports is the more comprehensive of the two and should be briefly described in the District report.

Rast, J.R. and T. L. Hopkins. 1989. The Zooplankton of the Little Manatee River Estuary, Florida. First yearly report. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Rast, J.P., M.E. Flock, T. T. Sutton and T. L. Hopkins. 1991. The Zooplankton of the Little Manatee River Estuary: Species Composition, Distribution, and Relationships with Salinity and Freshwater Discharge. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

In contrast to fish and benthic macroinvertebrate studies, which have been conducted in many rivers, this is the only true zooplankton study in the region's tidal rivers and it is very informative. The second report describes the abundance and distribution of zooplankton, which for many species are more abundant in the lower reaches of the tidal river. Following the tidal river engine concept developed by Peebles (illustration below), this is where the larval stages of many fishes are concentrated early in their life history when they feed on zooplankton. As they grow to juveniles, these fishes migrate to lower salinity waters and feed more on benthic oriented prey. See the illustration below, all evidence I've seen indicates this conceptual model is generally true.



The abundance of zooplankton in higher salinity waters in the lower river probably also results in increased grazing of phytoplankton and contributes to the tendency for chlorophyll *a* concentrations to be lower and more stable near the mouth of the river. Conversely, ungrazed phytoplankton blooms in lower salinity waters probably results in more deposition (see illustration).

The District minimum flows report could briefly summarize the zooplankton study. Along with one table, this would fit on one page and not substantially affect the pagination of the report. Suggested text for a brief discussion of the zooplankton is provided on the following page

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2.2 Zooplankton (Suggested text)

Zooplankton in the Lower Little Manatee River were studied during 1988 and 1989 by the University of South Florida College of Marine Science (Rast et al. 1991). These data were collected concurrently with the ichthyoplankton work in the lower river (Peebles and Flannery, 1992), at the same five locations that ranged from kilometers 0 to 14.2, plus a nearby station in Tampa Bay. This project provides valuable information for the abundance and distribution of major zooplankton groups in the lower river, including; holoplankton (entire life cycle in the water column), meroplankton (in the water column for only a portion of their life cycle), tychoplankton (swept off of the river bottom) and hypoplankton (swim off the bottom for a limited amount of time).

Average values for the abundance and estimated biomass of these zooplankton groups are listed in Table X. Holoplankton and meroplankton had their highest values and biomass near the mouth of the river and Tampa Bay, whereas combined tycho-hypoplankton had highest values in the middle and upper parts of the lower river (year 1 only as two stations were discontinued in year 2).

Table X. Average density (numbers/m3) and biomass (in parentheses as mg dry weight/m3) for total holoplankton, meroplankton and tycho-hypoplankton for 25 trips from 1/29/88 – 1/31/89

	Bay or River Kilometer					
	Tampa Bay	**0.0**	**3.8**	**7.1**	**10.3**	**14.3**
Holoplankton	309,000 (147.7)	235,000 (87.6)	177,000 (44.5)	150,000 (34.4)	84,300 (15.1)	29,700 (5.7)
Meroplankton	40,900 (23.8)	12,000 (6.5)	4,350 (3.9)	3,540 (1.7)	4,220 (3.6)	1,490 (1.0)
Tycho-hypoplankton	1,520 (3.7)	1,290 (3.5)	1,390 (22.6)	5,820 (11.3)	4,590 (12.7)	1,530 (3.1)

Zooplankton are very important prey for the early life stages of many fishes, and their abundance in the river is important to the nursery function provided for many estuarine dependent fish species. Based on 48 total samples, the report by Rast et al. (1991) provided informative plots of zooplankton density versus salinity and the rate of freshwater inflow for eleven dominant species or taxonomic groups (e.g., *Acartia tonsa*, *Oithona colcarva,* copepod nauplii, polychaete larvae).

The numbers and biomass of the major zooplankton groups were were also plotted vs. salinity and freshwater inflow at the five stations in the river and Tampa Bay. The response of the different species or groups to inflow and salinity differed, with the abundance of several taxa or groups associated with the lower part of the river increasing upstream with decreased freshwater inflow. On the other hand, benthic harpacticoid copepods maintained relatively high abundance in the upper river stations except for very high flow events. In general, this project provides very useful information on how zooplankton species and communities respond to changes in salinity and freshwater inflow, which can affect fish nursery use of the lower river and is related to the establishment of minimum flows.

3.1 Overview – Mollusk Report

Dr. Ernest Estevez of Mote Marine Laboratory performed a field intensive survey of the distribution of mollusks in subtidal and intertidal habitats in the Little Manatee River during August 2006. The draft minimum flows report has one sentence on page 78 that cites Estevez (2006) and states this work was performed, but mentions no findings from the study.

The minimum flows report should provide one table and a brief description of the findings of the Mote study for three reasons. First, the mollusk communities show clear gradients with regard to salinity in the river, which supports the District's use of salinity as a parameter for determining the minimum flows. Secondly, the report describes the distribution of oyster bars in the river, which are important for shoreline stability, improving water quality, and creating habitat for reef associated fauna in the tidal river. Lastly, as previously discussed, the Lower Little Manatee River is an aquatic preserve and the District report should describe the biological communities of the lower river, especially as they relate to freshwater inflows and the determination of minimum flows.

Based on mollusk studies conducted within the District, noted invertebrate biologist Dr. Paul Montagna of Texas A&M University was the senior author of the journal article below that assessed the relationship of salinity to the distribution of mollusk species in tidal creeks and rivers in the region. This study can also be cited along with a discussion of the Mote Marine Study.

> Montagna, P. A., E. D. Estevez, T. A. Palmer and M. S. Flannery. 2008. Meta-analysis of the relationship between salinity and molluscs in tidal river estuaries of southwest Florida, U.S.A. *American Malacological Bulletin* 24:101-115.

Two short paragraphs about the Mote study and Montagna et al. findings are provided on the following page, including one figure. I suggest that this text or something similar, including the figure, be included in minimum flows report to enhance the biological information presented for the river and provide additional support of the recommended minimum flows

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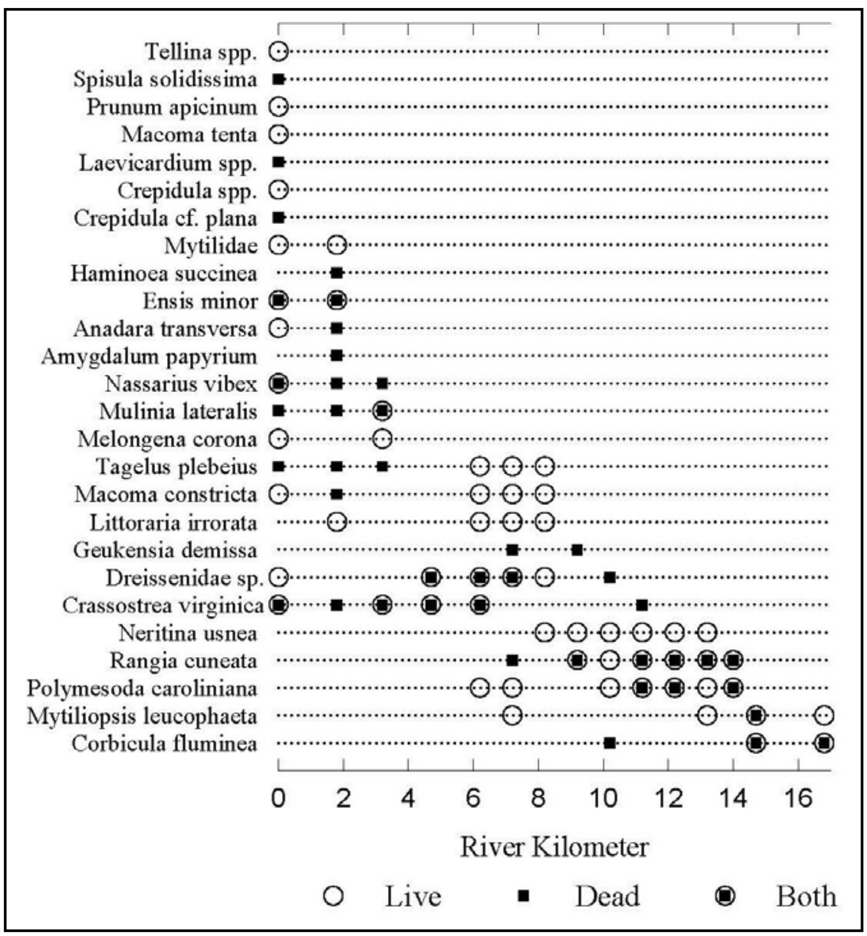
3.2 Mollusks (Suggested Text)

In August of 2006, Dr. Ernest Estevez of Mote Marine Laboratory performed a survey of the distribution of mollusk species in subtidal and intertidal habitats in the Lower Little Manatee River that identified both live mollusks and dead mollusk material (Estevez 2006). Sampling transects were established at 15 locations in the river ranging between river kilometers 0.4 and 16.8 In addition to their presence within the sampling transects, the distribution of oysters in the river was visually described, with large oyster reefs most conspicuous between kilometers 3 and 5 and in the back bays. Smaller oyster reefs with mostly dead material were near the river mouth, with small reefs widely distributed upstream to near kilometer 11, where only dead material was found.

A total of 26 mollusk species or taxa were found (Table x), which is similar to the species richness found using similar methods in other tidal rivers in the District. Mollusk species showed district distributional patterns in relation to salinity gradients in the lower river. In a study of mollusk communities from eleven tidal tributary systems within the District, Montagna et al. (2008) found that salinity was the primary factor affecting the distribution and species composition of mollusk communities.

Figure X. Distribution of mollusk species vs. kilometer in the Little Manatee River, including subtidal and intertidal samples with live mollusks and dead mollusk material, from Estevez (2006).



4.1 Overview – Vegetation in the lower river floodplain.

Section 4.1.2 in the draft minimum flows report describes vegetation communities along the tidal reach of the Lower Little Manatee River. The first sentence in the section says that estuarine conditions extend 15 miles (24 kilometers) upstream from the river mouth, but that is incorrect. Based on extensive field work, Peebles and Flannery (1992) report that brackish waters (>1 psu) typically do not extend farther than 16 to 18 kilometers upstream. Also, as described on page 17 in the minimum flows report, minor tidal fluctuations in water levels can sometimes occur about 1 kilometer upstream of the US 301 bridge, but brackish water does not extend nearly that far.

The description of vegetation communities in the river on pages 69 and 70 in the draft report is pretty good and it references the previous minimum flows report from 2011 (Hood et al. Appendix A). Such a description may be in Hood et al., but I ran out of time and could not find such a discussion in that report which focuses on the freshwater section of the river. However, other reports that can be cited that describe vegetation along the lower river (Peebles and Flannery 1992, Clewell et al. 2002).

Most importantly, vegetation communities along the tidal reach of the Little Manatee River were mapped by the Florida Marine Research Institute (FMRI 1997), with reference the given below. This study focused on five tidal rivers including the Little Manatee. Ground truthing was conducted on the Little Manatee and the report contains a very detailed map of vegetation communities along the river and a discussion of the distribution of plant species and communities.

> Florida Marine Research Institute. 1997. Development of GIS-based vegetation maps for the tidal reaches of five gulf coast rivers. Report prepared by the Florida Department of Environmental Protection Florida Marine Research Institute for the Southwest Florida Water Management District.

I showed a slide of the vegetation map from this project at the kick-off meeting of the peer review panel on October 5th. I strongly recommend the minimum flows report include the FMRI map and the cite the report that produced it, at it is much more detailed than the FLUCCS vegetation map shown in the draft report. In that regard, it better supports the District's recommended minimum flows that are based on the maintenance of low salinity habitats. The aerial photography on which the FMRI map is based was taken in 1990, but from my frequent trips on the river it does not appear that vegetation in this part of the river had changed or been altered significantly since that time.

If the District prefers, it could still include the FLUUCS map shown on page 70, but also present the more detailed FMRI map. The report could qualify that map was based on photography from 1990, but it is unlikely that vegetation in this section of the river has changed significantly since that time. This map is impressive and I suggest it be displayed full page with landscape orientation as shown on the following page. This would follow nicely the discussion on pages 69 to 71 in the draft minimum flows report. That discussion could possibly be slightly improved in a second round of edits, but getting the FMRI map and citation in the minimum flows report is very important, in no small part because he District should highlight the excellent work it has funded.

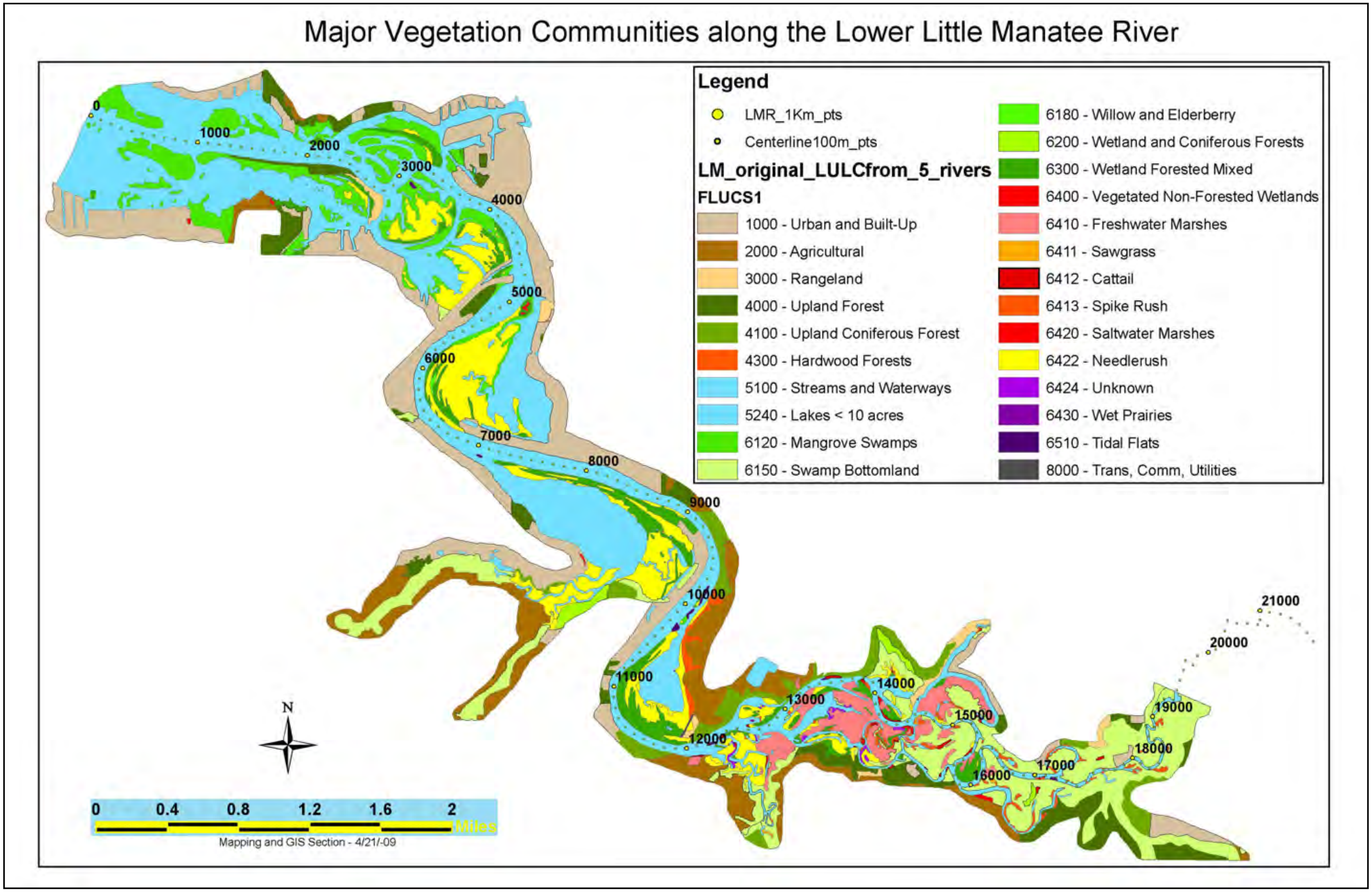


Figure X. Major vegetation communities along the Little Manatee Rive from FMRI (1997), with channel distances in meters.

5.1 Overview - Residence time analyses

In Section 5.4.5 the draft minimum flows report has a good description of EFDC hydrodynamic model for the Lower Little Manatee River that was developed by faculty and staff from FSU (Huang and Liu 2007). As in other tidal rivers (Alafia, Myakka, Lower Peace), model simulations of changes in salinity were a key analytical approach used to determine the minimum flows.

What the minimum flows report does not describe is that this project also included residence time simulations for the lower that were described in the project report (Huang and Liu 2007). This was pursued because the earlier minimum flows analyses for the Lower Alafia River found relationships between residence time (as water age) and very high chlorophyll *a* concentrations in sections of that tidal river. Since then, the District has made a point of having residence time simulations performed for tidal rivers, including the Lower Peace and the Little Manatee.

The project by Huang and Liu simulated residence time as Estuarine Residence Time (ERT) and Pulse Residence Time (PRT), with values of water age at ten locations in the tidal river used to calculate PRT at those locations. Two journal articles concerning residence time in the Little Manatee were also produced from this work (Huang et al. 2020, 2011), for which references are listed below.

Huang, W., X. Liu, X. Chen and M. S. Flannery. 2010. Estimating river flow effects on water ages by hydrodynamic modeling in the Little Manatee River estuary. *Journal of Environmental Fluid Mechanics* 10(1-2):197-211.

Huang, W., X. Liu, X. Chen and M. S. Flannery. 2011. Critical flow for water management in a shallow tidal river based on estuarine residence time. *Water Resources Management* 25(10): 2367-2385.

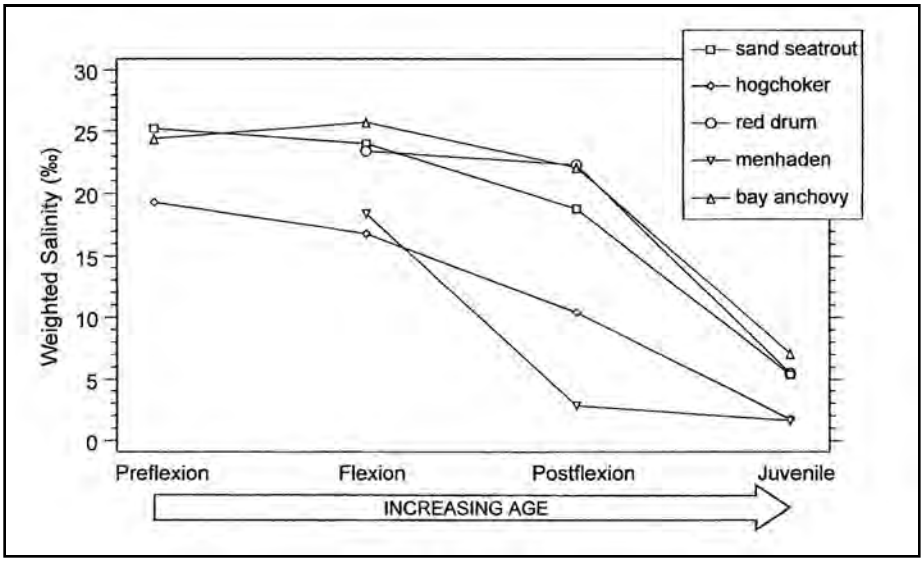
In comments I will submit in a week or so, I will recommend that further analyses be performed to evaluate flow thresholds for switching between low, medium, and high flow blocks specific to the lower river. At present, the thresholds for the flow blocks for the estuarine section of the river were based solely on freshwater analyses, which the District has never done before. This is probably not the best approach and needs to be addressed with additional analyses specific to the lower river.

In that regard, I think that examination of residence time as a function of freshwater inflow needs to be conducted, including evaluating the effects of various flow reductions on residence time. Next week, I will present some information concerning residence time (as water age) and the occurrence of high chlorophyll *a* concentrations in some segments of the tidal Little Manatee River.

But that is for another day. At this time, I recommend that the minimum flows report reference the residence time work performed by Huang and others, possibly showing the results of some residence time simulations in the minimum flows report.

6.1 Overview and suggested text for ichthyoplankton reports

On page 4.3.3 the report has one paragraph that summarizes the Ichthyoplankton work performed by Dr. Ernst Peebles of the University of South Florida College of Marine Science. This summary is good and well written, but I recommend two additions. First, the figure from Peebles and Flannery (1992) below be shown in the minimum flows report. As I mentioned at the peer review kick-off meeting, I think if there is one figure that best justifies the District's minimum flows program for tidal river estuaries, this is it.



Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages, from Peebles and Flannery (1992)

To reference this figure, the text could be added to say something like "Based on detailed microscopic work that identified early life stages as eggs, larvae, or juveniles, density weighted mean salinity values for different life stages were calculated. For a number of species, this showed a movement from higher salinity to lower salinity waters located further upstream as the species matured from larval to juvenile stages (Figure x). This occurs as these fish develop stronger swimming ability and have a change in food habits, switching from diets rich in zooplankton near the mouth of the river to more benthic food resources further upstream (Peebles 2005)." A reference for this second report is below.

Peebles, E. 2005. Review of feeding habits of juvenile estuarine dependent fishes and blue crabs: Identification of important prey. Report prepared by the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

The second addition I suggest pertains to the report by Peebles (2008). At present the draft minimum flows report has one sentence that says "These data were re-evaluated in 2008 using newly developed analytical methods (Peebles 2008)." Some of these findings in the 2008 report are very interesting and are relevant to freshwater inflow management. I suggest the District and JEI review

the summary section for this report and select two or three findings to briefly mention in the minimum flows report. I suggest “These data were re-evaluated in 2008 using new analytical methods that included analyses of organism dispersion as a function of freshwater inflow and organism associations with water masses of varying water age. The study also assessed community heterogeneity as a function of freshwater inflow and mean salinity at the sampling stations in the river.”

6.2 Overview and suggested text for Nekton sampling conducted as part of the Fisheries Independent Monitoring Program of the Florida Fish and Wildlife Conservation Commission

The consultant has done a very good job of accessing and analyzing the extensive data for nekton (fishes and free swimming macroinvertebrates) in the estuarine section of the Little Manatee River collected by the Fisheries Independent Monitoring Program (FIM) of the Florida Fish and Wildlife Conservation Commission (FFWCC or FWC). On page 93 the draft minimum flows report provides a one sentence summary of a report produced by the FFWCC for the District based on these same data collected between 1996 and 2006 (MacDonald et al. 2007). That sentence mentions this study “demonstrated the importance of the Little Manatee River estuary for providing habitat throughout the year, as peaks in juvenile abundance of offshore spawners, juvenile nearshore spawners, estuarine spawners, and tidal-river residents occurred in different seasons (MacDdonald et al. 2007).”

Though this characterization is helpful, I suggest the minimum flows report could mention a couple other analyses or data presentations from the MacDonald et al. (2007) report. Also, it is not critical, but one page of figures from that report could be shown to highlight the types of information that are presented in it. I suggest something like below, including the figures for Red drum shown on the following page.

“This report also provides useful analyses and tabular and graphical presentations of the abundance and distribution response of various species in relation to freshwater inflow, plus the size classes, salinity at capture, and abundance of species in different sections and habitats in the lower river. As an example, a series of graphics for the seine catch of Red drum (*Sciaenops ocellatus*) from MacDonald et al. (2007) are shown on the following page.” (see figure on the following page).

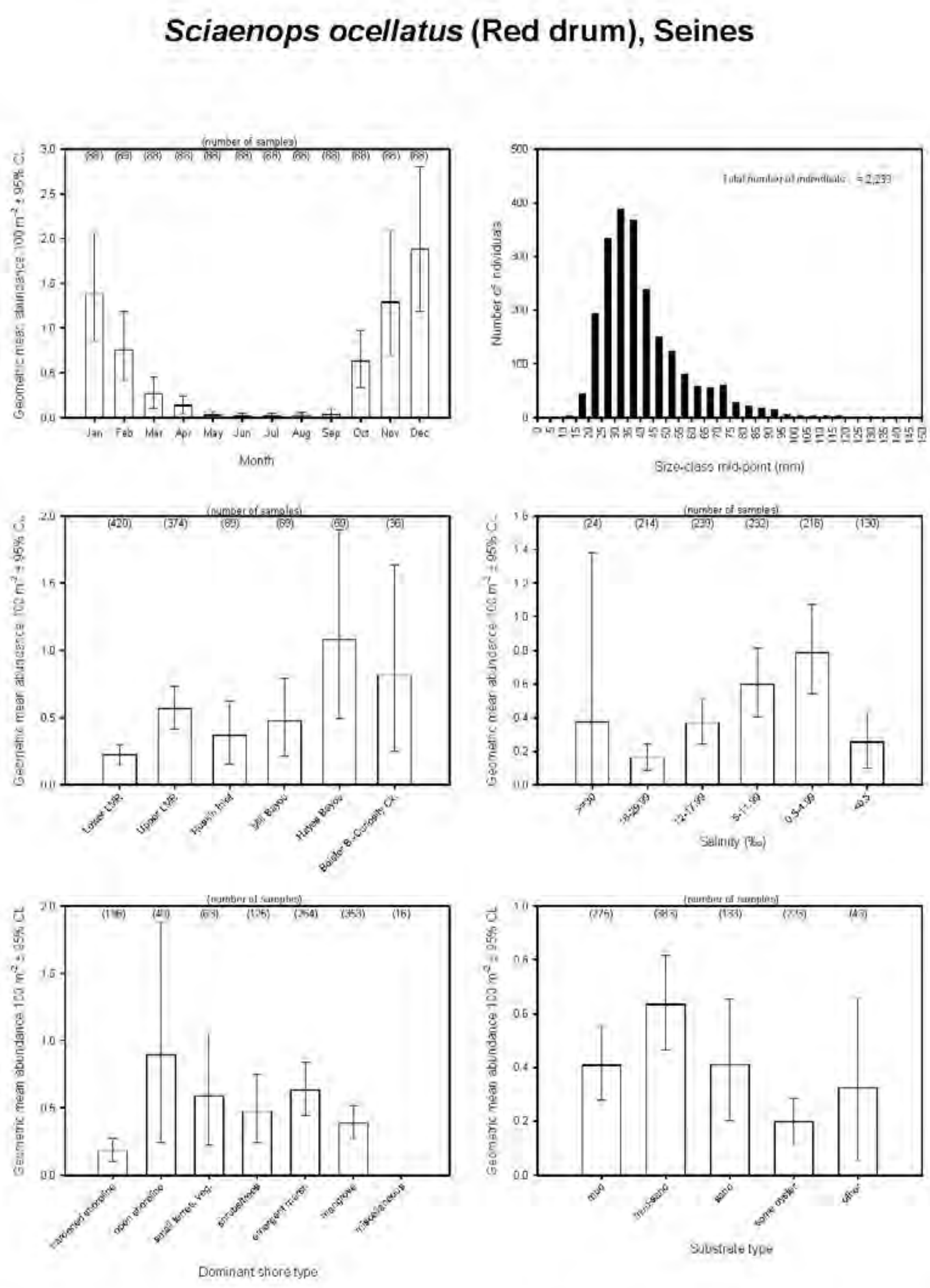


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

Figure X. Graphics for the seine catch of Red drum (*Sciaenops ocellatus*) in the Lower Little Manatee River reprinted from MacDonald et al. (2007).

6.3 Multi-River Fish Reports

Both FFWCC and USF prepared reports for the District that analyzed data pooled for the 18 or so rivers they studied for the District. The consultant might find some useful results in these reports that are relevant to the findings presented in the Little Manatee minimum flows report. References for these reports are below.

Hollander, D. and E.B. Peebles. 2004. Estuarine Nursery Function of Tidal Rivers in West-Central Florida: Ecosystem Analyses Using Multiple Stable Isotopes. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Peebles, E.B. 2005. Review of Feeding Habits of Juvenile Estuarine-Dependent Fishes and Blue Crabs: Identification of Important Prey. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Burghart, S.E. and E.B. Peebles. 2011. A Comparison of Spring-Fed and Surface-Fed Estuaries: Zooplankton, Ichthyoplankton, and Hyperbenthos. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Gunther, C.B., T.C. MacDonald and R.H. McMichael. 2011. Comparison of Nekton Community Structure Among Spring- and Surface-Fed Estuarine Rivers of Florida's West Coast. Report prepared by the Florida Fish and Wildlife Conservation Commission for the Southwest Florida Water Management District.

Verbal comments to be given at the Little Manatee River minimum flows peer review meeting, October 27, 2021

By Sid Flannery

Good afternoon. Today I would like to talk about the need to establish flow based, minimum flow blocks separately for the freshwater and estuarine sections of the Little Manatee River. I support the use of flow-based blocks, but on the Little Manatee the District based the thresholds for identifying low, medium, and two high flow blocks strictly on analyses of the freshwater section of the river, and then applied three of those same flow blocks to the estuary. Well this is a first, as the District has never done that before, and it is a serious misstep for the Little Manatee River and sets a bad precedent.

The District has previously used flow-based blocks to establish minimum flows for a number of estuarine rivers in the region. For example, last year, the District adopted minimum flows for the Lower Peace River for the second time, using three flow-based blocks that were based on salinity relationships in the estuarine section of the river.

The important thing is for these other tidal rivers, low flow cutoffs and flow-based blocks for the estuarine sections of the rivers were based on relationships of freshwater inflow to variables and parameters within the estuary.

An important factor to consider is that the response of many variables in estuarine rivers to freshwater inflow is nonlinear. Even if you take a fixed percentage of daily flow, say 20 percent, the relative effects of those withdrawals on habitats and other factors can be much greater at low flows than at high flows. Therefore, when applying the percent of flow method in a tidal river, you have to see if there are sensitive flow ranges for the response of different variables to freshwater inflow.

In that regard, I prepared a series of graphs of different variables vs. flow in the Lower Little Manatee that the District uploaded to the minimum flows WebForum this morning. I think the low flow cutoff of 35 cfs for the lower river is suitable, and similar to the 40 cfs cutoff currently in effect for the Florida Power Light withdrawals, which I was involved in evaluating years ago based on estuarine relationships.

However, the 72 cfs threshold for switching from medium to high flow blocks clearly looks to be too low for the lower river, as 72 cfs is in a very sensitive flow range for some important variables, particularly in the low salinity reaches of the river.

Also, based on gaged flows at US 301 for the last twenty years, flows would have been above 72 cfs fifty-two percent of the time. The estuarine section of the Little Manatee has a surface area of 2.2 square miles, and for the ecological functions, 72 cfs is not a high rate of inflow for an estuary of this size.

I strongly suggest the review panel recommend that flow rates to identify low, medium, and high flow blocks be evaluated separately for the fresh and estuarine sections of the Little Manatee. Given the modeling tools that have been developed, I think this could be done fairly quickly.

There is an interesting parallel to this. When minimum flows for the Lower Peace River were evaluated for the first time in 2010, the Section Manager wanted the minimum flows for the lower river to use seasonal blocks. As a check, we examined how the percent withdrawals for seasonal blocks 2 and 3 would perform if they were applied during low flows, which would have happened fairly frequently. We found that at low flows, the percentage withdrawals for seasonal blocks 2 and 3 would cause greater than a 15 percent change in salinity based habitats, but at higher flows they did not. Based on those findings, the first adopted rule for the Lower Peace River had a flow threshold that seasonal blocks 2 and 3 could not be applied until flows in the river went above 625 cfs.

That type of analysis could to done for the Little Manatee. For example, for a 30% withdrawal, for each day calculate the percent reduction in low salinity habitats relative to baseline, then plot these results vs. the corresponding rates of baseline flow. You will find that at some rate of increased flow, these withdrawals will not cause more than a 15 percent change in habitat, while at lower flows they will. You could examine these results to determine a threshold for identifying high flows. I expect that a similar approach could be taken the estuarine fish habitat analysis as well.

Also, From the water management perspective, it entirely practical to implement minimum flows rules that differ between the fresh and estuarine reaches of rivers, in fact that has been the standard District practice for years.

I hope the panel can review the documents that I have prepared for today and previous meetings, which can be found under the public comments section of the Webforum, as I think they provide very useful information pertaining to review of the draft report and the proposed minimum flows.

Finally, the Little Manatee River below Highway 301 is a State of Florida Aquatic Preserve and the crown jewel of the rivers flowing to Tampa Bay. If you are going to protect this valuable estuarine resource from significant harm, you need examine flow-based blocks that are analyzed specifically for this estuarine system.

Graphics related to the evaluation of flow thresholds for flow-based blocks for minimum flows for the estuarine section of the Little Manatee River

Submitted by Sid Flannery, October 27, 2021

Overview and organization of this document

This document provides a set of graphics and brief text related to the determination of flow rates that can serve as thresholds to identify flow, medium, and high flow blocks for minimum flows for the estuarine section of the Little Manatee River. It is being submitted as part of the independent peer review that is being conducted for the draft minimum flows report for the Little Manatee River published by the Southwest Florida Water Management District (the District).

As part of the review process, I have been commenting as a private citizen and have previously submitted three sets of documents to District staff and the peer review panel for their consideration. My comments that will be presented to the peer review panel meeting on October 27, 2021 are attached as an Appendix to this document.

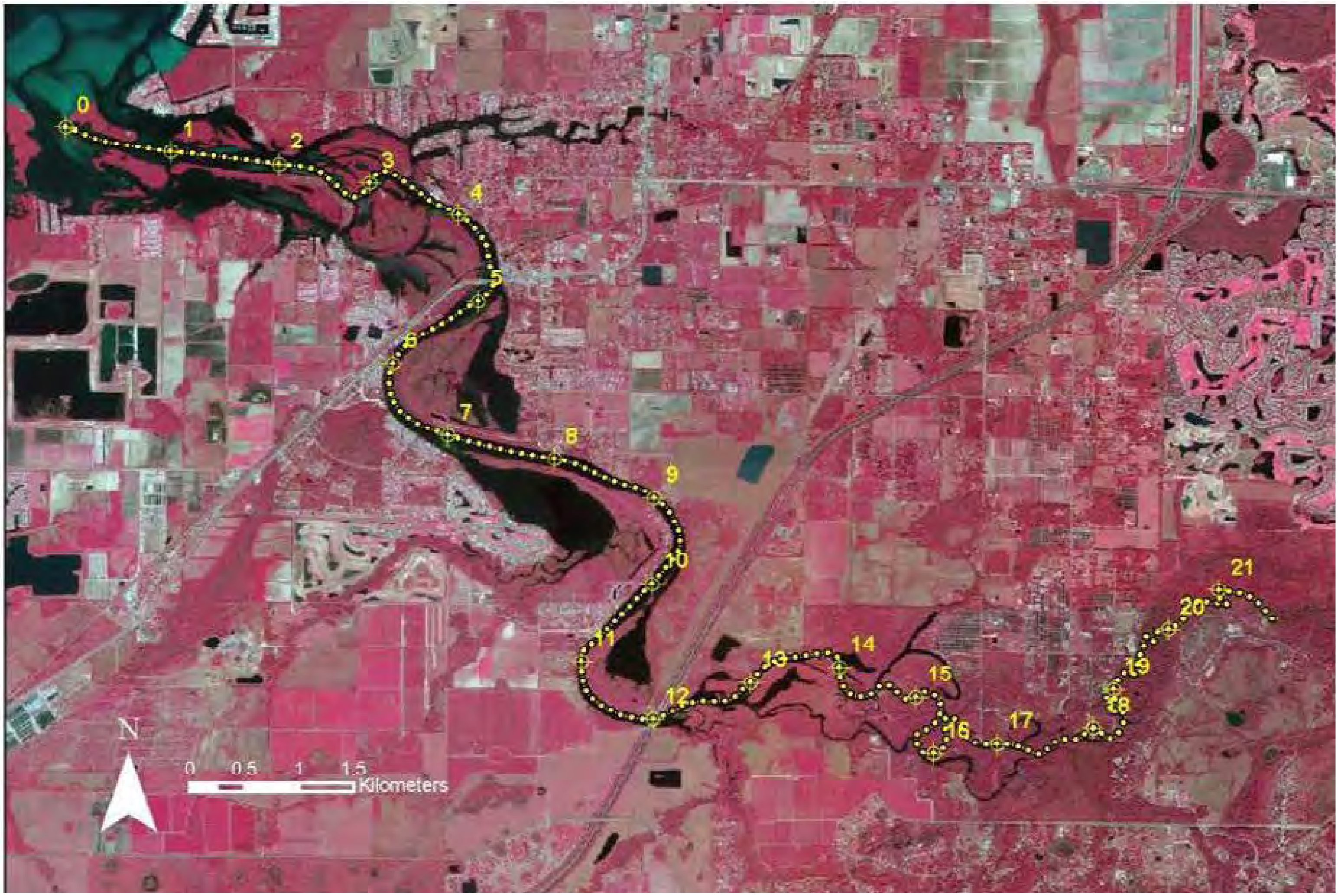
The draft minimum flows report for the Little Manatee identifies flow rates of 35 and 72 cfs to serve as thresholds to identify low, medium, and high flow blocks for the minimum flows. These flow rates were based solely on analyses of the freshwater reach of the river, but they are being applied to the estuarine reach of the river as well. As my comments in the Appendix state, the District has never done that before, and I strongly recommend that thresholds to identify flow-based blocks be evaluated separately for the freshwater and estuarine sections of the river. Those comments also describe a type of analysis that was done for the first determination of minimum flows for the Lower Peace River that I think should be performed for the Little Manatee to assess appropriate flow blocks for the estuarine reach of the river.

Given the very short time frame of the peer review process, the graphics presented in this document were put together very quickly and are by no means a comprehensive set of graphics related to this topic. I'm sure there are other relationships that could be examined. I did not have time to review biological information for the river in this regard, but plots of chlorophyll *a* vs. flow are included, which I think are very meaningful.

Many of the graphics have a reference line for 72 cfs, which was visually approximated using power point. As the Appendix states, I think the 72 cfs is clearly too low to serve as a threshold to identify the high flow block for the estuarine section of the Little Manatee. Some brief text is included with some of the graphics, particularly for chlorophyll *a*. All text was also was prepared quickly and is not a through treatment of these relationships.

For evaluating any apparent shifts or inflexion points in the data, readers should consider the following graphics essentially represent a baseline condition. That is, the application of minimum flows will reduce the flows, basically moving the relationships to the left. For example, with the proposed minimum flows, a flow of 70 cfs could be reduced to 56 cfs and a flow of 110 cfs could be reduced to 77 cfs. Therefore, in considering what might be an appropriate threshold to switch between flow-based blocks, the threshold should include a buffer that is slightly above the apparent inflexion point in order to best manage a sensitive flow range.

For reference, a centerline map of the Little Manatee River is shown on the next page.



Centerline map of the Lower Little Manatee River with distances in kilometers

Chlorophyll *a*

I have not had time to review appendices to the minimum flows report the deal with water quality, so I don't know if they contain graphics or analyses similar to what I have presented below. Regardless, it is very informative to plot chlorophyll *a* concentrations versus freshwater inflow in tidal rivers. When doing so, the relationships with inflow in the Little Manatee are similar to what have been observed in other tidal rivers for which there are abundant chlorophyll data (Lower Alafia, Lower Peace), with one difference that is discussed on the following page.

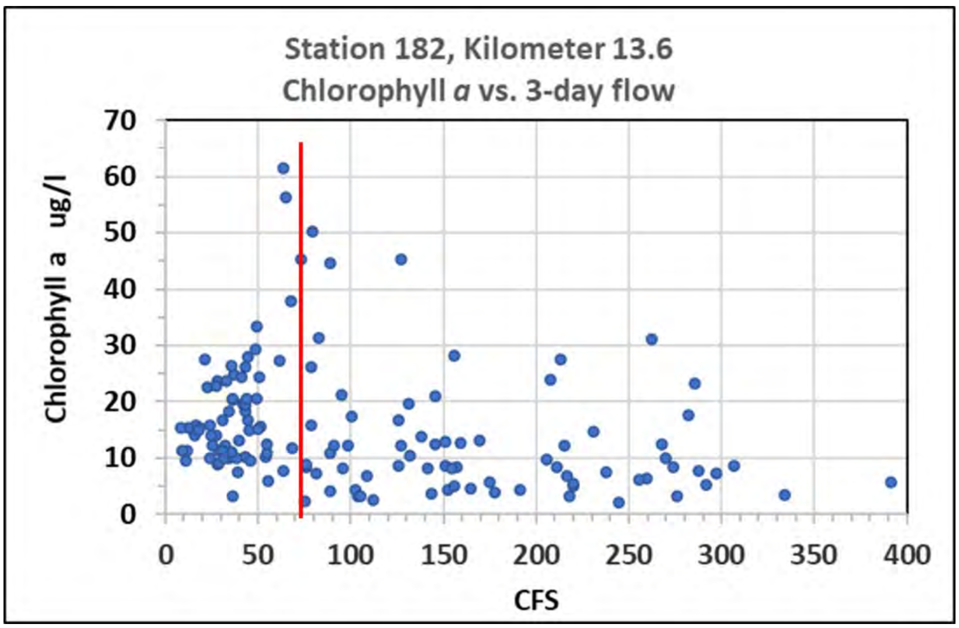
As part of the peer review process, I submitted a document titled *Overview and suggested text to describe technical reports about the Little Manatee River* that was posted on the minimum flows WebForum under public comments. That document provides citations and brief descriptions of District sponsored studies of phytoplankton related parameters (including chlorophyll *a*) in the estuarine reach of the Little Manatee, with one study also including data from the Lower Peace and Alafia rivers. I have not had time to access those data, but can make some comparisons and conclusions based on previously published findings.

The graphics below are taken from water quality sites monitored the Environmental Protection Commission of Hillsborough Country (EPCHC, often referred to simply as EPC) that were presented in the draft minimum flows report. The EPC is to be highly commended for expanding their water quality sampling network to add three new data collection sites in the Little Manatee, starting in 2009. These data, plus the longer-term site at Station 112, provide very extensive monthly water quality data at those four locations in the tidal Little Manatee River.

Go to next page

The figure below is from station 182, located in the braided oligohaline section of the river near kilometer 13.6. The pattern that is shown is typical of the upstream reaches of tidal rivers, in that high chlorophyll concentrations are not frequently observed at very low flows (20 to 30 cfs below) probably due to low nutrient loading. However, when flows increase, high chlorophyll concentrations can occur due to greater nutrient loading, with residence times that are still fairly long allowing phytoplankton blooms to develop.

However, at higher flows, high chlorophyll *a* concentrations are not frequently observed as water is moving through these upper reaches of the tidal river fairly rapidly with low residence times. Water color also increases at high flows, which limits light penetration. This tendency would be shown more clearly if the horizontal axis below was expanded to include higher flows, but the emphasis on this graphic is on lower flows. Three-day flow is the average flow for the day of sampling and the preceding two days.



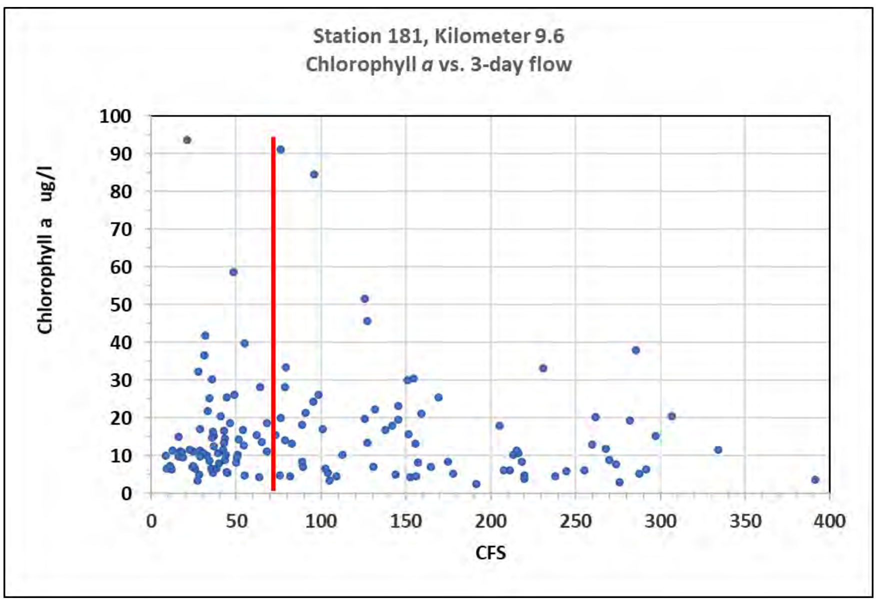
A red reference line is shown in the figure above at approximately 72 cfs, which is the threshold to switch from the medium to high flow block in the proposed minimum flows, which will allow a change in percent withdrawals from 20 percent to 30 percent. Again, this threshold was based solely on analyses of the freshwater reach of the river upstream of US highway 301. As shown in the figure above, 72 cfs is right in the middle of the flow range of when very high chlorophyll *a* concentrations can occur at this location.

What is interesting about the Little Manatee is that peak chlorophyll *a* concentrations often occur in very low salinity waters, even close to the tidal interface between fresh and brackish waters. As described in the *Overview and suggested text* document, peak chlorophyll *a* concentrations often occur in mesohaline waters in the tidal reaches of the Peace and Alafia Rivers. It appears

this difference in the Little Manatee is that water slows down considerably in the braided section of the river upstream of I-75, with longer residence times there compared to the upper reaches of other tidal rivers.

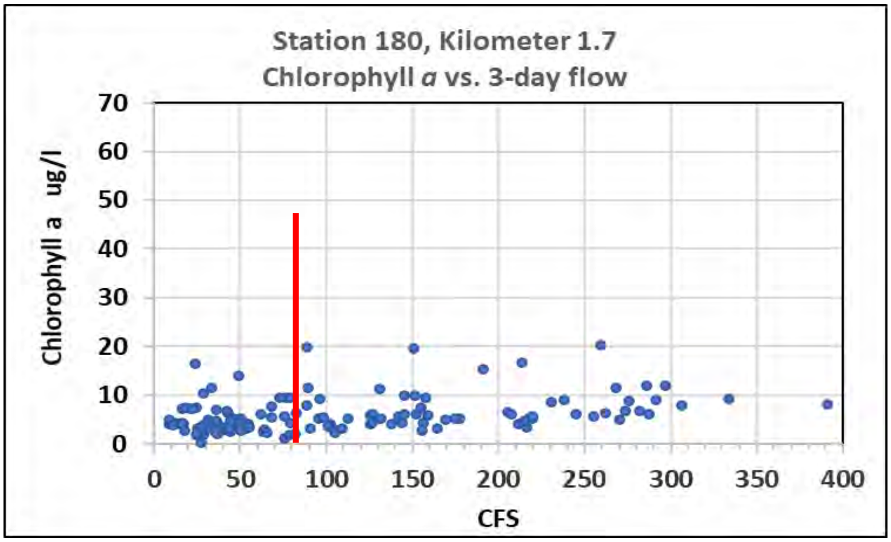
As part of the development of the EFDC hydrodynamic model for the Little Manatee, Drs. Huang and Liu of Florida State University did residence time simulations for the river that are summarized in the *Overview* document that was previously submitted. The District has also done residence time analyses in the Lower Peace and Alafia Rivers, with the minimum flows report for the Lower Alafia presenting a good discussion of the relationships of residence time to chlorophyll *a* in that river.

The relationship of flow to chlorophyll *a* will change at different locations in a tidal river due to changes in the volume of the estuary, residence time, available nutrients, light penetration and tidal exchange with the bay. Plots are presented for EPC stations 181 and 180 in the following discussion, with data shown below for station 181, which is located near kilometer 9.6.



The highest peak chlorophyl *a* concentrations in the Little Manatee recorded by the EPC are at Station 181. High concentrations above 80 µg/l were limited to when three-day average flows were less than 100 cfs, with two concentrations above 90 µg/l at flows below 77 cfs. The minimum flows report has a time series plot of yearly geometric means for chlorophyll *a* that shows that during some years, the FDEP impairment threshold of an annual geometric mean of 11 µg/l is exceeded at this station. I agree with some review panel comments that this threshold is probably too low for productive tidal rivers. However, individual chlorophyll *a* concentrations can be strongly affected by the rate of freshwater inflow, and the occurrence of problematic very high chlorophyll concentrations from large phytoplankton blooms can be exacerbated by flow reductions in sensitive flow ranges in various sections of a tidal river.

The graph below is for station 180, which is located near 1.7 kilometers upstream of the mouth of the river. For easier comparison to the other figures, the Y axis is taken up to 70 µg/l. It is obvious that chlorophyll *a* concentrations are much lower at this location and have a very different relationship with freshwater inflow, due likely to the volume of the estuary, tidal flushing from the bay, and limited available nutrients at low flows. However, at this location there is a tendency for slightly higher chlorophyll *a* concentrations at higher flows, as nutrient delivery from the watershed is increased.



It should be noted that the Little Manatee River has been enriched with nitrogen due to human activities in the watershed. The draft minimum flows report found that with the exception of organic nitrogen at one site, trends for various forms of nitrogen have either been showing no trend or decreasing at EPC stations in the lower river in recent years. However, as described in the document I submitted titled *Technical review of the Little Manatee River flow characterization,* as part of a large study of the Little Manatee River watershed that was conducted by the District and other agencies in the late 1980s, long-term nitrogen data indicated that agriculture activities have increased nitrate concentrations in the river considerably compared to decades prior to the mid-1970s. Given that the river is nitrogen enriched, it is important to carefully manage the effects of flow reductions on excessive phytoplankton blooms and high chlorophyll *a* concentrations in the river.

Again, I have not had time to review the appendices to the minimum flows report that deal with water quality, but the data for stations 181 and 182 in the mid to upper reaches of the tidal river indicate the 72 cfs threshold to switch to 30 percent withdrawals is too low, as it could exacerbate excessive phytoplankton blooms in that part of the river. New analyses should be conducted to develop a threshold for a high flow block for the estuary based on relationships in the lower river, rather than from the freshwater reach where the 72 cfs flow threshold was derived.

SALINTY

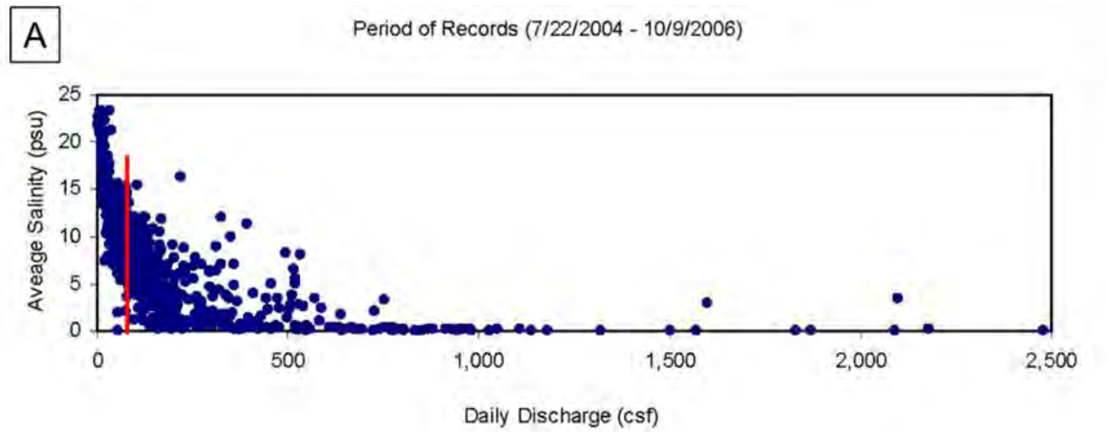
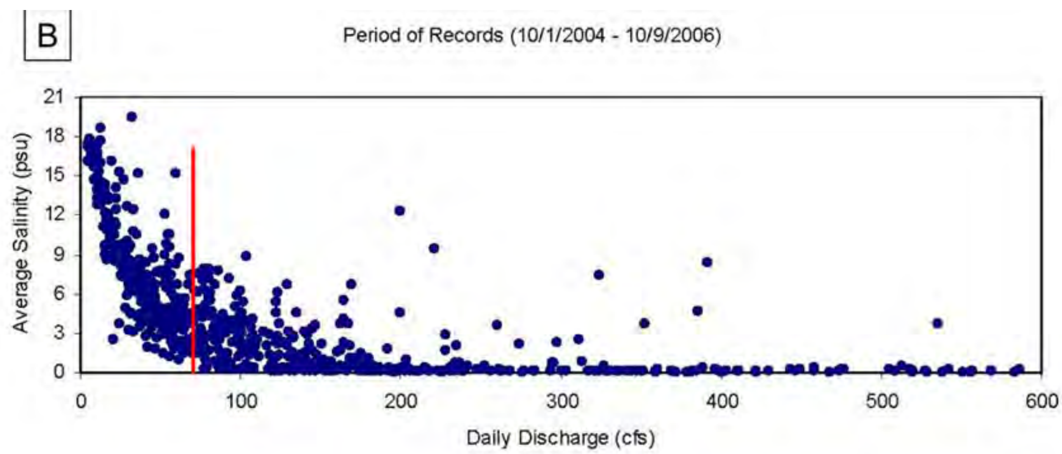


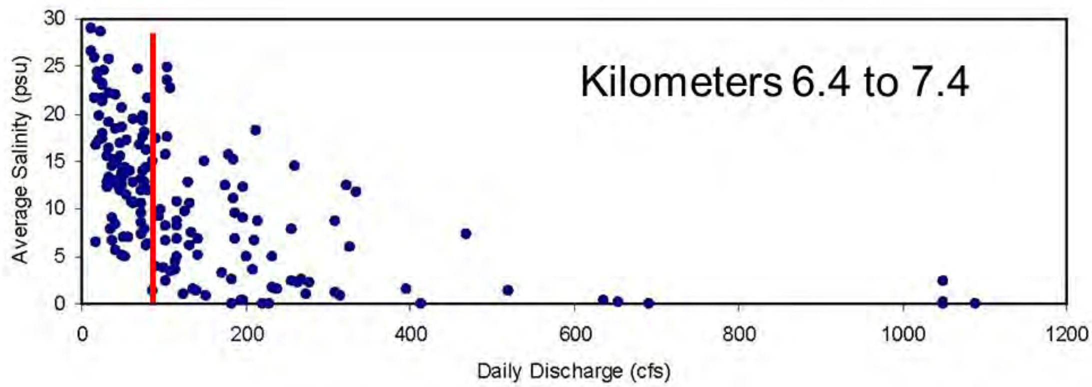
Figure 15. **Salinity versus daily discharge for the USGS 02300546 gage, Little Manatee Rive at Ruskin, FL (RKM = 8.3)**

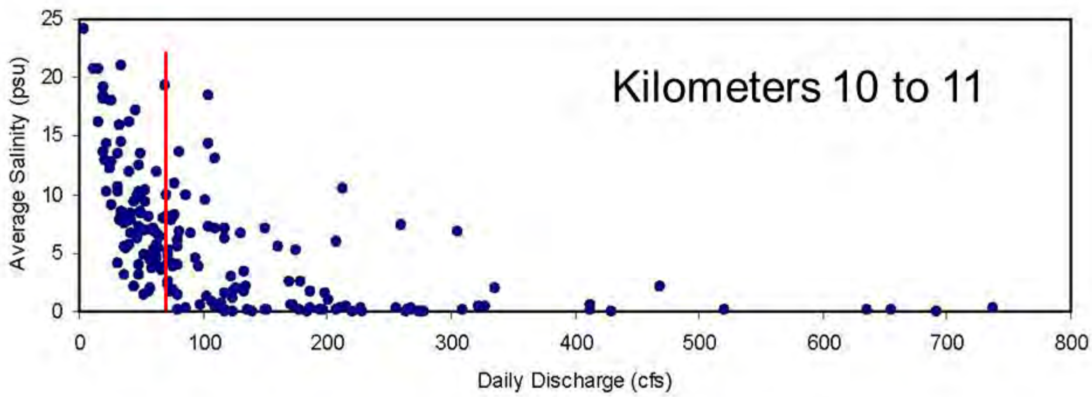


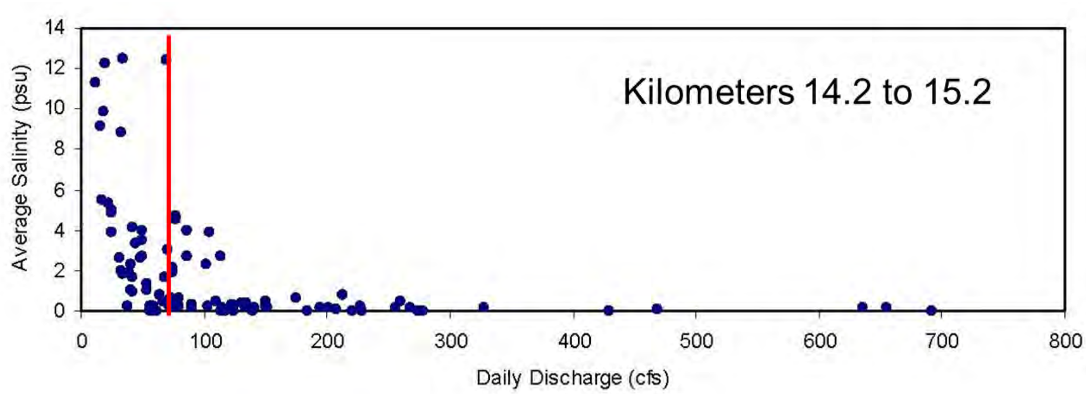
'igure 16. **Salinity versus daily discharge for the USGS 02300542 gage, Little Manatee River at I 75 near Ruskin, FL (RKM = 12.1)**

Red reference lines inserted at approximately 72 cfs

The USGS operated a series of continuous salinity recorders in the river to support the development of the EFDC hydrodynamic model for the river during 2004 to 2006. Plots of average daily salinity from the top and bottom sensors at each location are shown above for two recorders located at kilometers 8.3 and 12.1. The recorder at 12.1 is at the I-75 bridge, which is just downstream of the braided zone of the river that contains abundant oligohaline marshes that grade upstream to tidal freshwater marshes and forest. Salinity is very responsive to flow in the range of 72 cfs at this location, with the response dampening at higher flows.

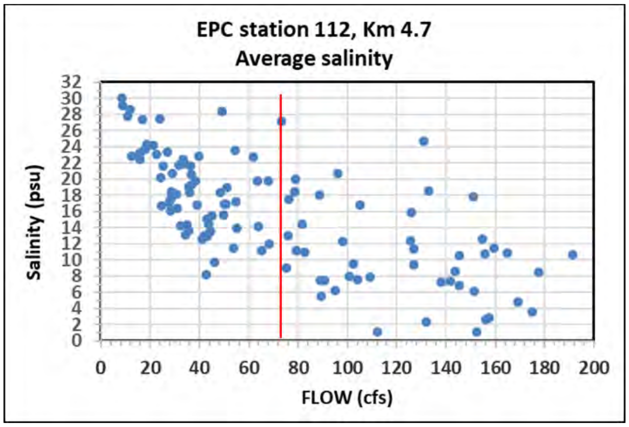


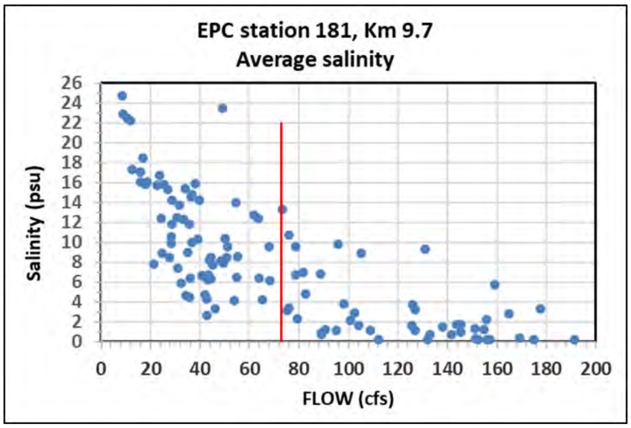


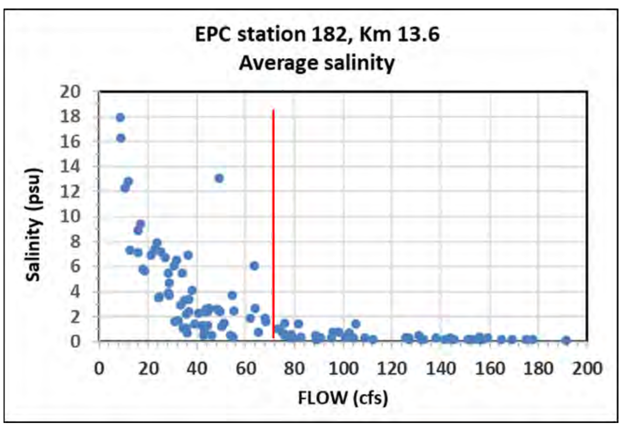


Red Line reference lines inserted at approximately 72 cfs

These graphics on this page are average salinity values from vertical profiles taken by the District and other parties between March 1985 and October 2006. I don't think that 72 cfs represents a good high flow threshold to increase withdrawals, as salinity is very responsive to flow reductions at these sites near that flow value, with a dampened and flatter response at higher flows. Considering that for the most recent twenty year period, 72 cfs has been exceeded 52 percent of the time, a higher threshold to identify high flows would be more appropriate for this estuarine system.







The graphics above are from the Hillsborough County EPC's water quality stations in the tidal river that have been monitored since 2009. At these stations, EPC measures salinity at top, middle and bottom depths, with the average of these values shown above. For station 181 (middle graph), 72 cfs again appears to be too low to serve as a high flow threshold compared to a higher flow rates. The data at station 182 seem more supportive of the 72 cfs threshold, but these salinity values are lower than some average values for kilometers 14.2 to 15.2 reported by the District shown on the previous page. This might be because the District frequently sampled near high tide, or possibly because the District took salinity profiles at surface and 1 meter intervals.

Management Approach for Unimpounded Rivers **1321**

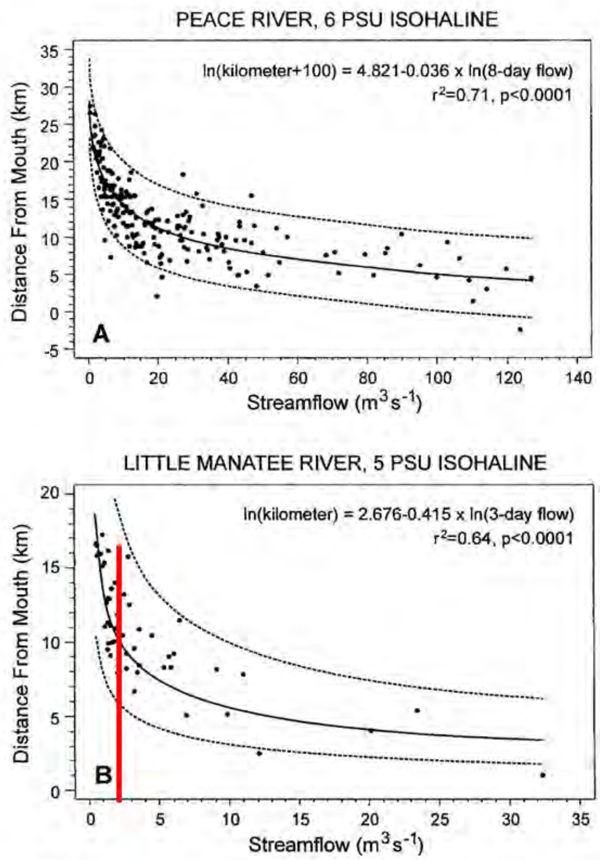


Fig. 3. Regressions of freshwater inflow with (A) the location of the 6 psu surface isohaline in the Peace River (adapted from Janicki Environmental 2001) and (B) the location of the 5 psu surface isohaline in the Little Manatee River (adapted from Peebles and Flannery 1992), with the 95% confidence limits for the predicted values. Regressions are plotted using non-transformed data.

The Figure above shows the strong nonlinear response that salinity isohalines can have with regard to changes in freshwater inflow. The red reference line for the Little Manatee River is near 2 m3/sec, which is equivalent to a flow of 72 cfs. Note there are three occurrences of the surface 5 psu isohaline between kilometers 13 and 16 near a flow rate of 72 cfs and others just below that flow rate. This graphic was taken from an article by Flannery et al (2002) in the journal *Estuaries* that dealt with the percent of flow method, which is referenced in the District's draft minimum flows report.

It should be noted the Little Manatee was one of the three estuarine rivers that provided data and findings that were very important to the initial development of the percent-of-flow method for regulating withdrawals and determining minimum flows for tidal rivers.

208 Environ Fluid Mech (2010) 10:197–211

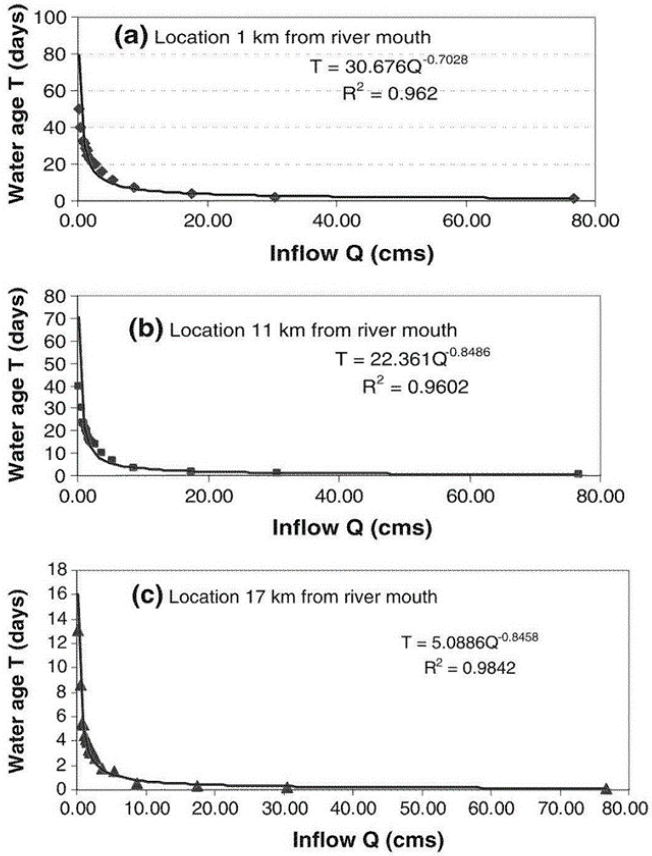


Fig. 9 Tidally-averaged water ages T (days) in responses to river inflows $Q(\mathrm{m}^3/\mathrm{s})$ at different locations along the river main channel. Least-square regressions were done by using power law. Data were obtained from hydrodynamic model simulations

The graphic above was taken from a journal article about water age simulations in the Little Manatee River by Huang et al. (2010) that is cited in the *Overview* document. Water age is a form of residence time, that is the travel time of fresh water from the head of the estuary to a given location, with three sites shown above. The horizontal axes in these figures cover a very high range of flows in m3/sec (for reference 72 cfs is equal to about 2 m3/sec and 4 m3/sec equal to about 141 cfs). Even so, the strong nonlinear response of water age at low flows river is clearly apparent at these locations. The Lower Alafia minimum flows report found that water age can be an important factor affecting very high chlorophyll concentrations.

I did not have time to analyze relationships between chlorophyll *a* and water age in the Little Manatee, but the relationships of chlorophyll *a* with flow shown on pages 5 and 6 are probably due in part to differences in water age at low, medium, and high flows. As such, the nonlinear response of residence time and water age to freshwater inflow should be considered in determining what are truly high flows for the estuarine section of the river. In my opinion, 72 cfs is too low a value for identifying high flows in that regard.

Finally, it interesting to note that the peer review panel for the previous minimum flows report included a graphic that indicated that simulations of residence time and water age can be important for assessing phytoplankton abundance in estuarine rivers. The graphic below was taken from page 9 in that report, with red arrows inserted to highlight the suggested work for hydrodynamic modeling for salinity and water age analysis.

I believe that in fairly short order, the data for the estuarine reach of the Little Manatee River can be reassessed to come up with a threshold to identify high flows that much better protects the lower river from significant harm, compared to the proposed 72 cfs threshold which is clearly too low.

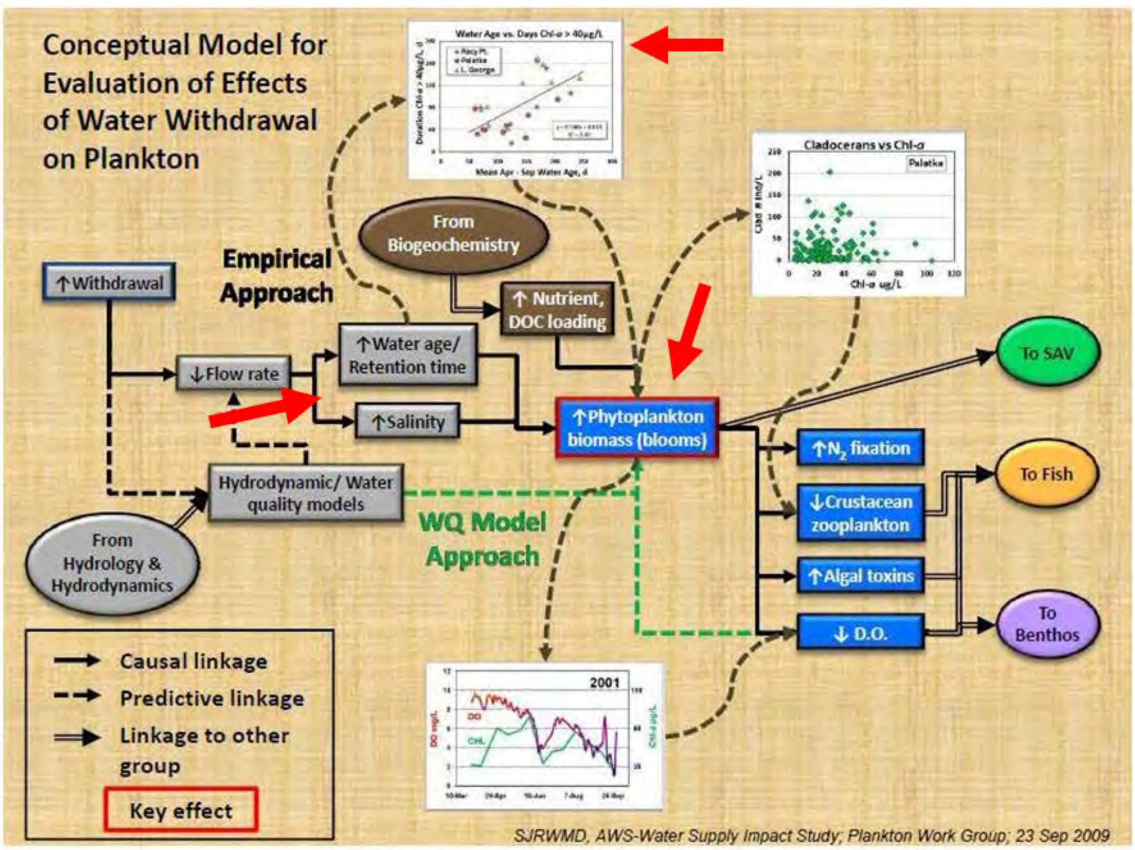


Figure 2. Multidisciplinary studies for assessing water withdrawal impacts on plankton. (SJRWMD 2009)

Figure adapted from Figure 2 in the peer review report for the previous minimum flows report for the Little Manatee River

Verbal comments for November 3 Little Manatee River minimum flows peer review meeting.

Prepared by Sid Flannery (ADDED PARAGRAPHS IN BLUE)

Today I would like to speak about how minimum flows are implemented using flow-based blocks. The review panel is considering whether the flow blocks should, or should not be, the same for the fresh and estuarine sections of the Little Manatee.

Well, they are not entirely the same in the currently proposed rule, which is shown in the table on your screen (below). Note than in Block 3 the freshwater minimum flows have a second high flow threshold of 174 cfs that is highlighted in yellow, which is not assigned to the estuarine minimum flows. You can subtract the numbers shown in red to calculate the percent withdrawals in each block. So, for block 3 in the freshwater section, flows cannot be reduced by 13 or 11 percent depending on the rate of flow Further downstream, flows to the lower river cannot be reduced by more than 30 percent at flows above 72 cfs.

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		

So, lets hypothetically change the threshold to switch from block 2 to block 3 for the lower river to 120 cfs. We still have the 13 and 11 percent limits to withdrawals in block 3 in the freshwater section, but flow reductions to the lower river cannot exceed 20 percent until flows go above 120 cfs, when percent withdrawals can increase to 30 percent. This is very simple and straightforward and poses no water management complications whatsoever.

There are two factors that typically make the percent of flow method very workable within the District. Estuaries in the region are generally not as sensitive to ecological impacts from flow reductions as are freshwater rivers, and minimum flows adopted for estuarine rivers usually allow for the same, or more often, greater percent withdrawals than for the corresponding freshwater sections. And, it is an obvious point, but the estuary is always downstream. If these two types of ecosystems were interspersed along the river channel it could be complicated, but that is not the case.

If we are to protect both the freshwater and estuarine sections of our rivers, it is critical to first evaluate the most effective flow blocks separately for these two very different ecosystems, then write the rules accordingly. Based on years of experience applying the percent of flow method to existing water use permits, I don't think that having separate flow blocks for the fresh and estuarine sections of a river would cause complications for water management, and changing the block 3 threshold for the lower Little Manatee certainly would not.

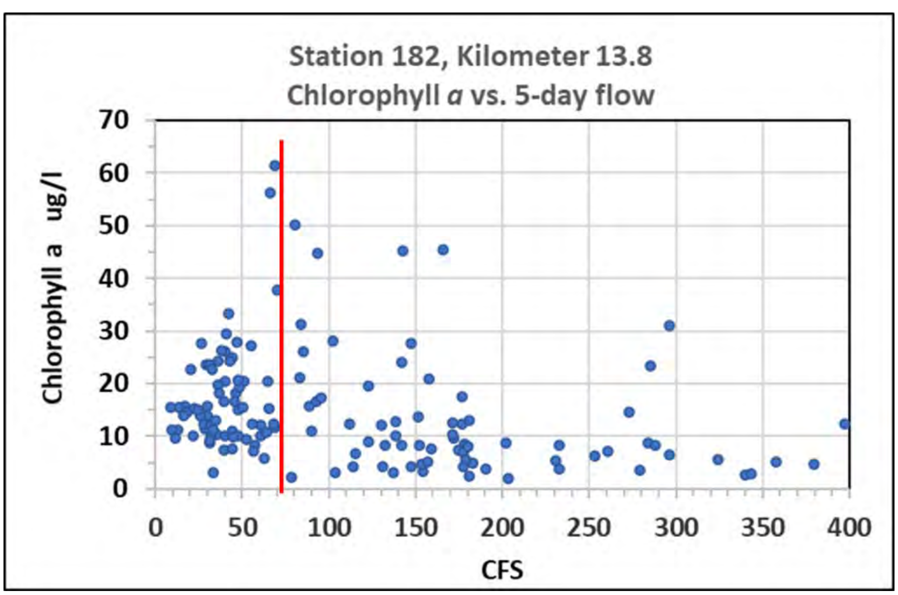
For years the District has included flow-based blocks in estuarine minimum flow rules based on analyses of relationships within those tidal rivers. However, with the Little Manatee, the District for the first time has assigned flow blocks developed for the freshwater section of the river to the estuarine section as well.

Assigning 72 cfs as the high flow block for the estuary does not allow for the evaluation of important ecological relationships in the lower river above that flow rate, which by the way, was near the median flow for the river for the last 20 years. Many of these relationships at higher flows are important to the ecological functions of the lower river, which could be evaluated to come up with a revised block 3.

For example, last week Dr. Ernst Peebles said that the combined zooplankton/ichthyoplankton catch in the lower river showed a shift in community heterogeneity around 100 cfs. Last week I also submitted to the WebForum a series of plots of salinity and other parameters vs freshwater inflow that showed these parameters respond strongly to freshwater inflow near 72 cfs, but less acutely at slightly higher flow rates, which could be evaluated to develop a revised block 3.

For example, upstream of I-75 there are widespread oligohaline marshes dominated by freshwater plants that have some salt tolerance such as sawgrass and cattails. The inundation of these marshes with fresh water in the wet season is important to their health and productivity. Plots of salinity versus flow in the graphics document show that salinity is very sensitive to flow reductions at 72 cfs in this reach of the river, but not so much at flows above 100 to 150 cfs.

The graphics document also includes plots of chlorophyll *a* concentrations versus flow at three locations in the river. Due to a combination of factors, the response of chlorophyll *a* vs. flow differs greatly between the lower and upper sections of the tidal river. At the two uppermost stations, 72 cfs is in the flow range where chlorophyll *a* is reaches peak values in the range of 40 to 90 ug/l (data from kilometer 13.8 shown below, some higher values observed at kilometer 9.6). It could be argued whether that represents an ecological imbalance or not, but in my opinion, 72 cfs is not a flow rate where there should be an increase in the percent withdrawal.



Also, a very useful analysis is to examine daily output from the EFDC model see in what flow range does a specific percent withdrawal rate cause usually reductions in low salinity habitats greater than 15 percent, similar to what was done for the Lower Peace River. I suspect the fish habitat analysis could be used in a similar manner.

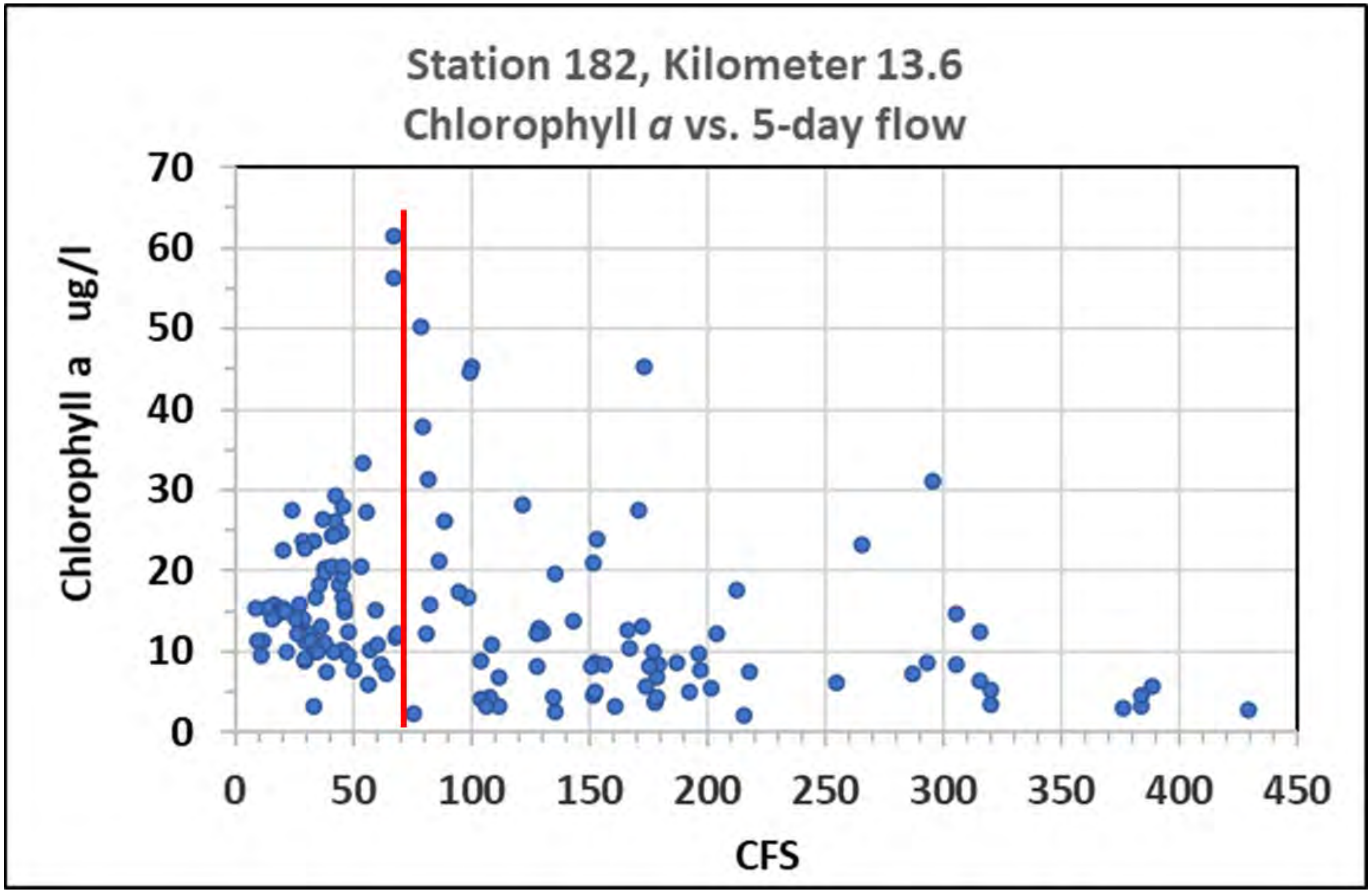
In closing, over the last 30 years the District had spent considerable time, effort, and money to conduct detailed technical investigations of the relationships of streamflow to the ecology of freshwater and estuarine rivers. In doing so, it has developed the very progressive percent of flow method, which has been successfully applied to many rivers.

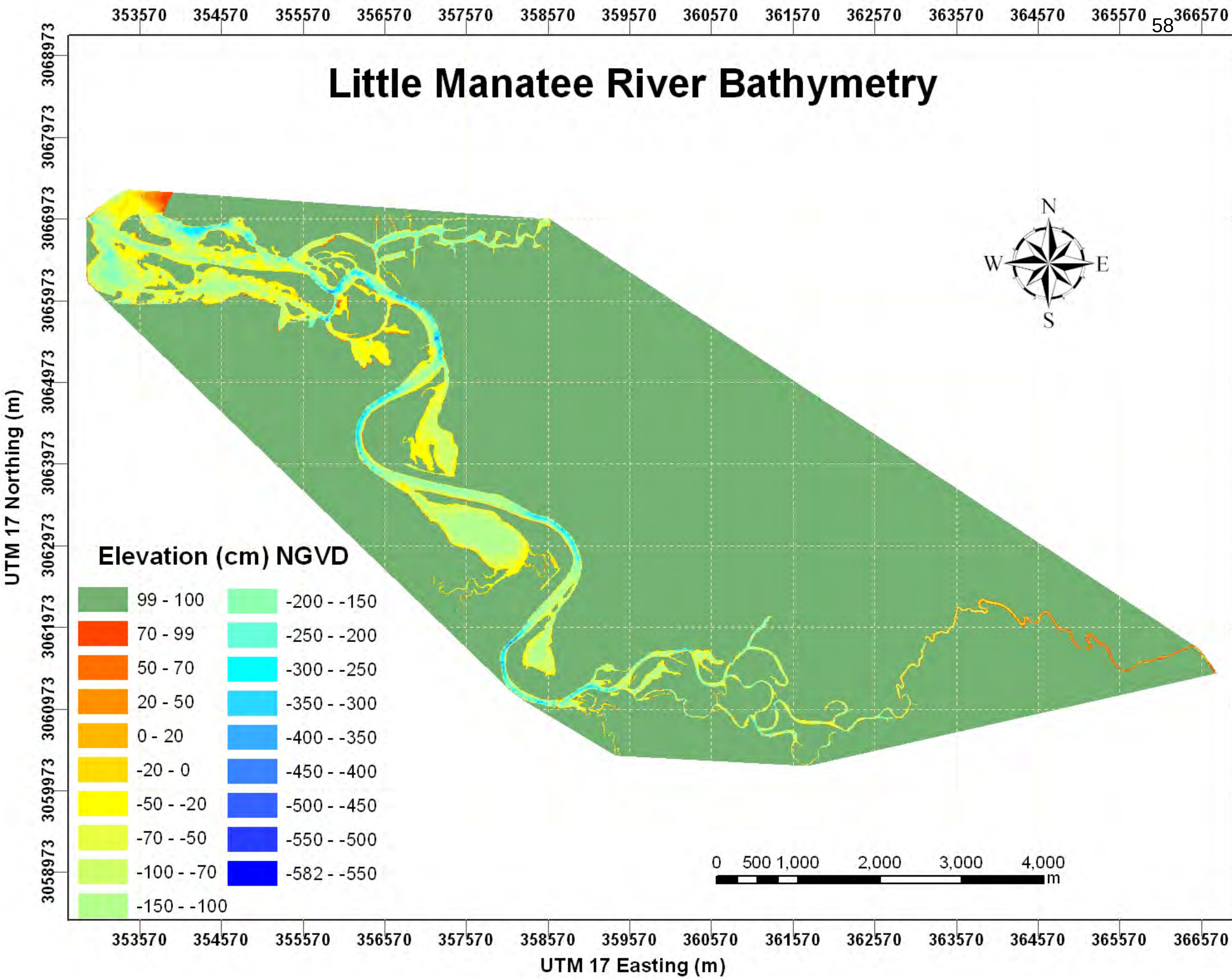
However, the percent of flow method is at a critical juncture right now. The topic of whether the flow blocks have to be the same for fresh and estuarine sections of rivers is extremely important and the Little Manatee could be viewed a precedent. Based on a number of ecological factors and practical water management considerations, I strongly believe that flow blocks for fresh and estuarine sections of rivers need to be evaluated separately. At a minimum, you don't want to simply apply the blocks that were developed for the freshwater section of a river to the estuary, as was done for the Little Manatee.

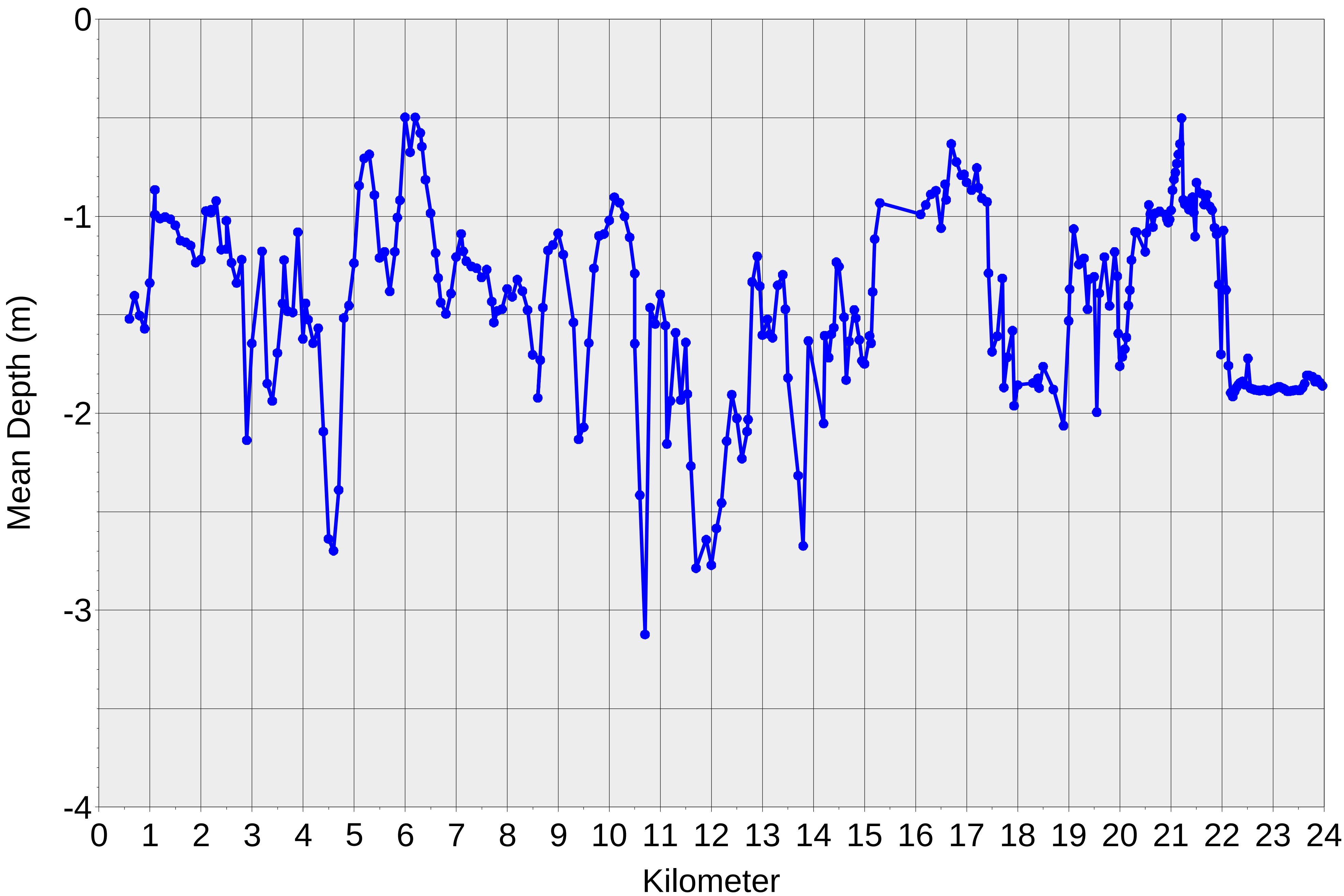
It looks like the review of the Little Manatee River minimum flows report is on a very fast track. I suggest the panel take additional time to consider further the flow blocks issue. The panel could get input from other parties, continue discussions with District staff, and consider some other analyses. There is no real need to hurry on this minimum flow on this very valuable river, and this is a critical factor that needs to be thoroughly assessed.

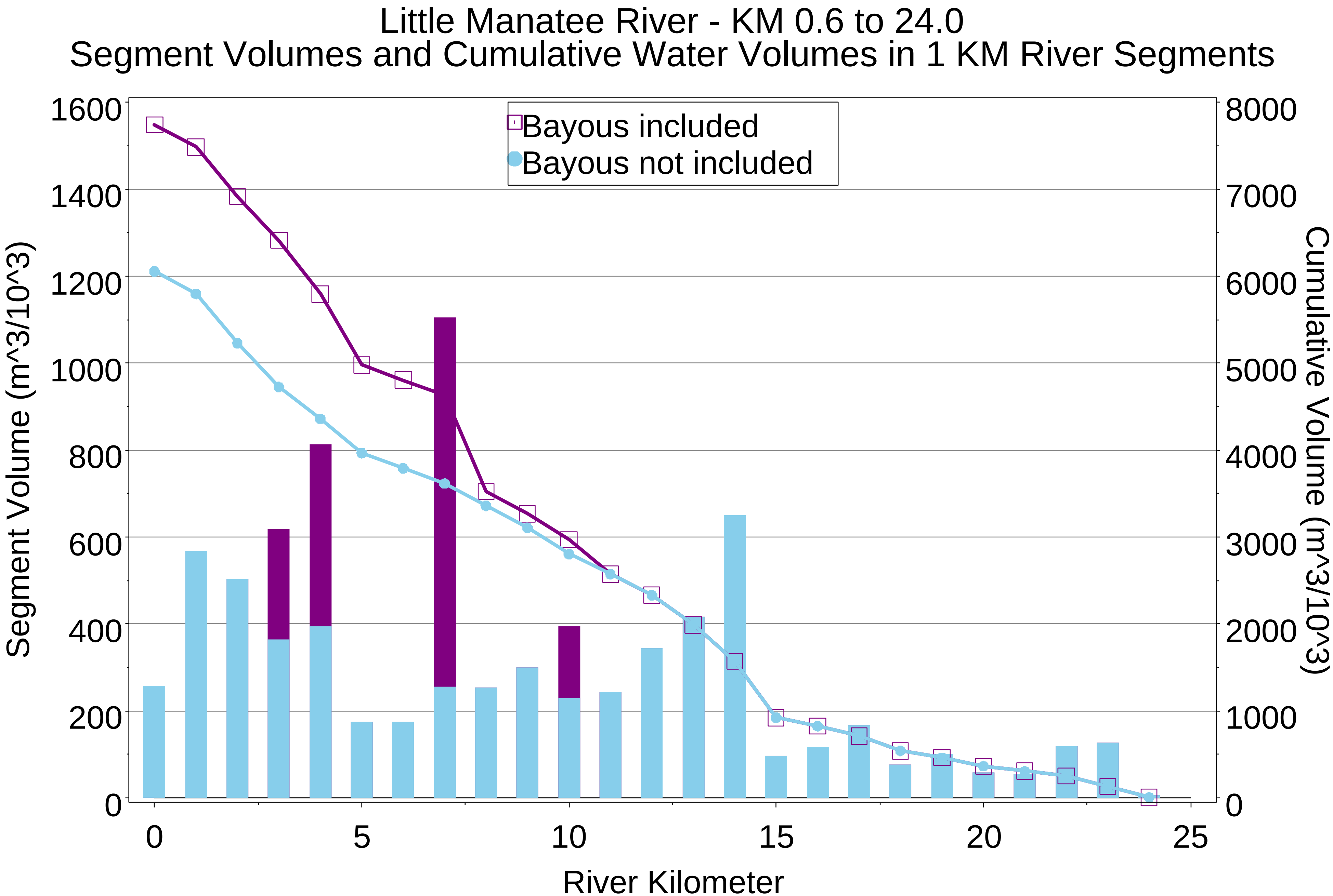
Table 6-9. Proposed minimum flows for the Little Manatee River.

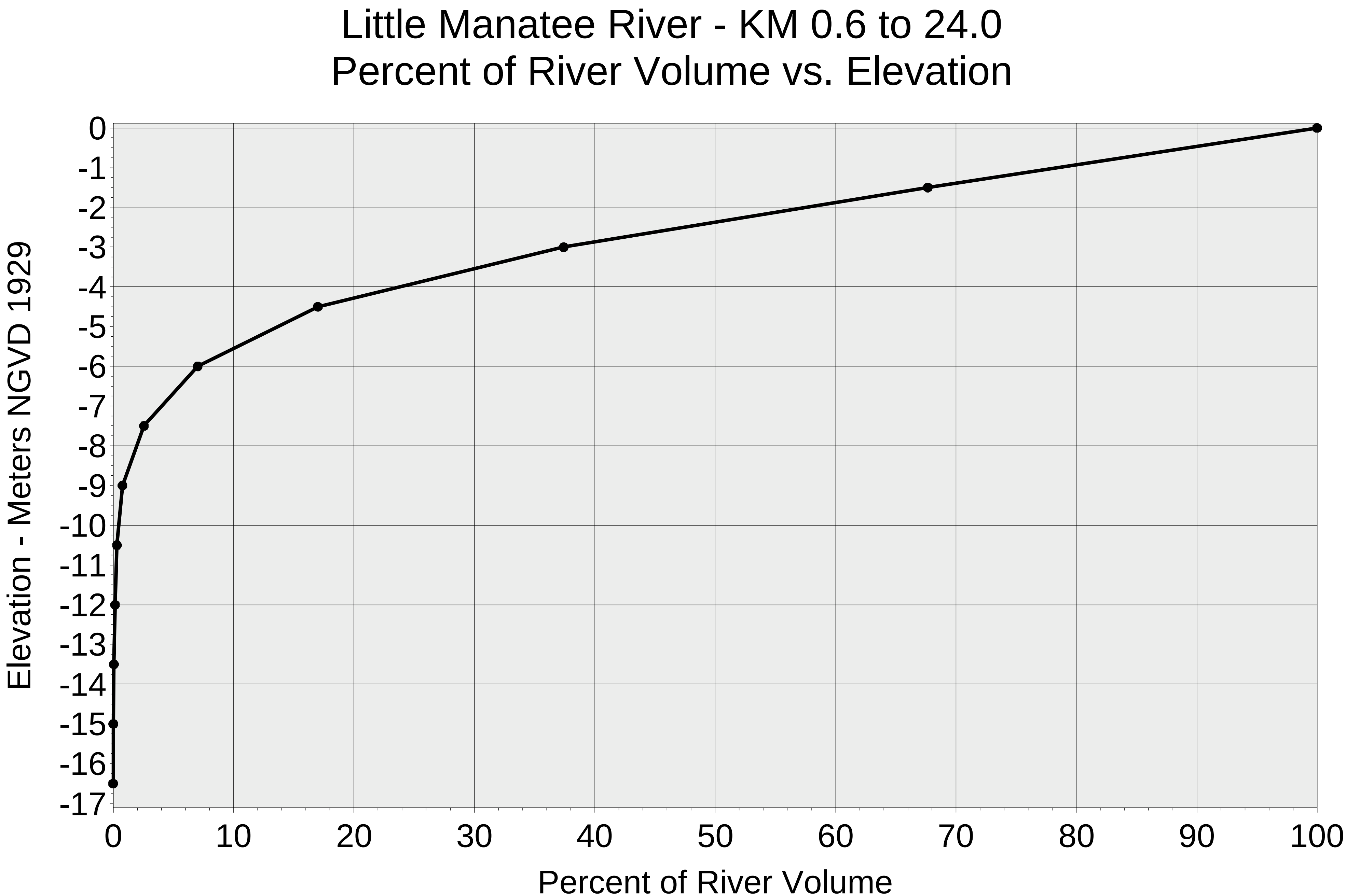
	Block 1 (≤ 35 cfs)	Block 2 (> 35 cfs and ≤ 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	87% of the flow on the previous day when the previous day's flow was > 72 cfs and ≤ 174 cfs, or 89% of the 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		

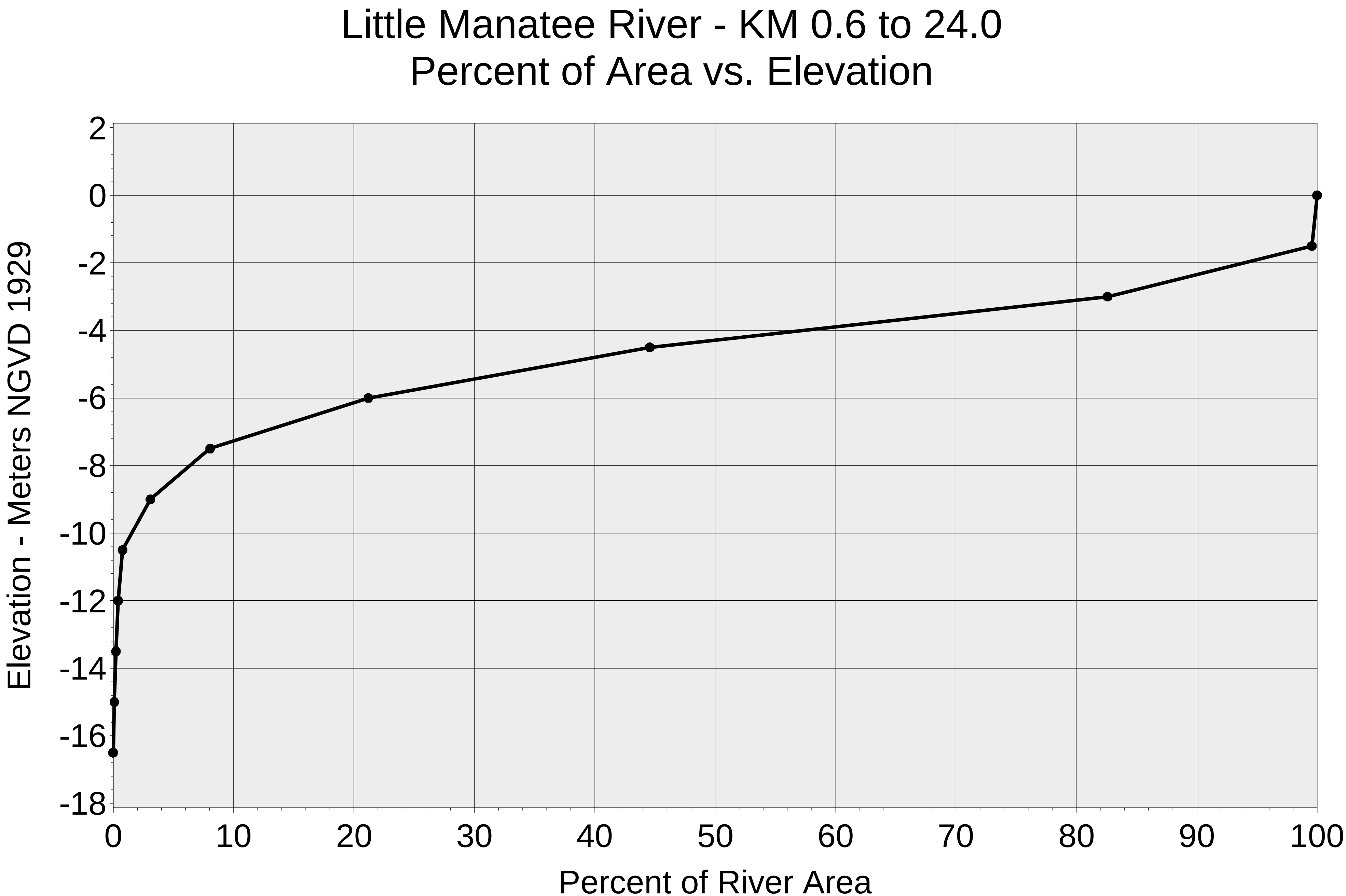

Station 182, Kilometer 13.6
Chlorophyll *a* vs. 5-day flow
Chlorophyll a ug/l
CFS
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
450

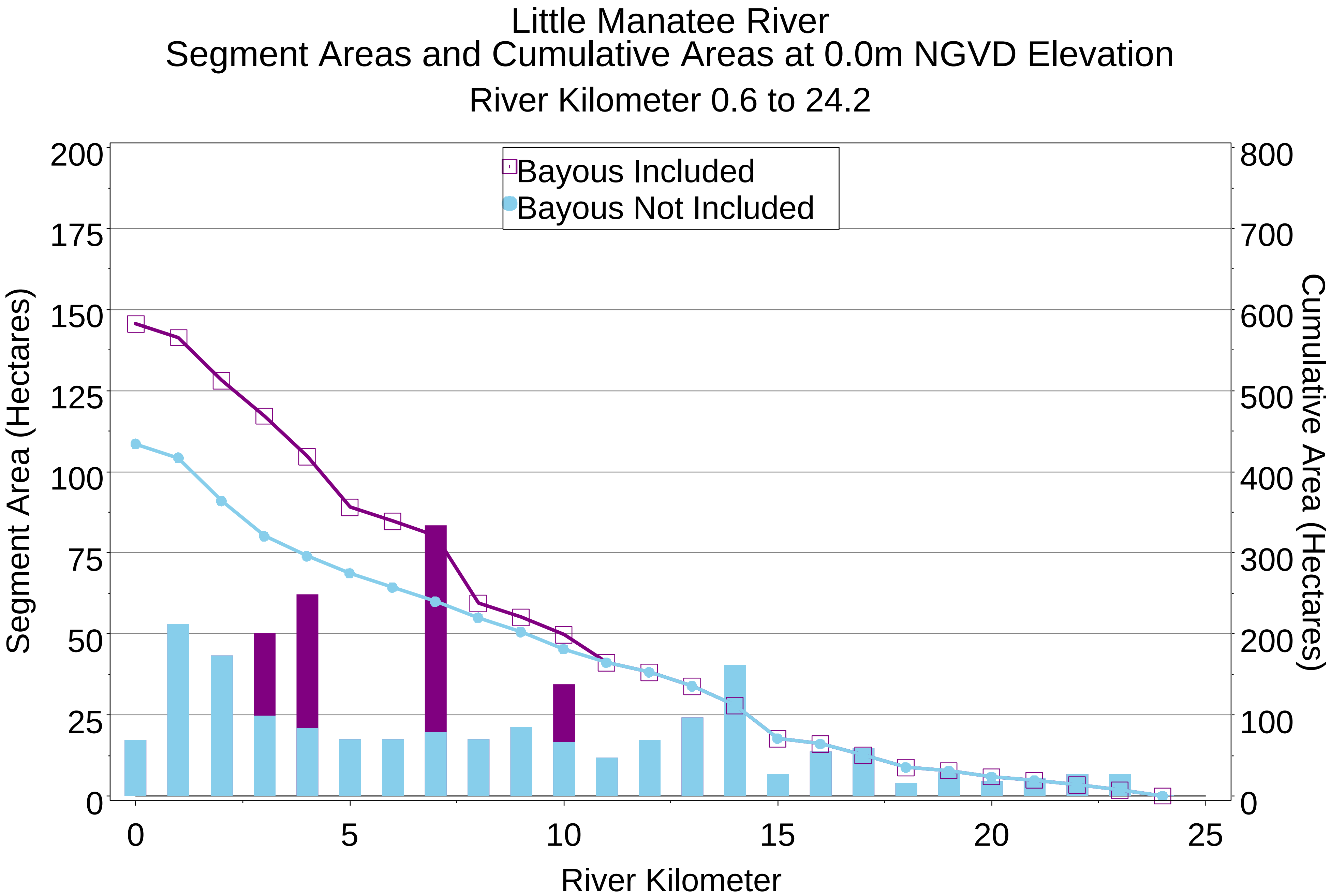

Little Manatee River Bathymetry
Elevation (cm) NGVD
99 - 100
70 - 99
50 - 70
20 - 50
0 - 20
-20 - 0
-50 - -20
-70 - -50
-100 - -70
-150 - -100
-200 - -150
-250 - -200
-300 - -250
-350 - -300
-400 - -350
-450 - -400
-500 - -450
-550 - -500
-582 - -550
N
S
E
W
0 500 1,000 2,000 3,000 4,000
m
353570 354570 355570 356570 357570 358570 359570 360570 361570 362570 363570 364570 365570 366570
3068973 3067973 3066973 3065973 3064973 3063973 3062973 3061973 3060973 3059973 3058973
UTM 17 Easting (m)
UTM 17 Northing (m)


0
-1
-2
-3
-4
Mean Depth (m)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Kilometer

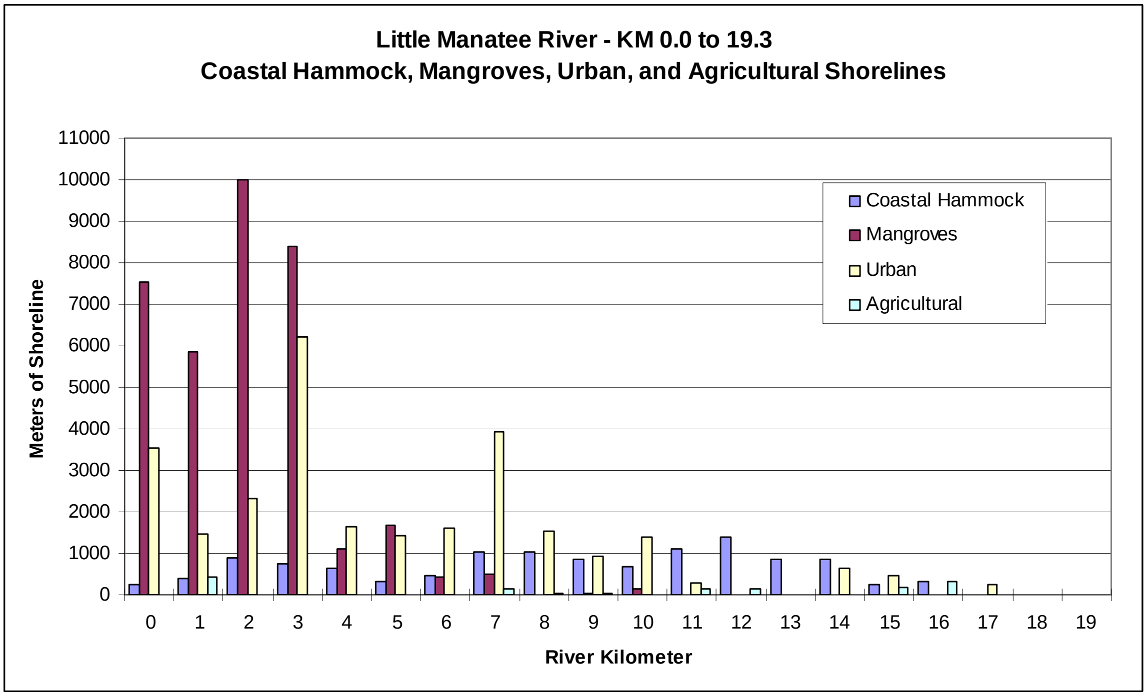

Little Manatee River - KM 0.6 to 24.0
Segment Volumes and Cumulative Water Volumes in 1 KM River Segments
Bayous included
Bayous not included
Segment Volume (m^3/10^3)
Cumulative Volume (m^3/10^3)
River Kilometer
0
200
400
600
800
1000
1200
1400
1600
1000
2000
3000
4000
5000
6000
7000
8000
5
10
15
20
25

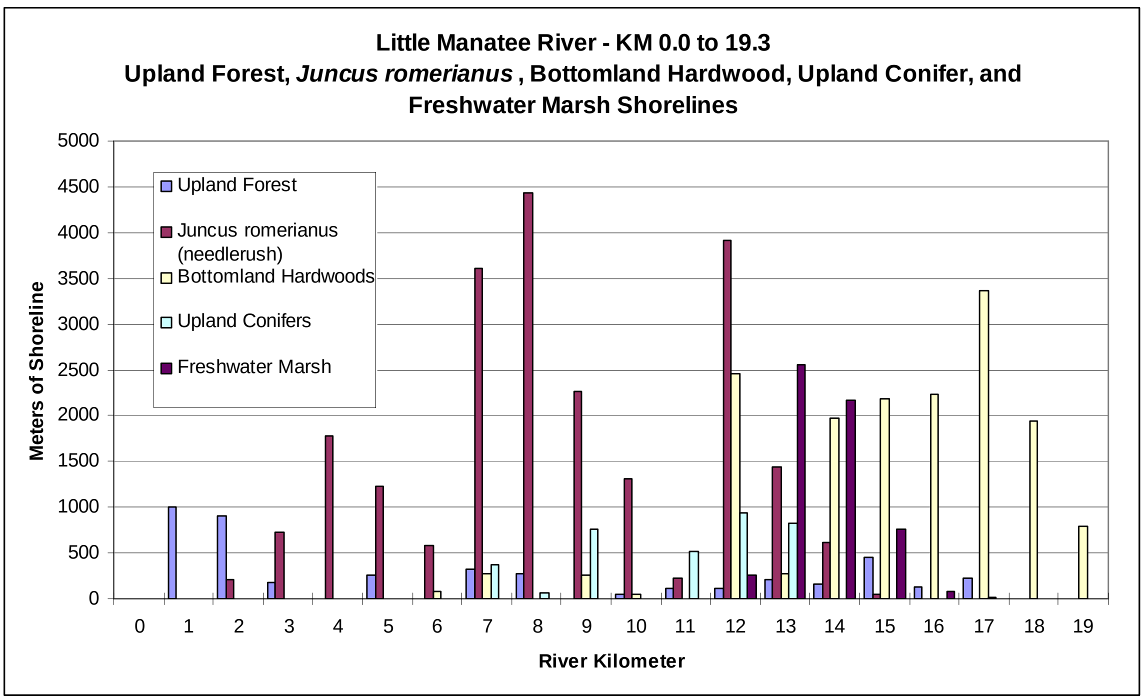

Little Manatee River - KM 0.6 to 24.0
Percent of River Volume vs. Elevation
Elevation - Meters NGVD 1929
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
0
10
20
30
40
50
60
70
80
90
100
Percent of River Volume

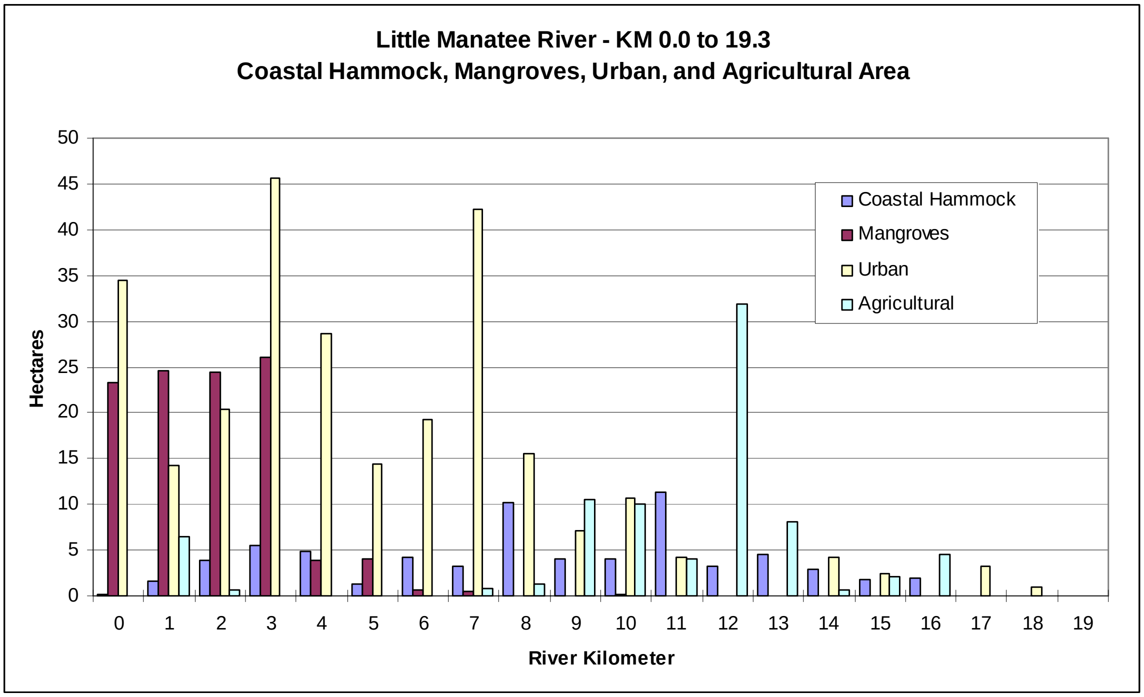

Little Manatee River - KM 0.6 to 24.0
Percent of Area vs. Elevation
Elevation - Meters NGVD 1929
Percent of River Area
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
10
20
30
40
50
60
70
80
90
100



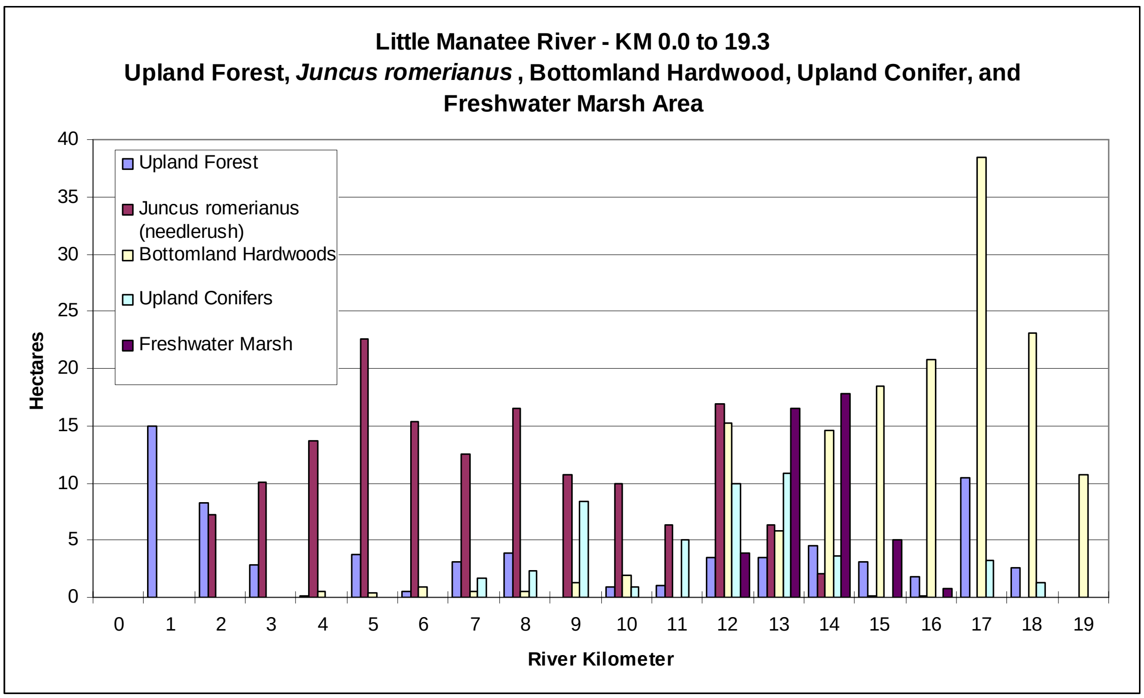
Little Manatee River
Segment Areas and Cumulative Areas at 0.0m NGVD Elevation
River Kilometer 0.6 to 24.2
Bayous Included
Bayous Not Included
Segment Area (Hectares)
Cumulative Area (Hectares)
River Kilometer
0
25
50
75
100
125
150
175
200
100
200
300
400
500
600
700
800
5
10
15
20
25


Little Manatee River - KM 0.0 to 19.3
Coastal Hammock, Mangroves, Urban, and Agricultural Shorelines
Meters of Shoreline
River Kilometer
Coastal Hammock
Mangroves
Urban
Agricultural
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

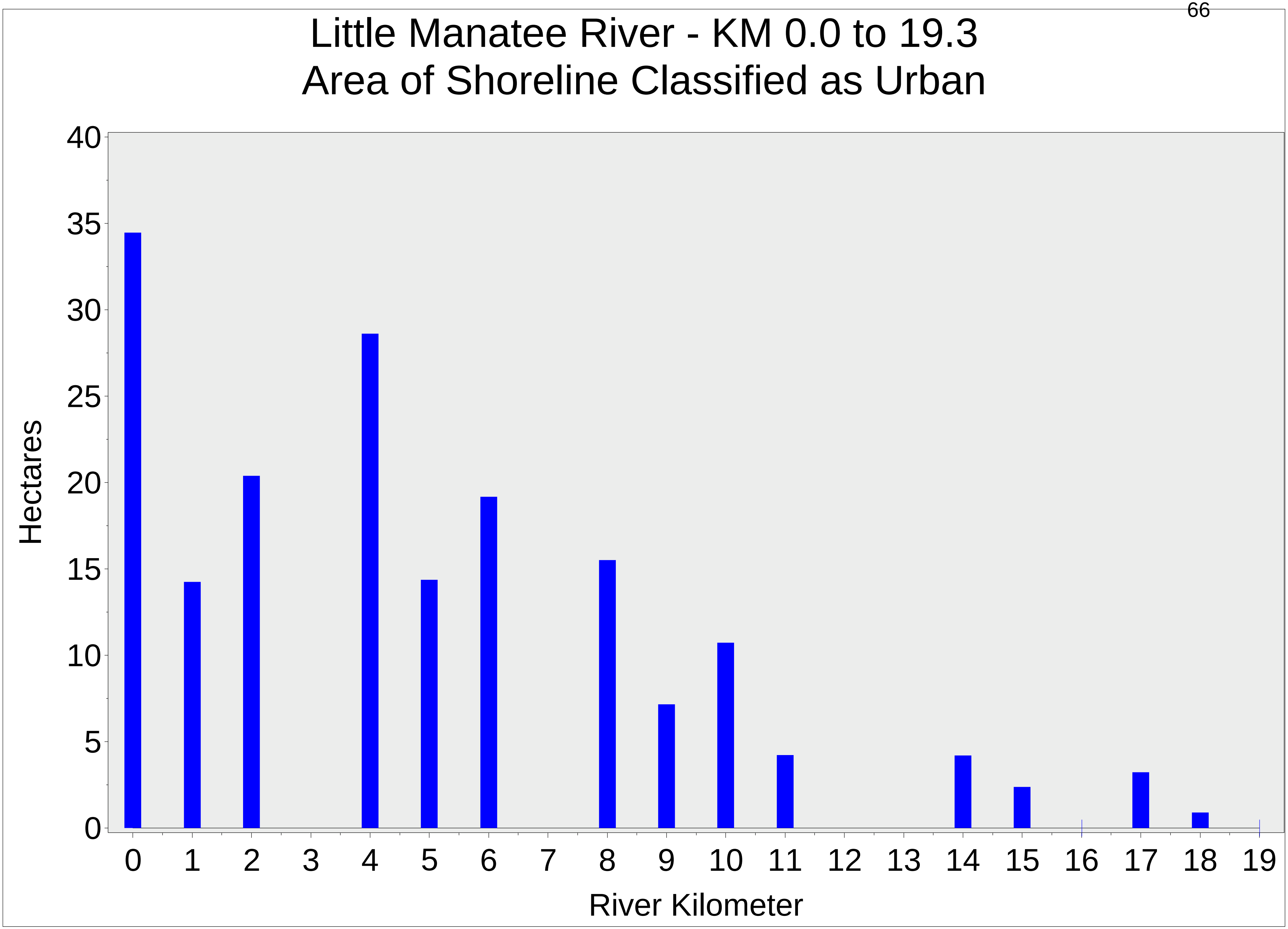

Little Manatee River - KM 0.0 to 19.3
Upland Forest, *Juncus romerianus* , Bottomland Hardwood, Upland Conifer, and Freshwater Marsh Shorelines
Meters of Shoreline
River Kilometer
Upland Forest
Juncus romerianus (needlerush)
Bottomland Hardwoods
Upland Conifers
Freshwater Marsh
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19



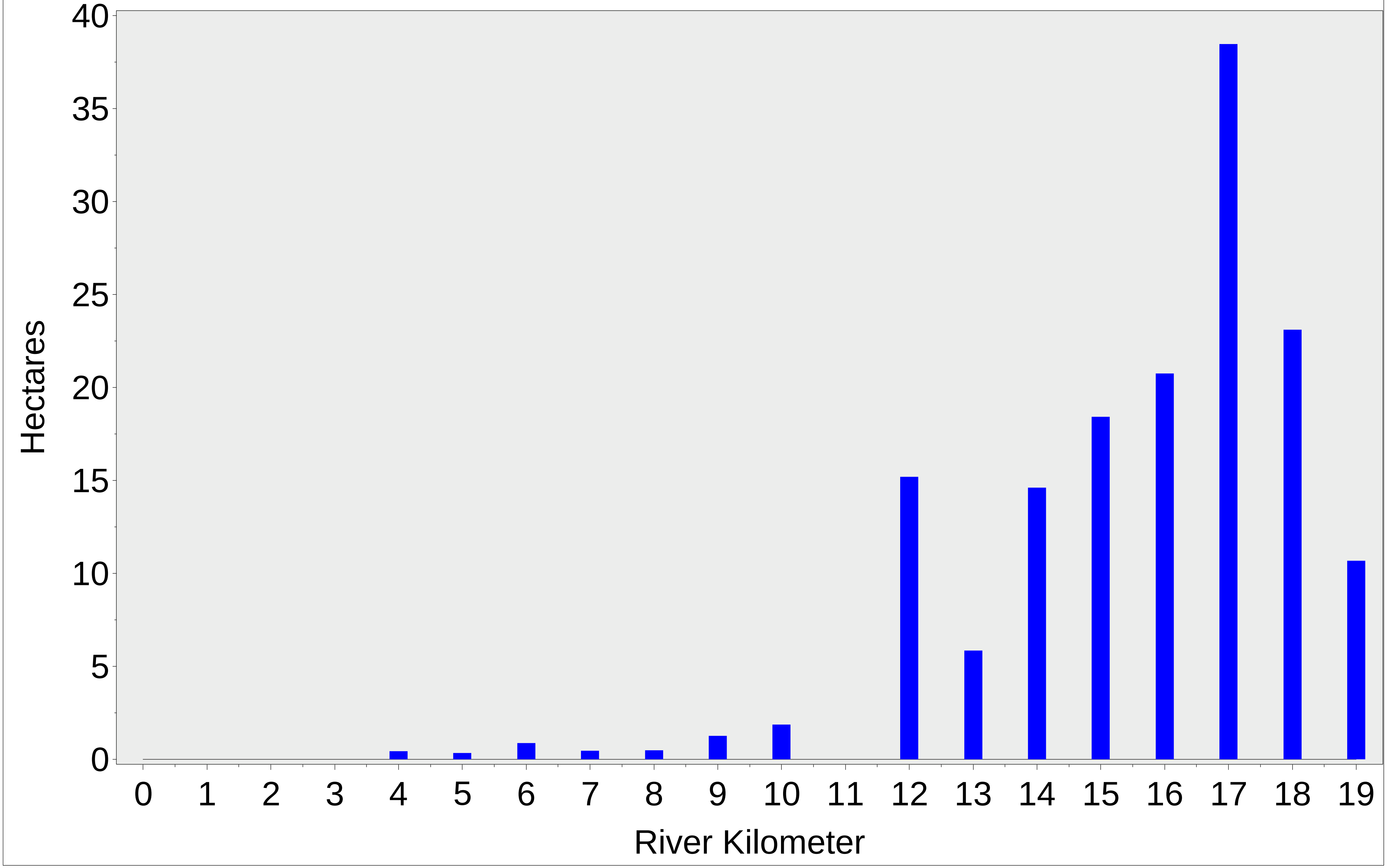
Little Manatee River - KM 0.0 to 19.3
Coastal Hammock, Mangroves, Urban, and Agricultural Area
Hectares
River Kilometer
Coastal Hammock
Mangroves
Urban
Agricultural
0
5
10
15
20
25
30
35
40
45
50
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

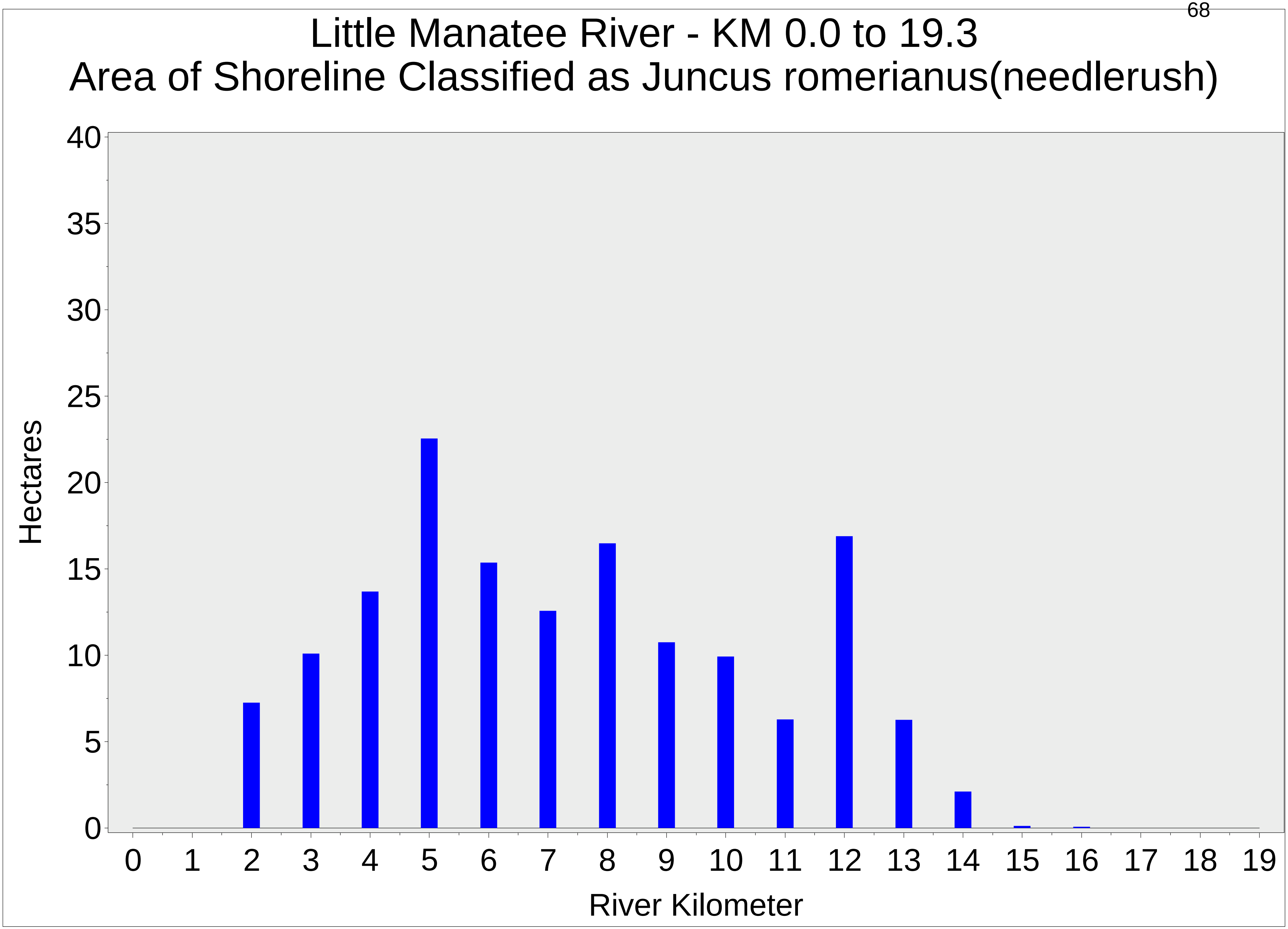


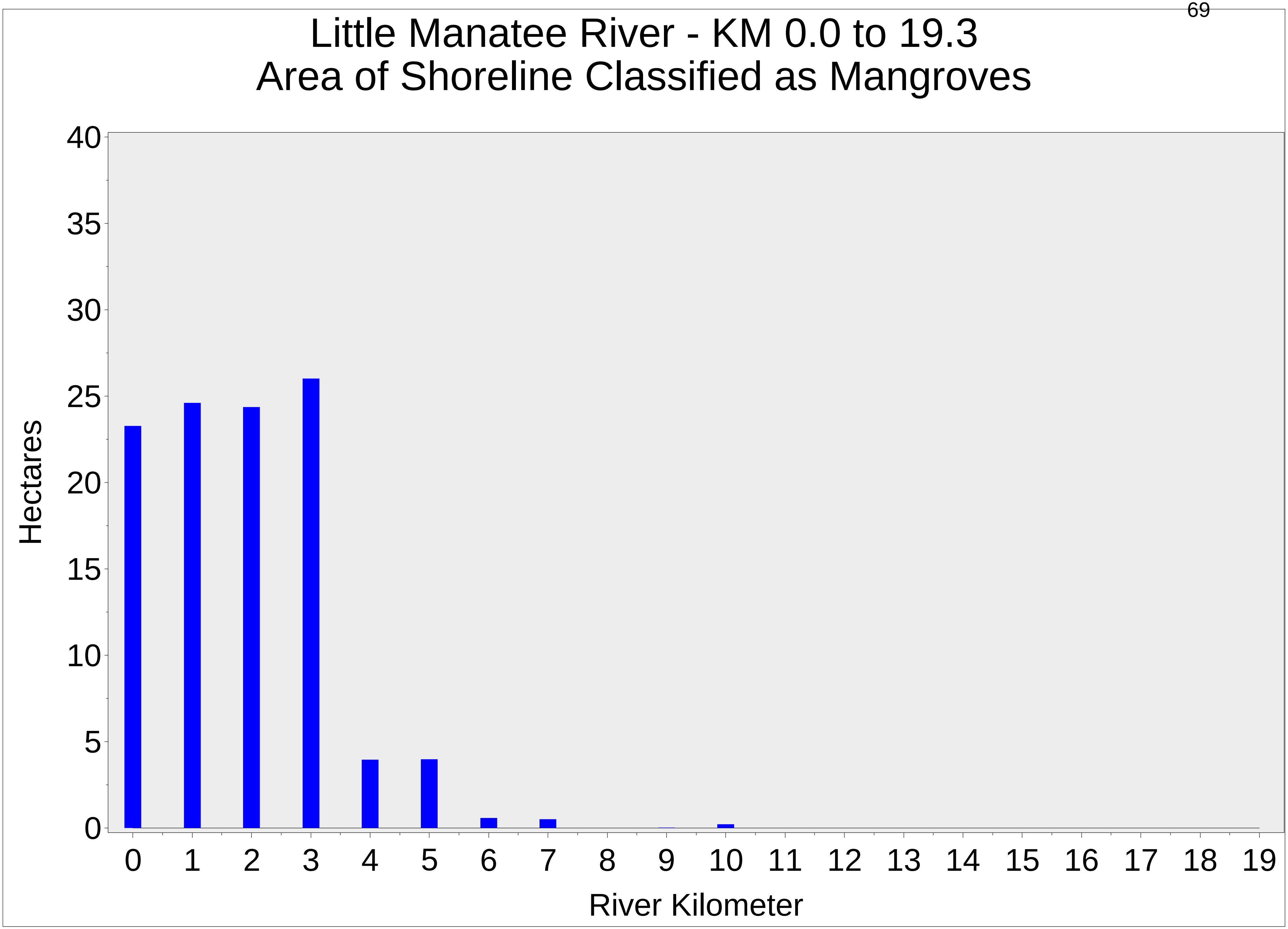
Little Manatee River - KM 0.0 to 19.3
Upland Forest, *Juncus romerianus* , Bottomland Hardwood, Upland Conifer, and Freshwater Marsh Area
Hectares
River Kilometer
Upland Forest
Juncus romerianus (needlerush)
Bottomland Hardwoods
Upland Conifers
Freshwater Marsh
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

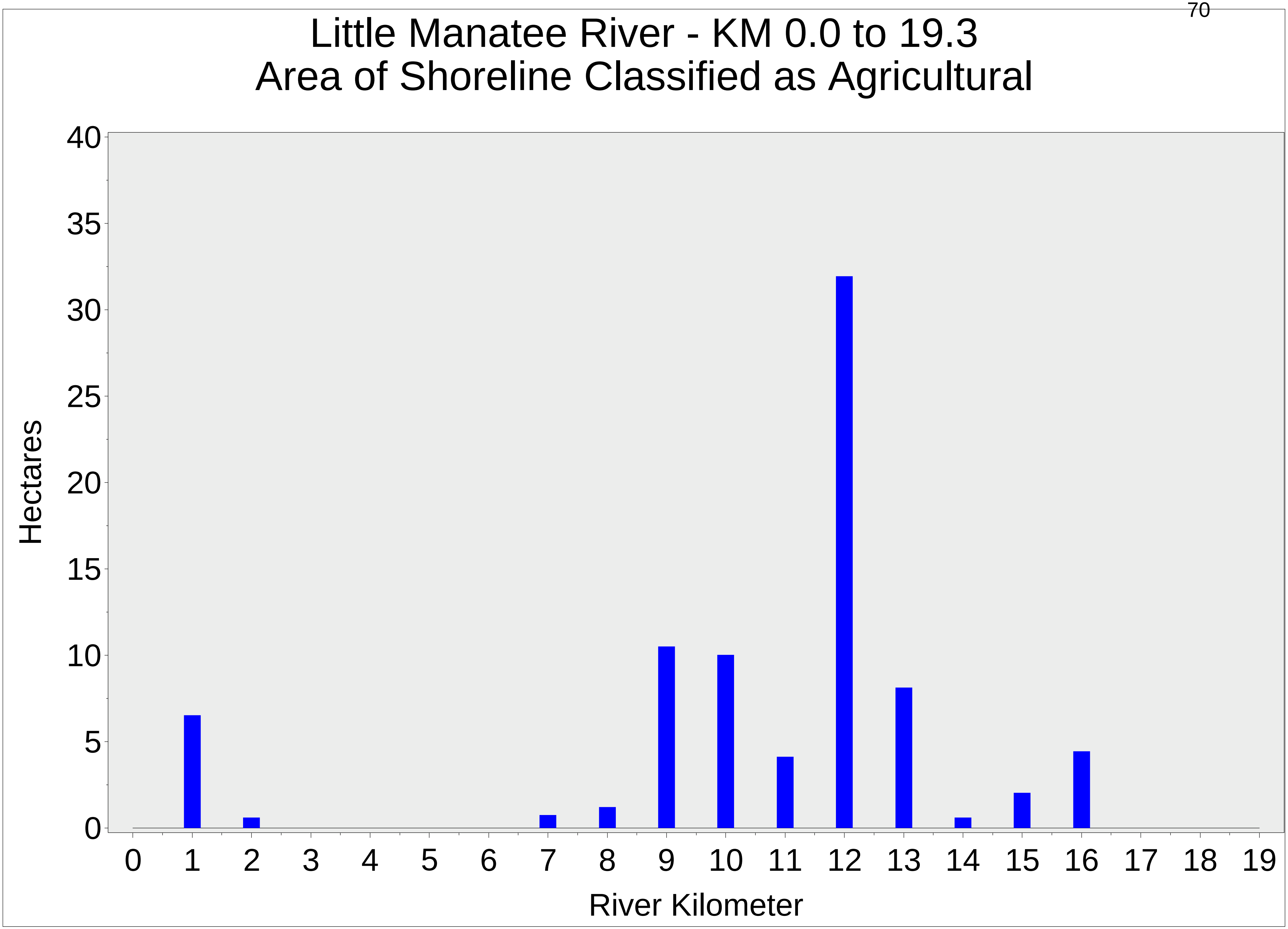

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Urban
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

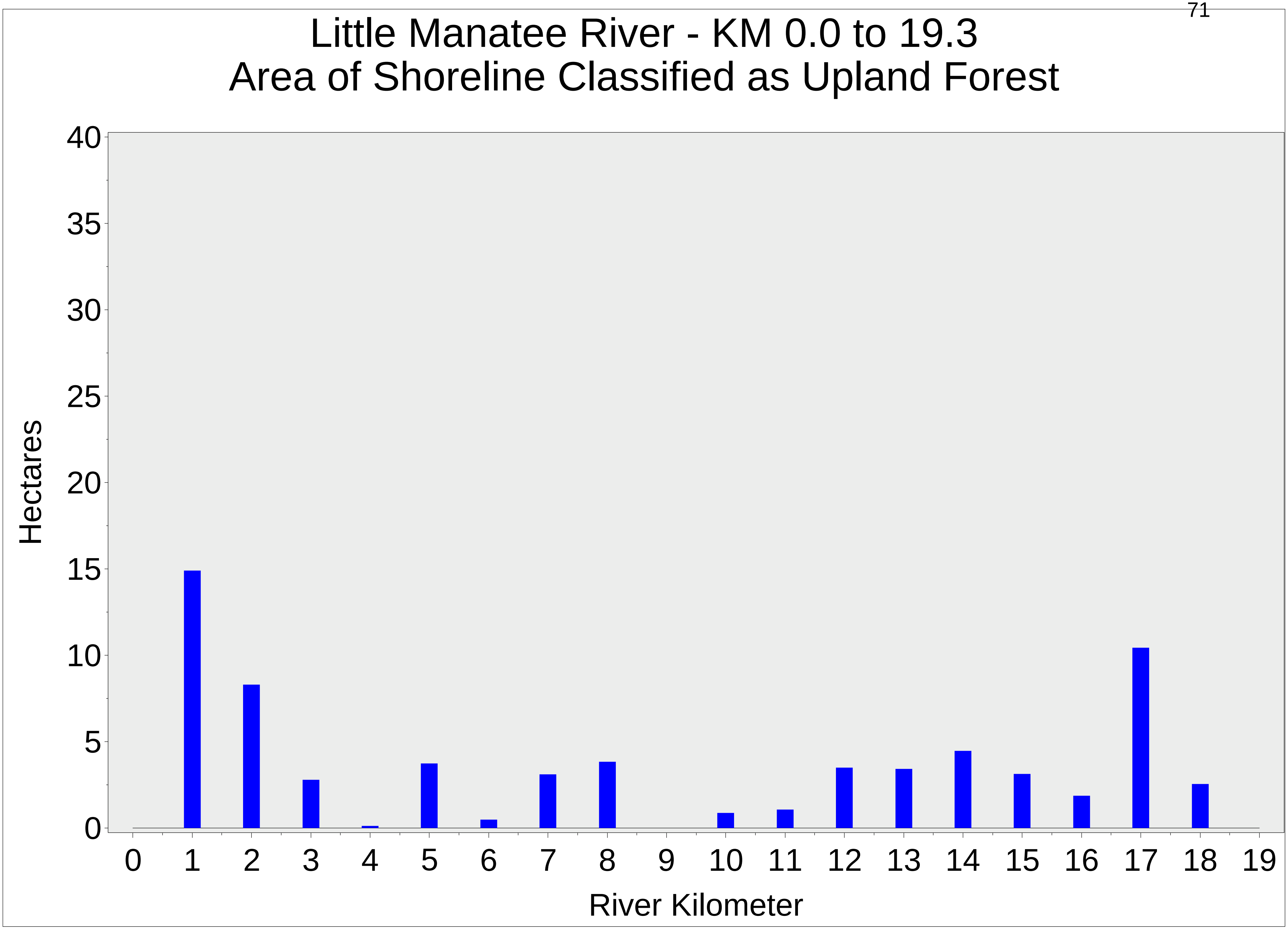
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Bottomland Hardwoods



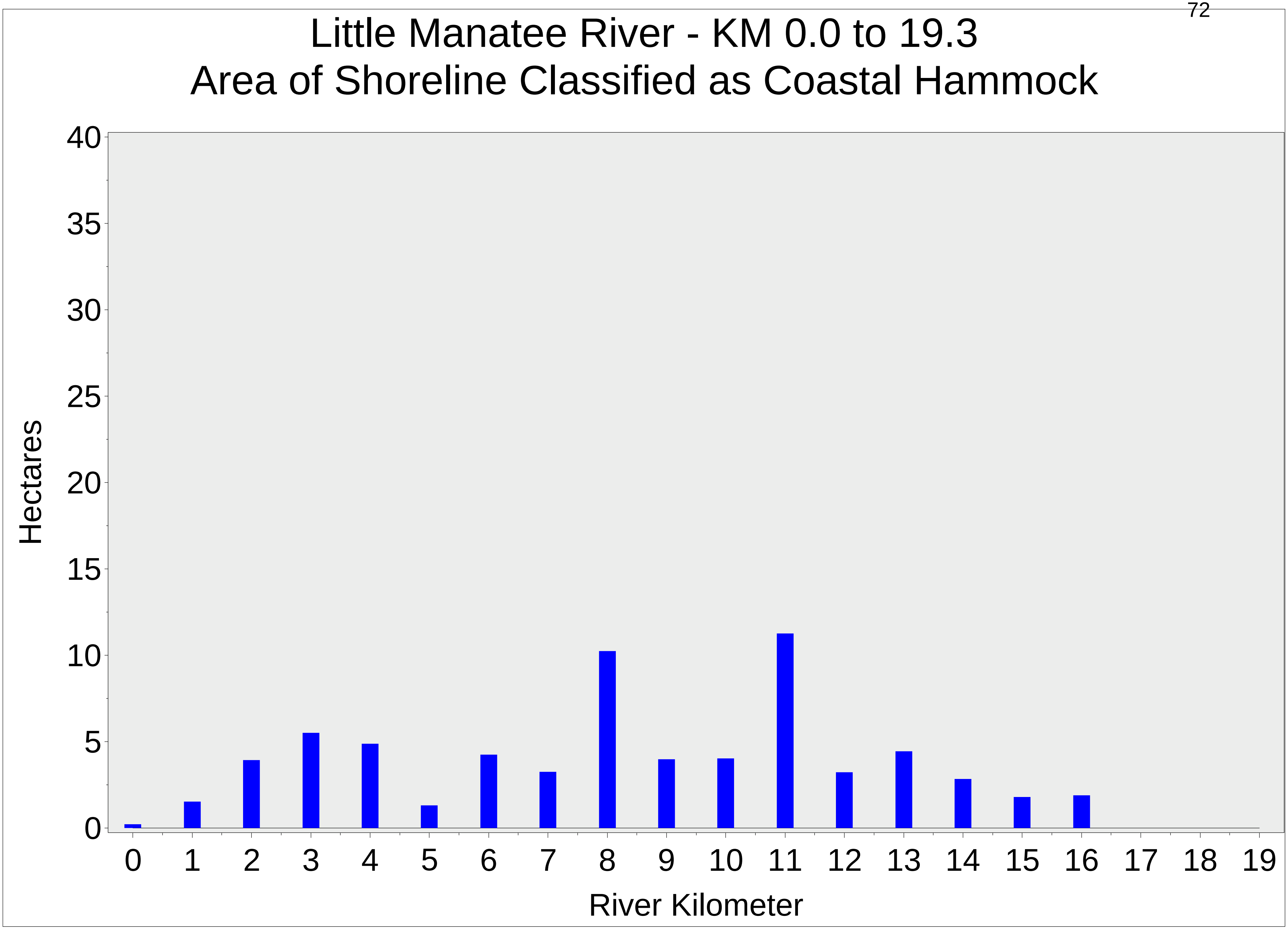

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Juncus romerianus(needlerush)
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Mangroves
Hectares
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

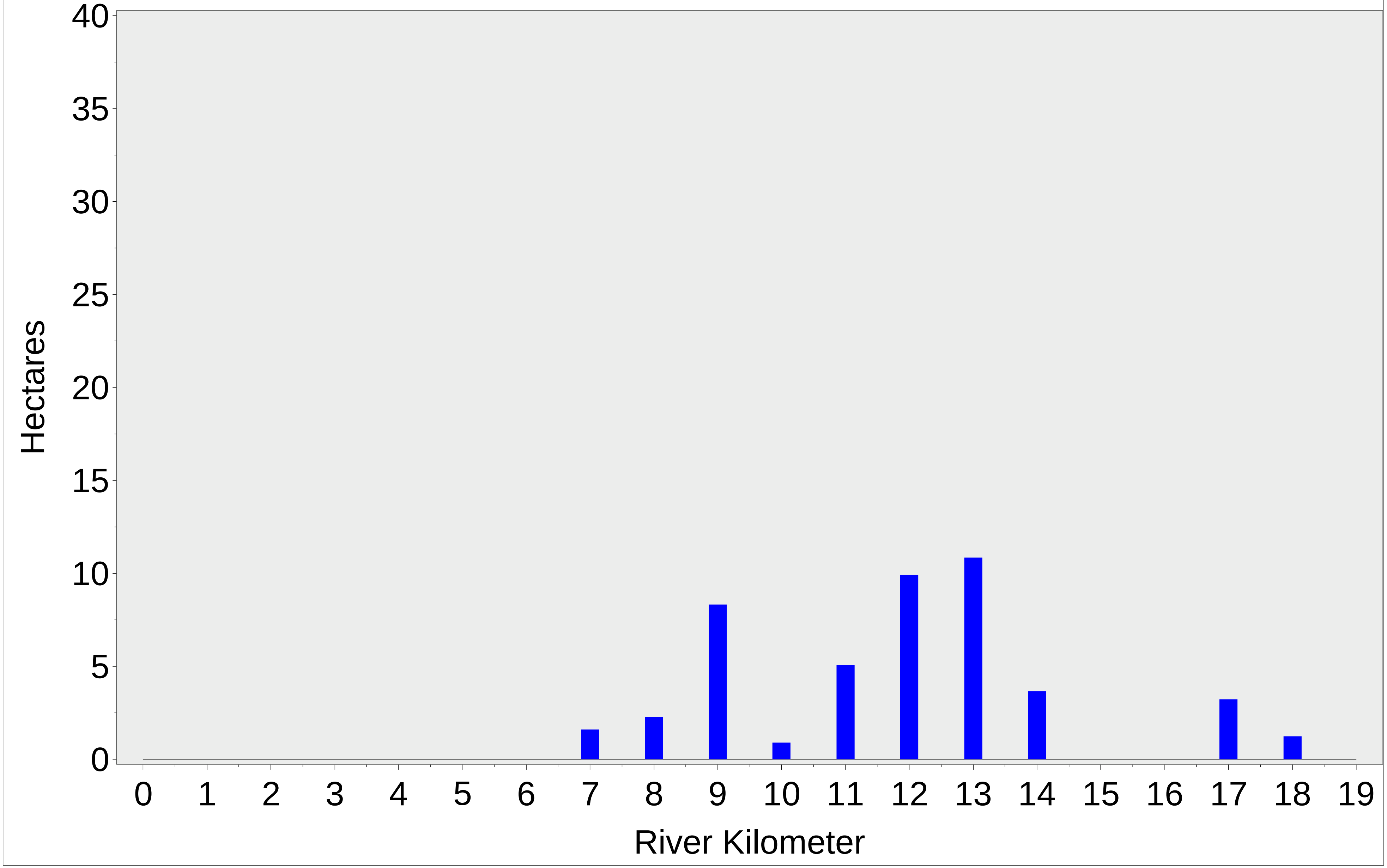

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Agricultural
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

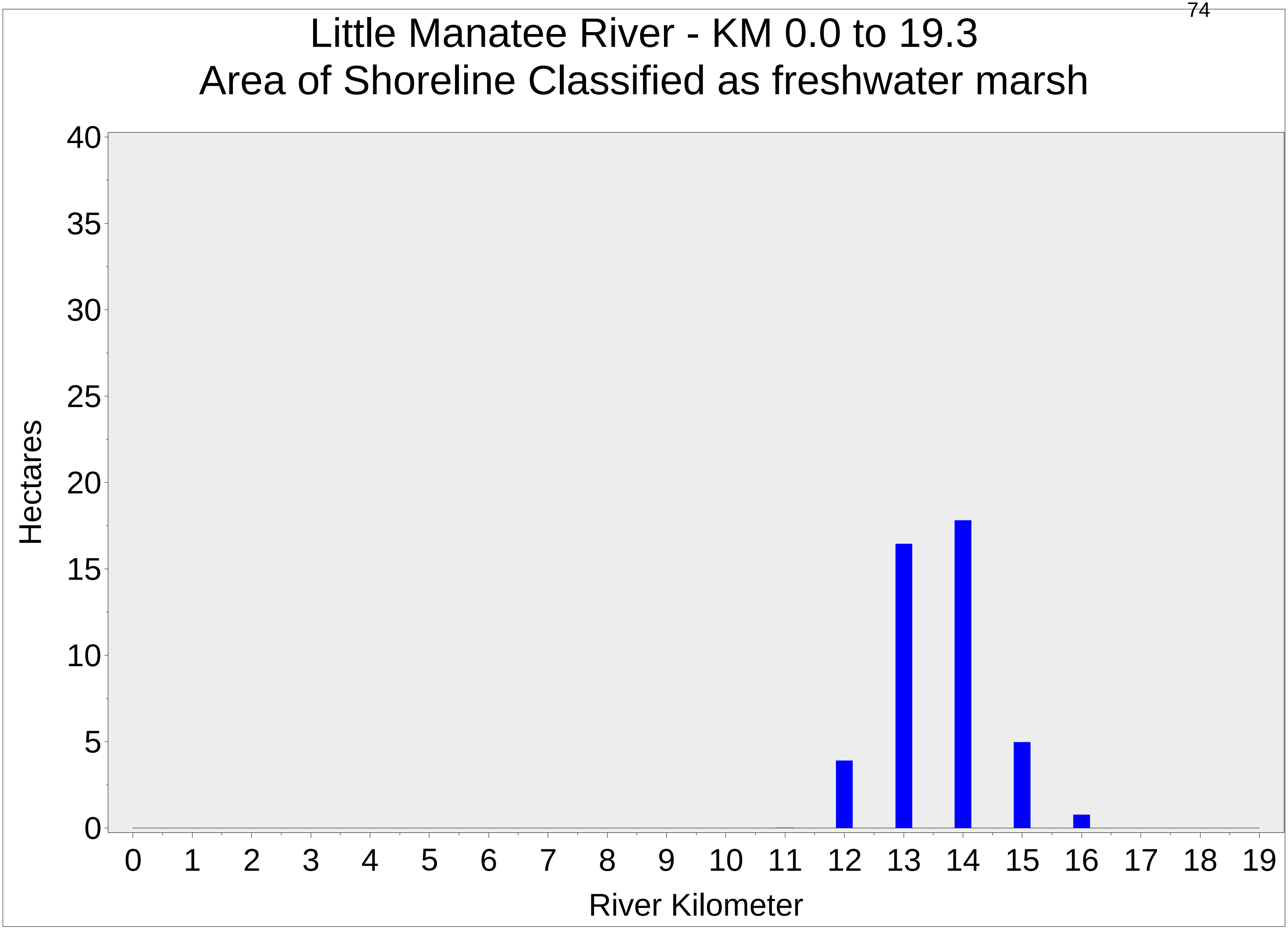


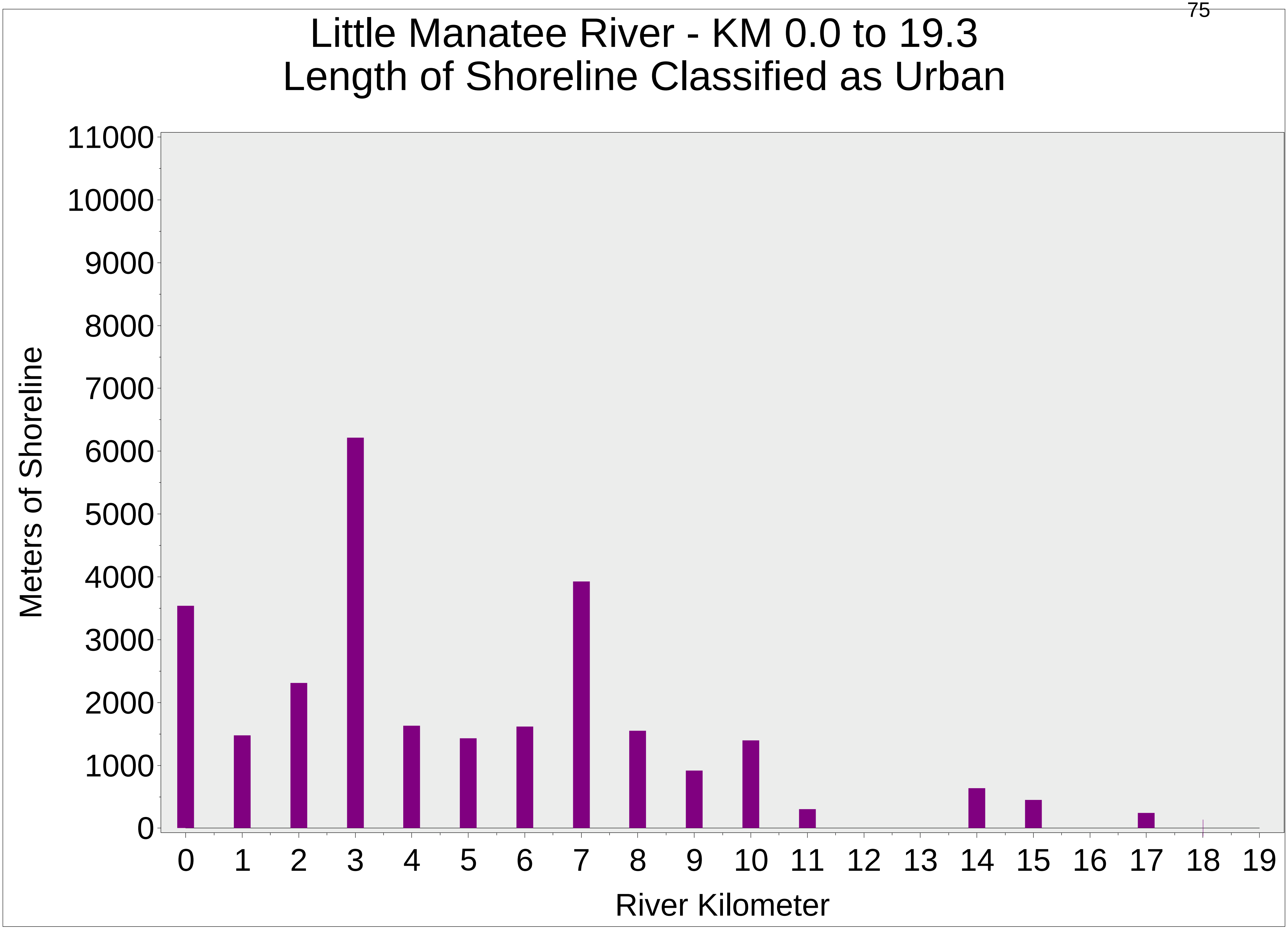
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Upland Forest
Hectares
River Kilometer
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

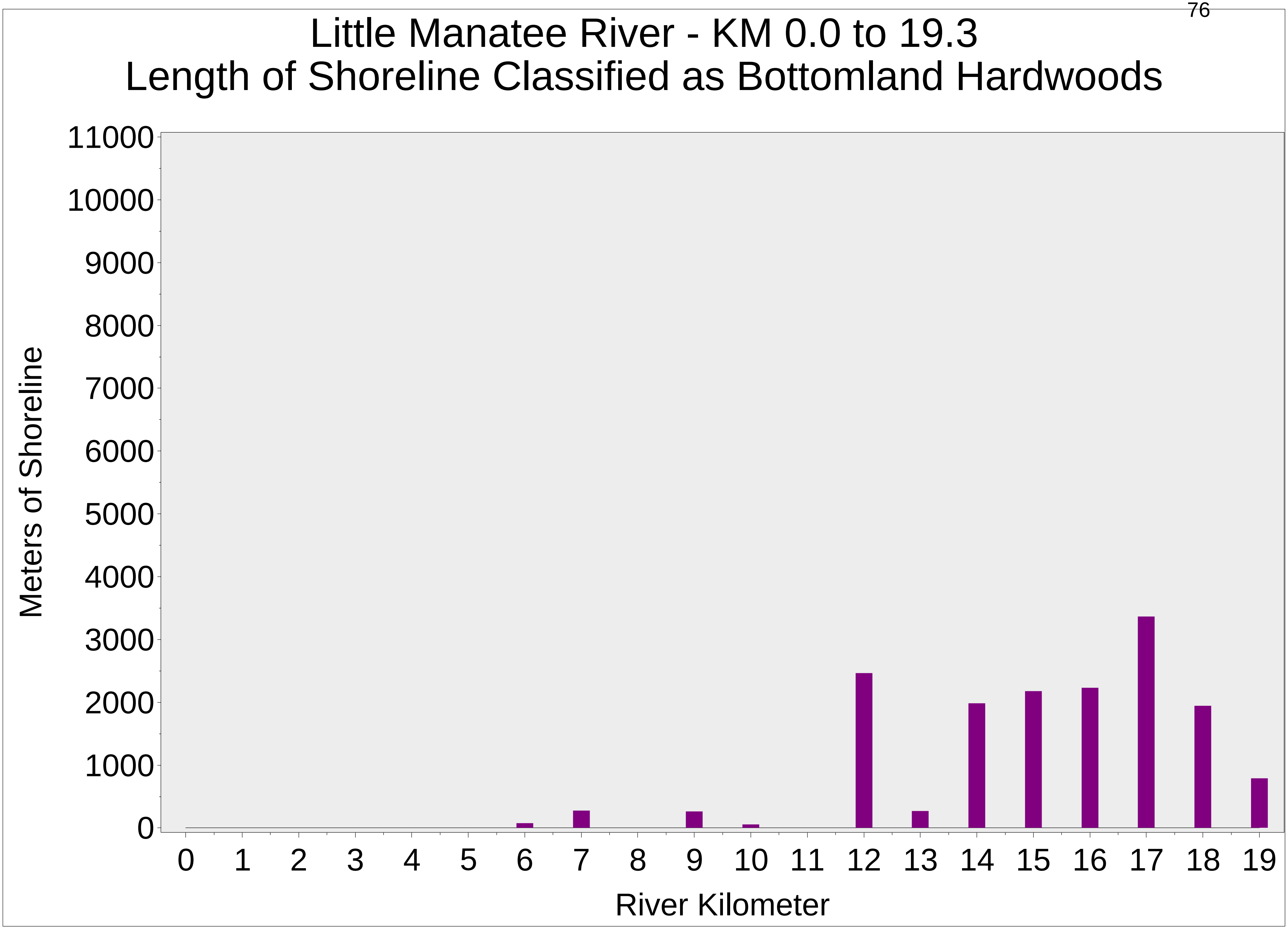

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Coastal Hammock
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Upland Conifers

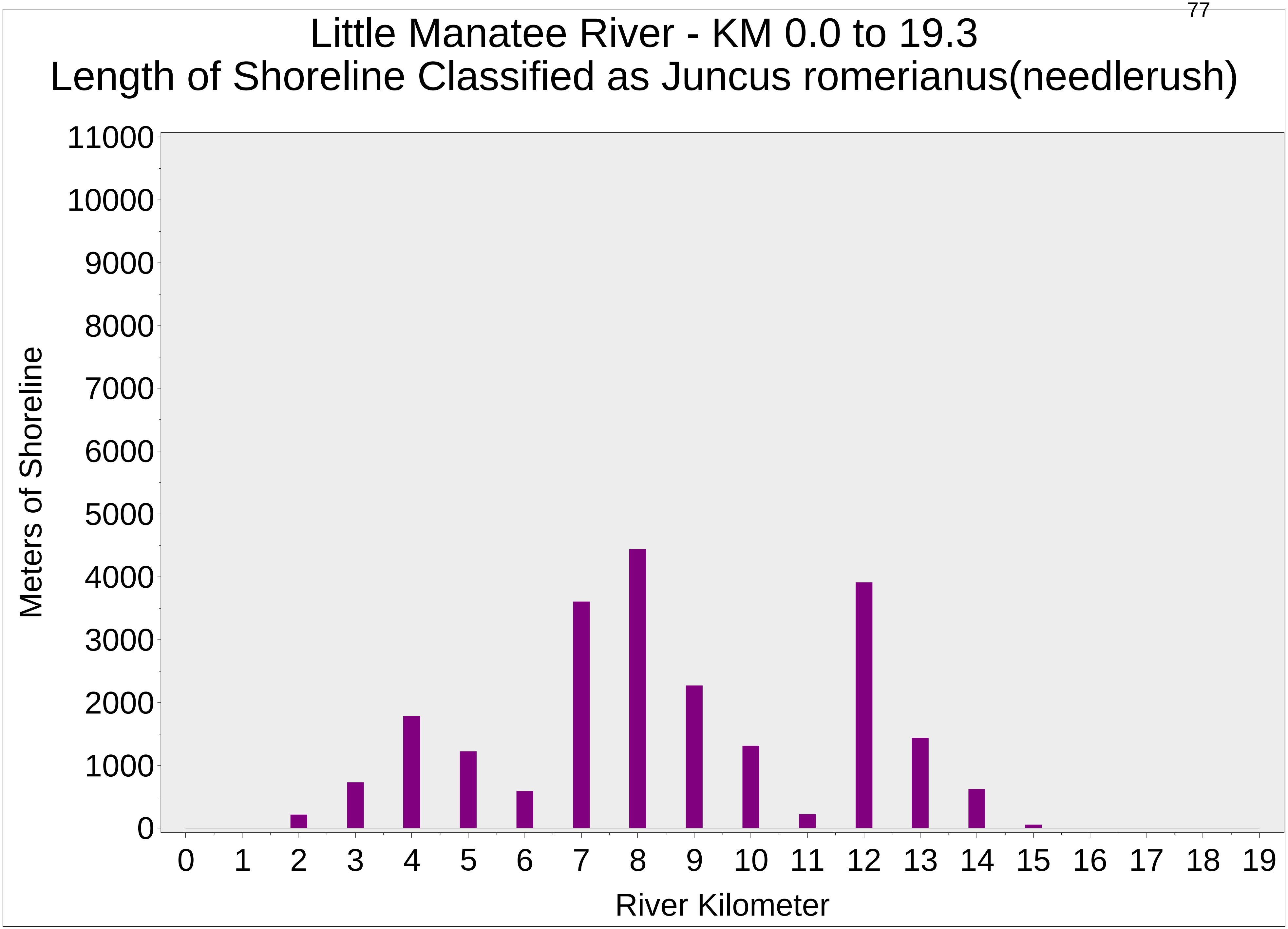


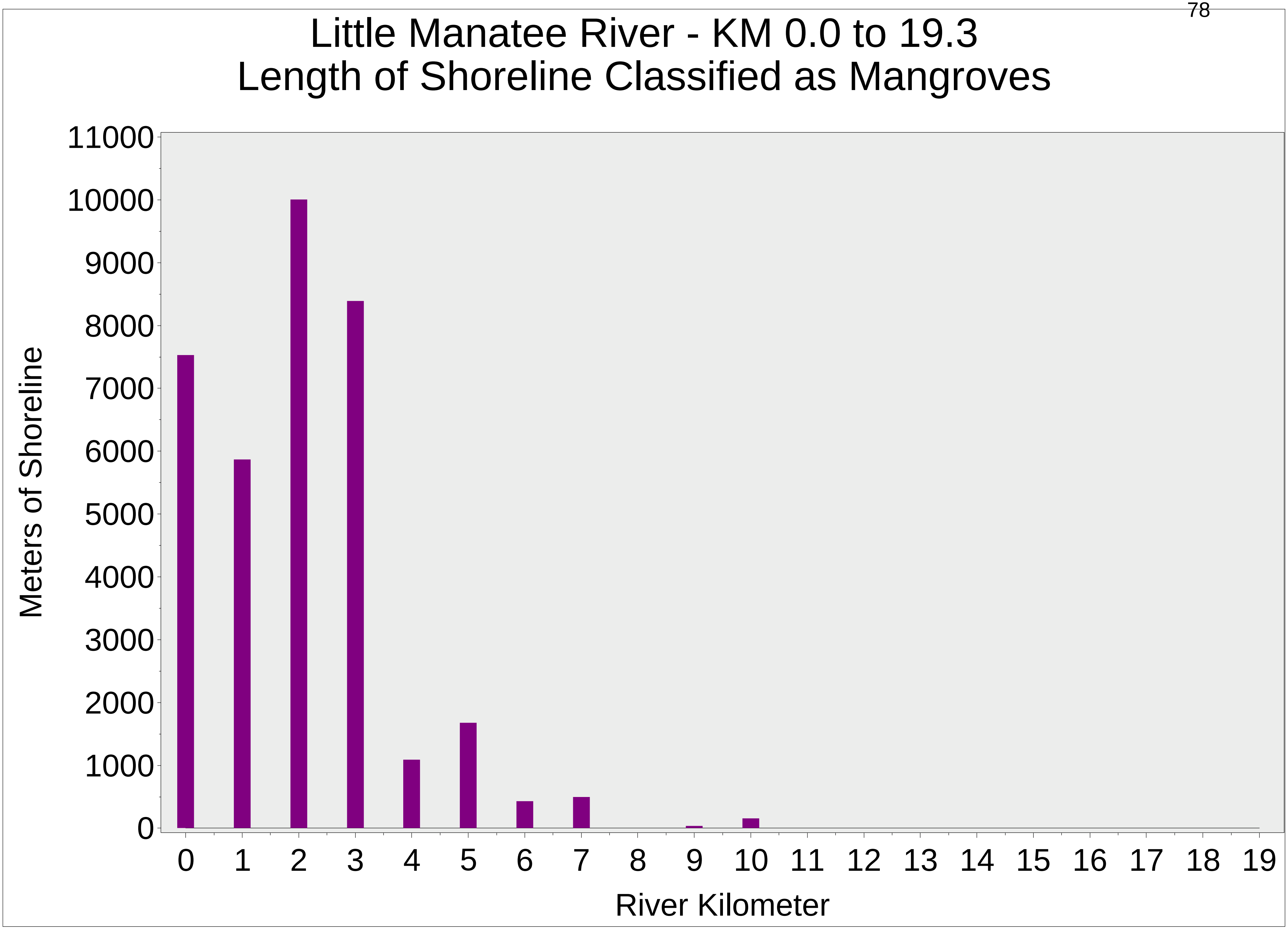

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as freshwater marsh
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

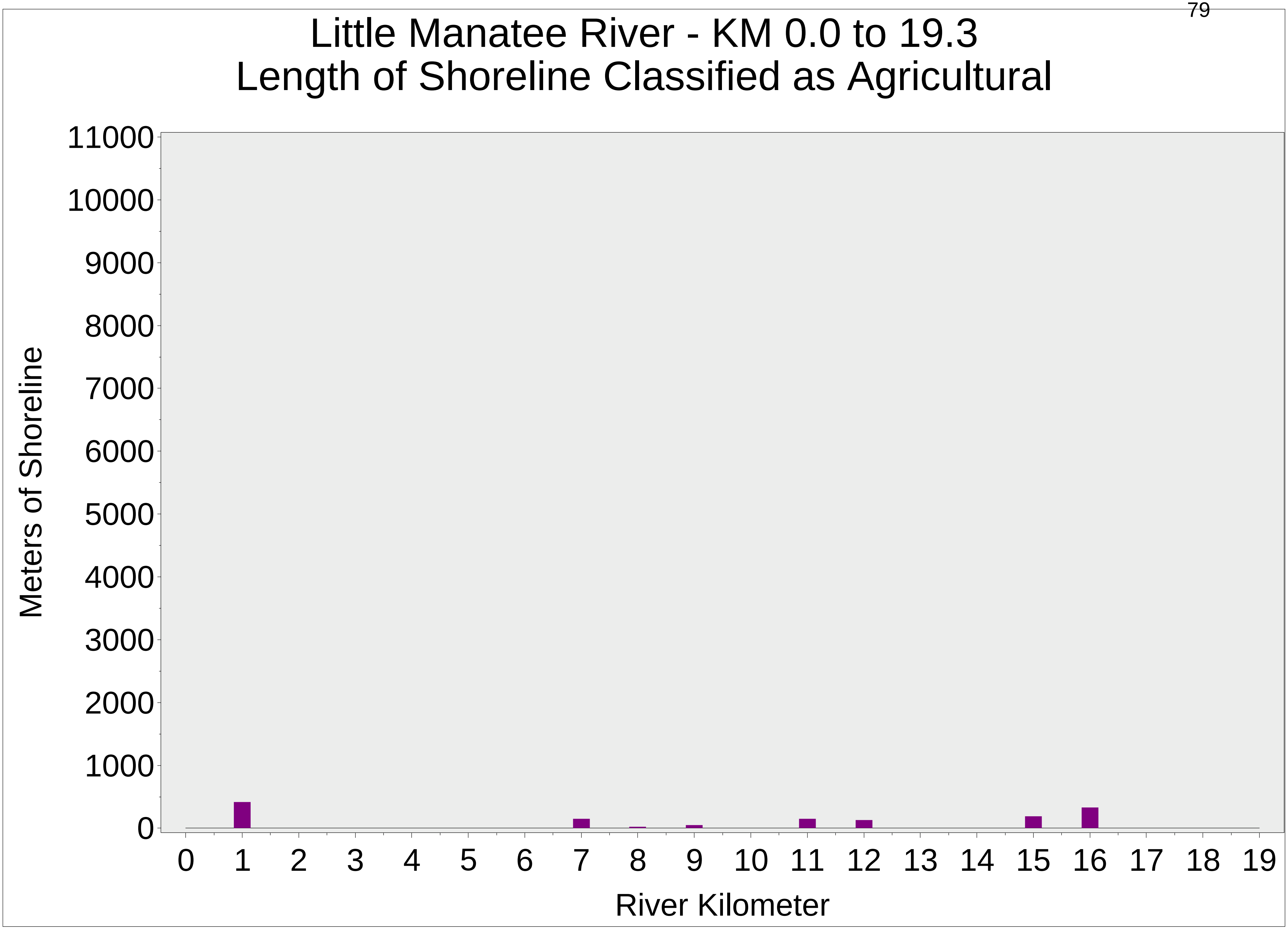

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Urban
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

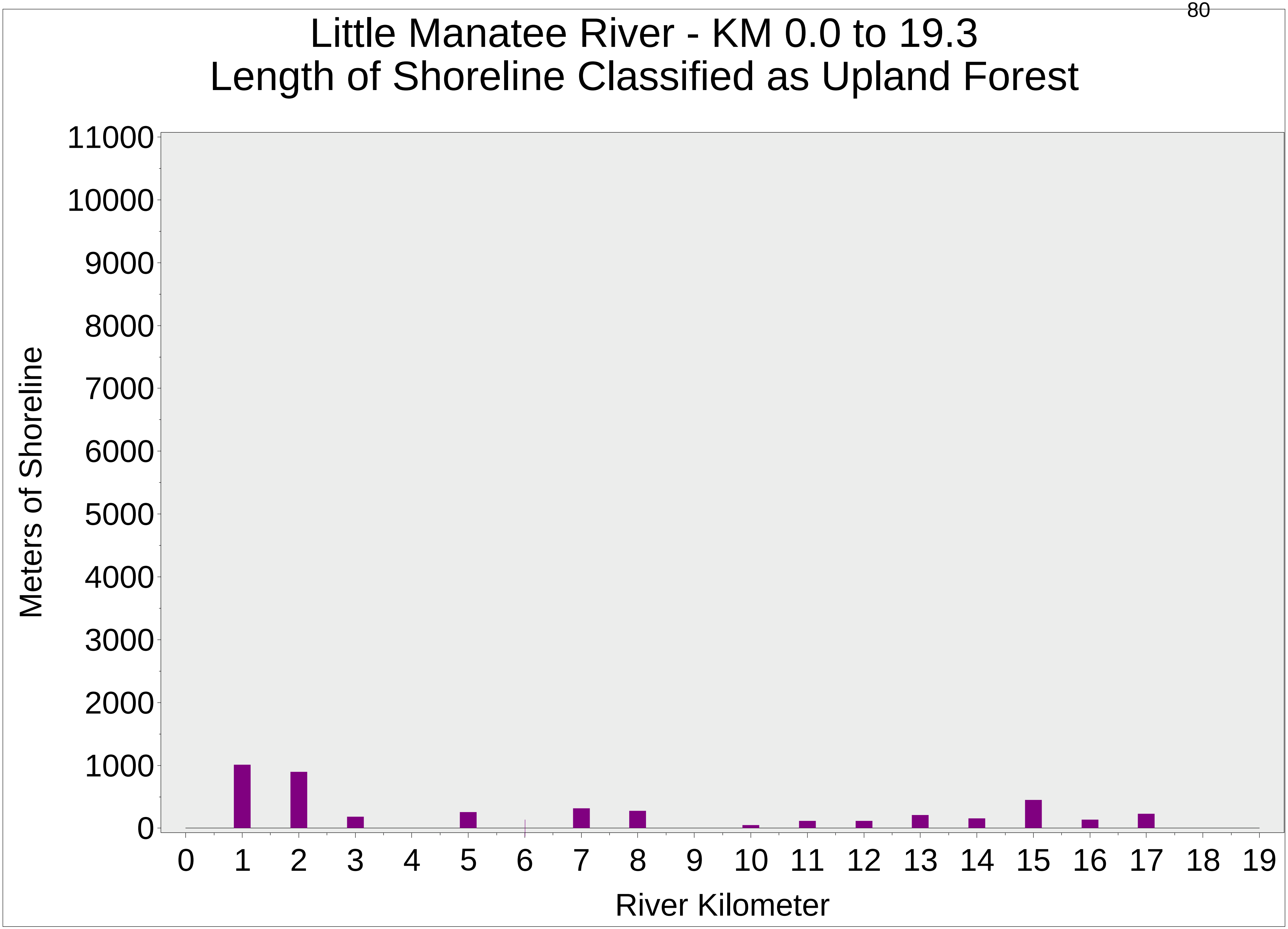


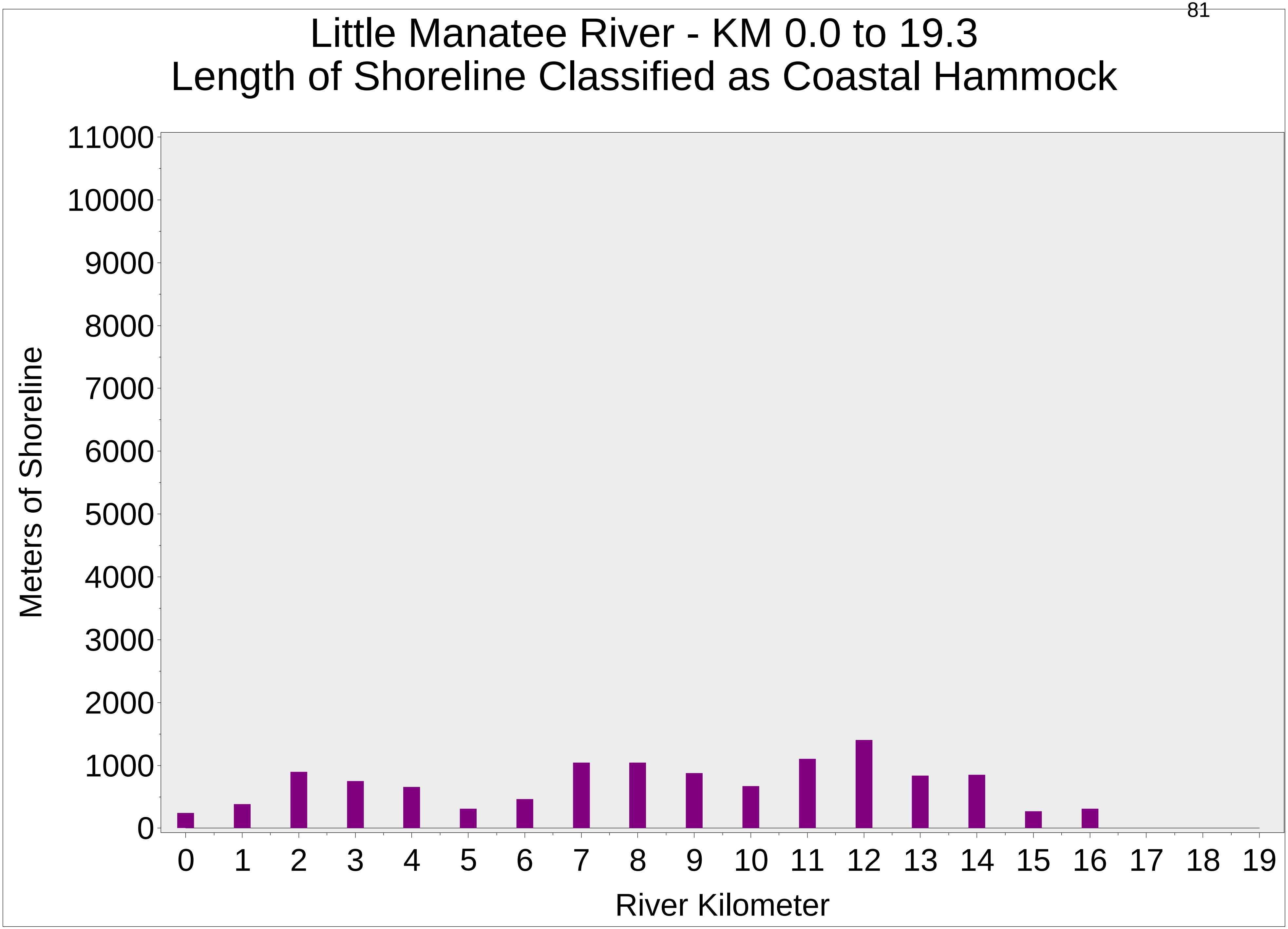
Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Bottomland Hardwoods
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

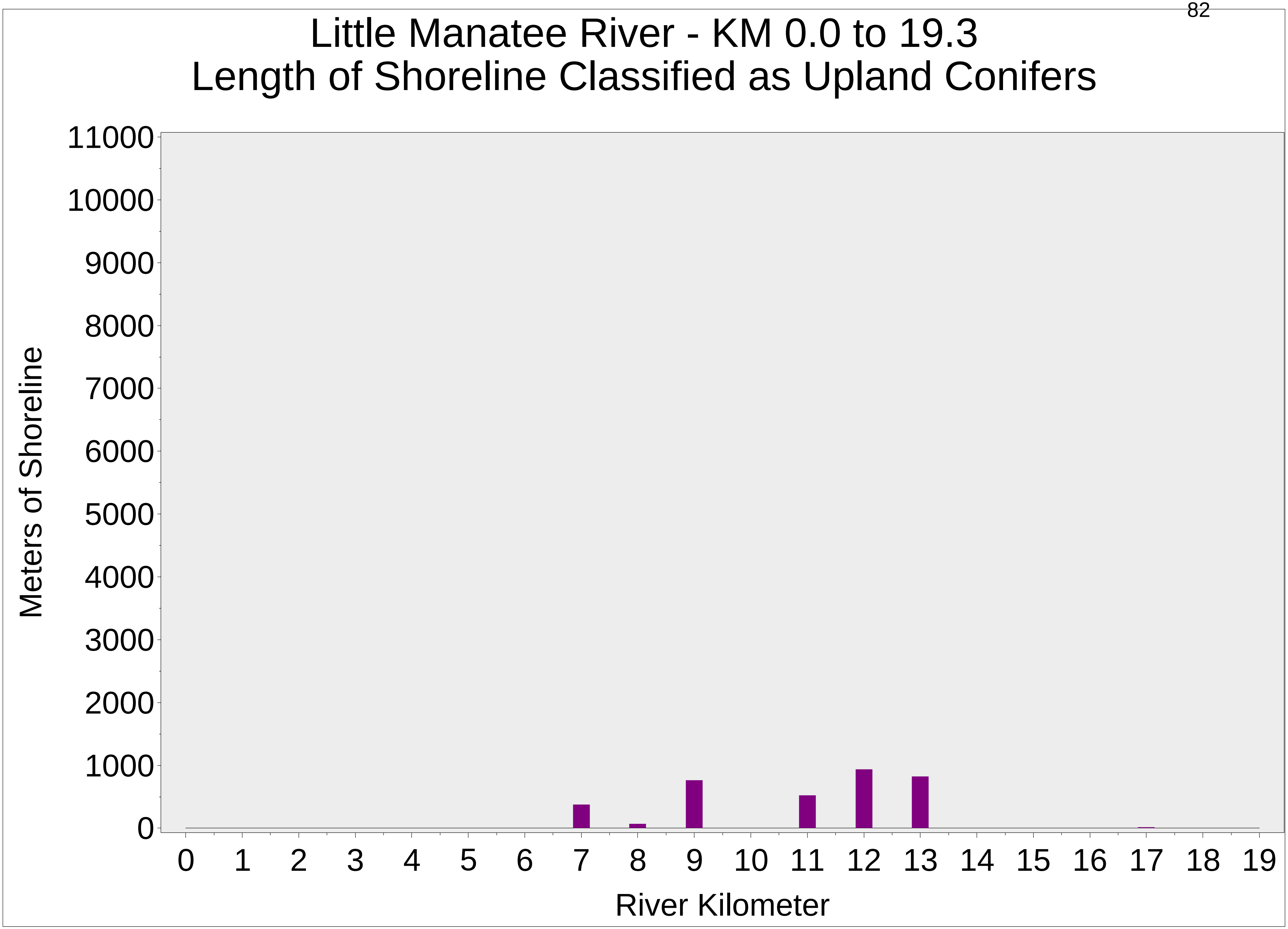

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Juncus romerianus(needlerush)
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Mangroves
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

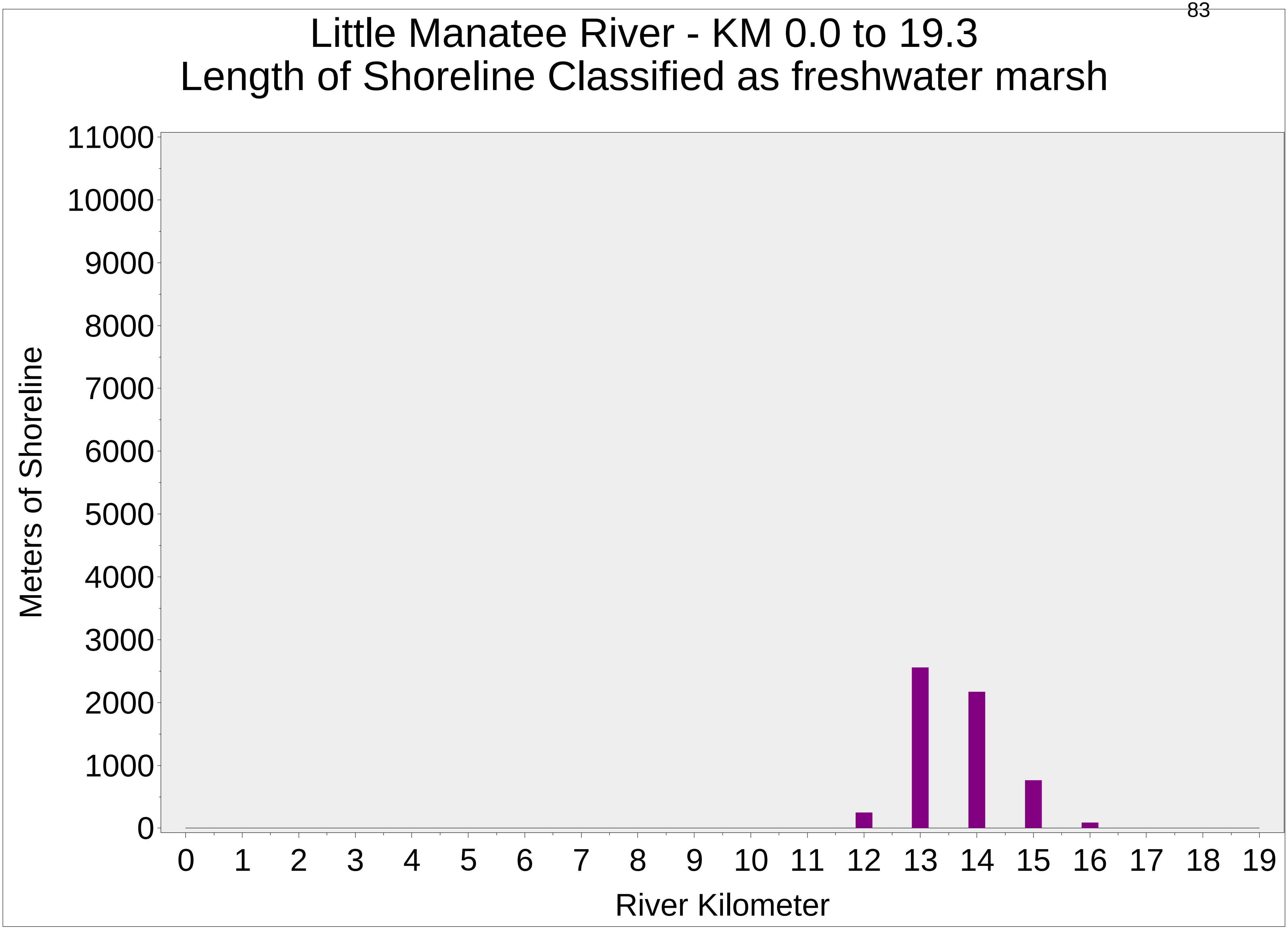

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Agricultural
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

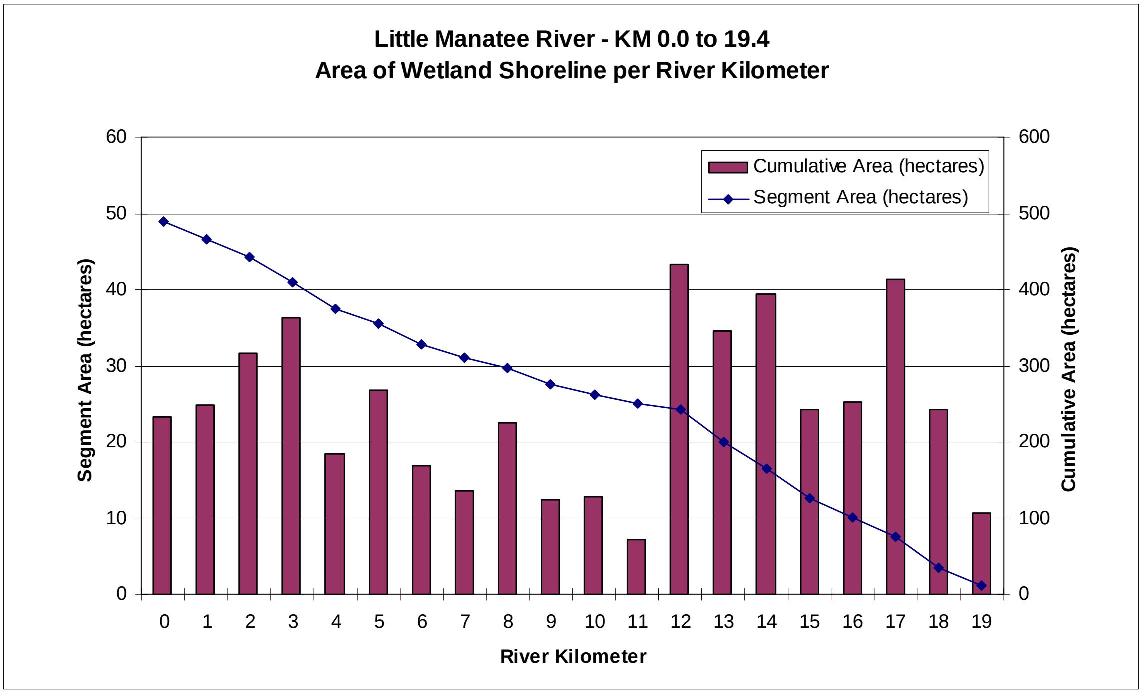

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Upland Forest
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

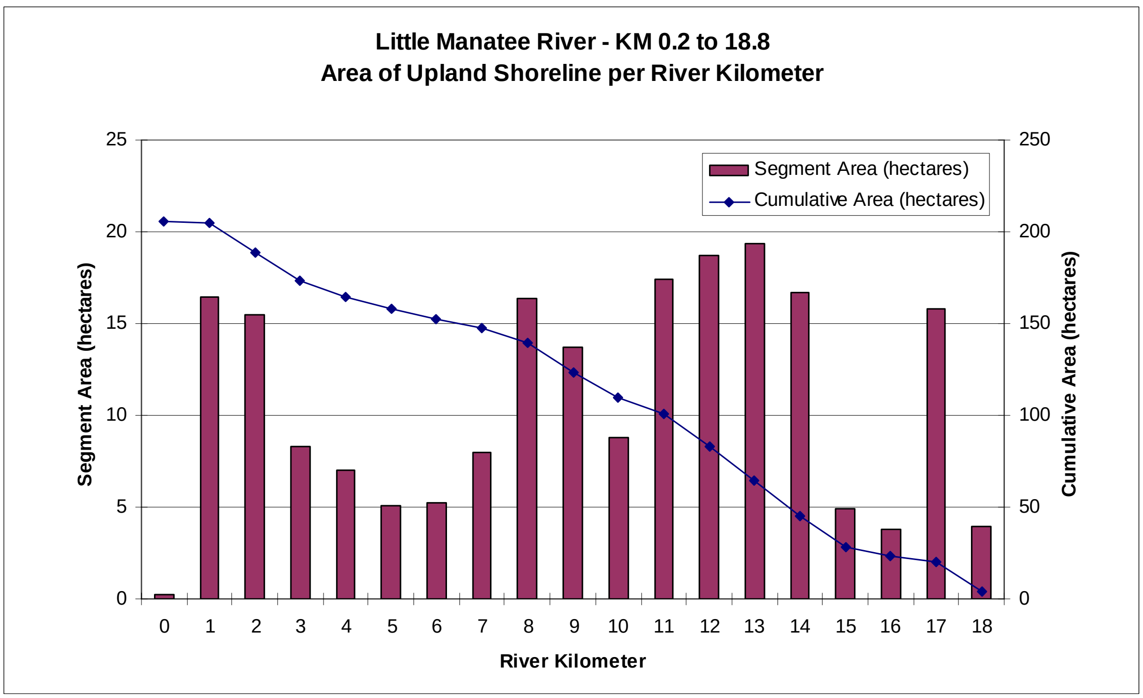

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Coastal Hammock
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

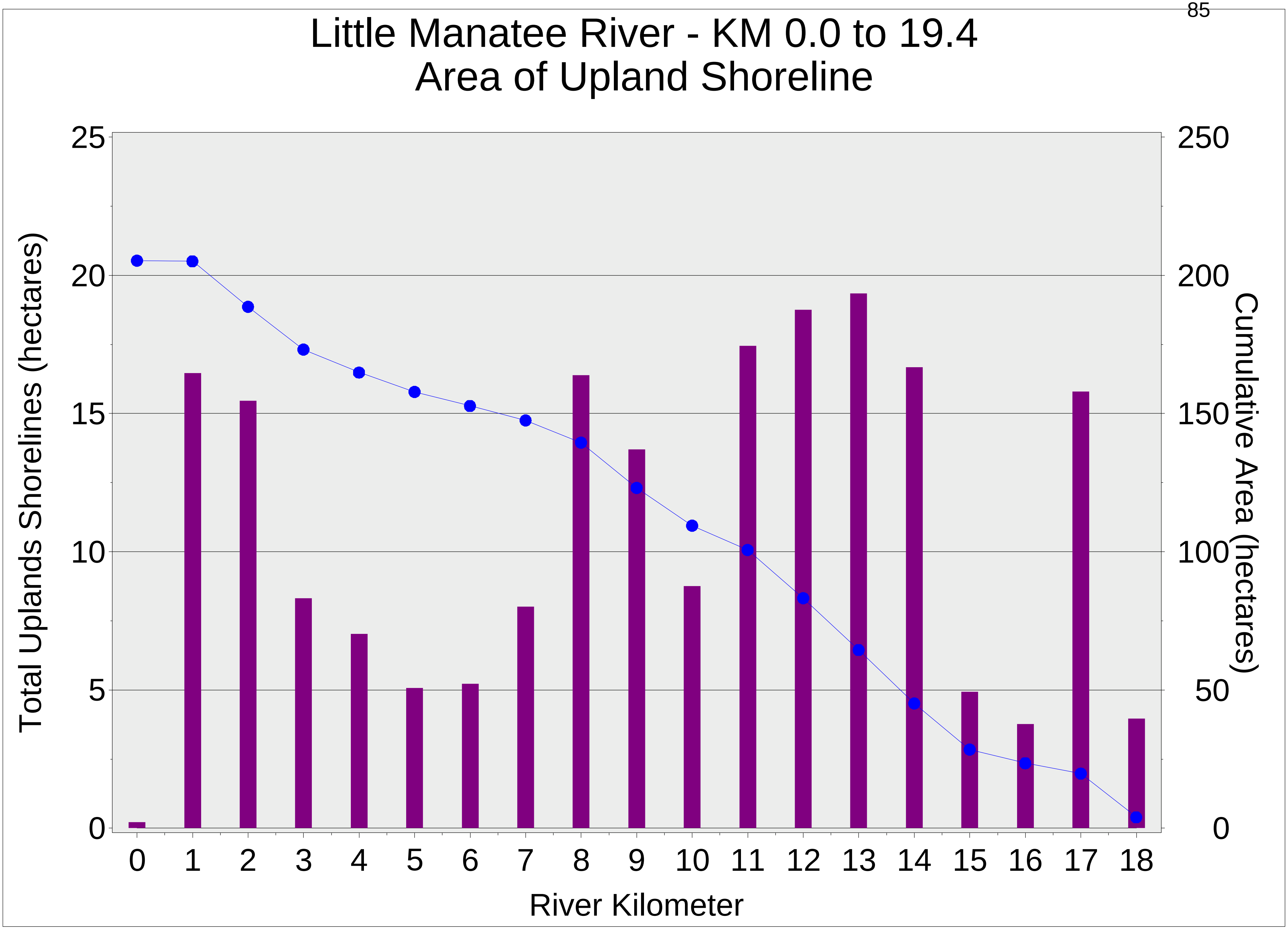


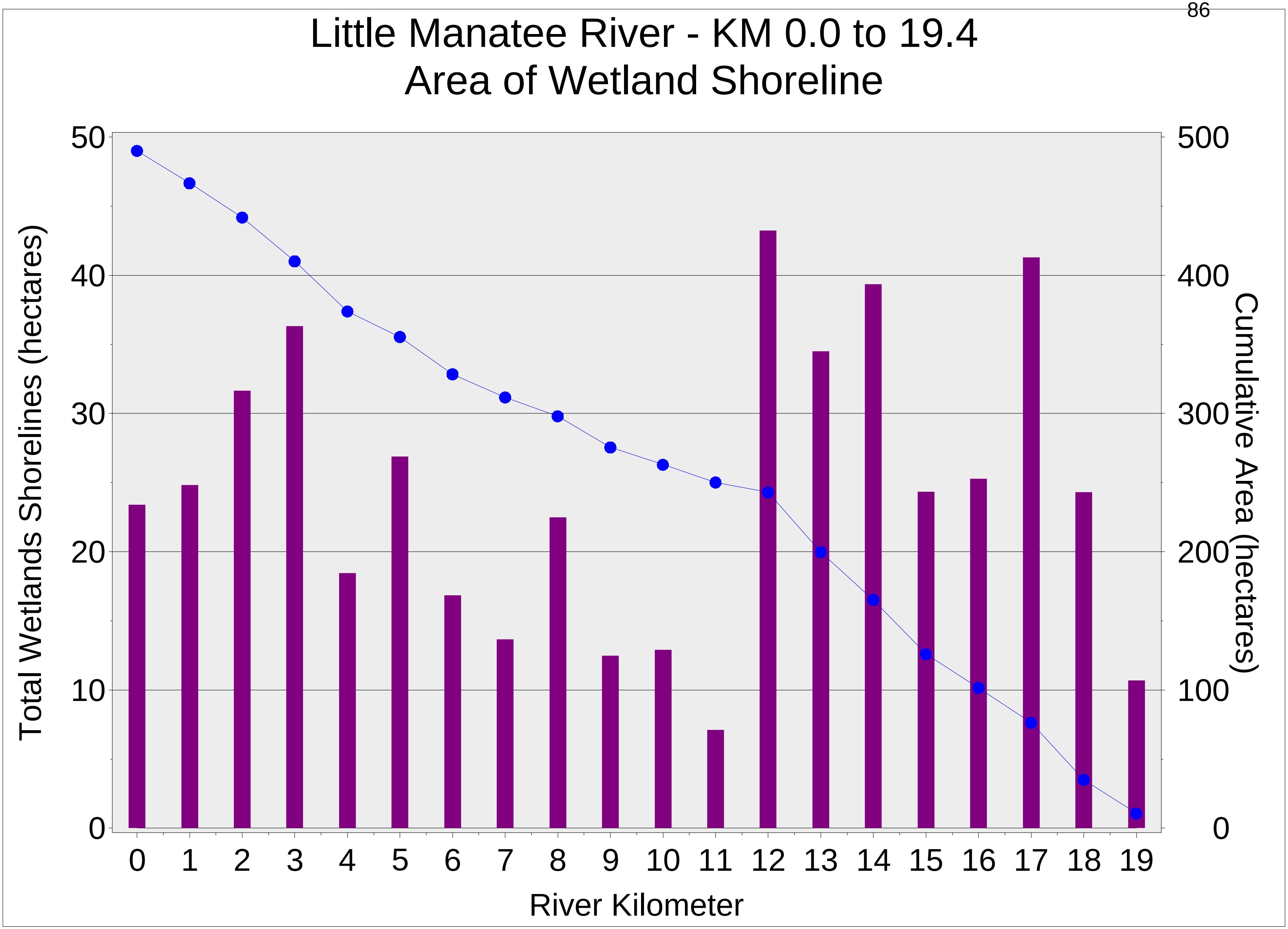
Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Upland Conifers
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as freshwater marsh
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.4
Area of Wetland Shoreline per River Kilometer
Cumulative Area (hectares)
Segment Area (hectares)
Segment Area (hectares)
Cumulative Area (hectares)
River Kilometer
0
10
20
30
40
50
60
100
200
300
400
500
600
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

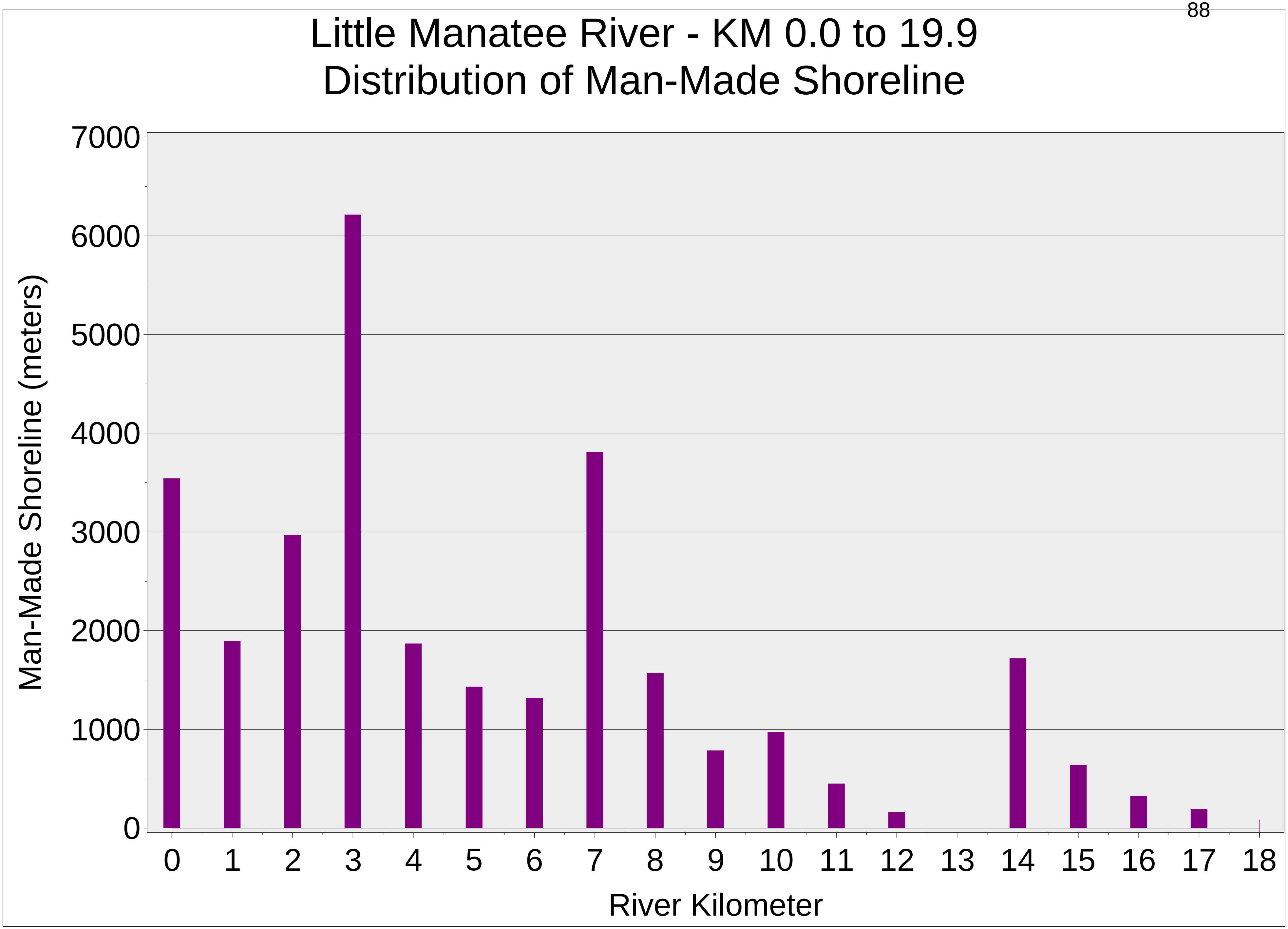

Little Manatee River - KM 0.2 to 18.8
Area of Upland Shoreline per River Kilometer
Segment Area (hectares)
Cumulative Area (hectares)
Segment Area (hectares)
Cumulative Area (hectares)
River Kilometer
0
5
10
15
20
25
50
100
150
200
250
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

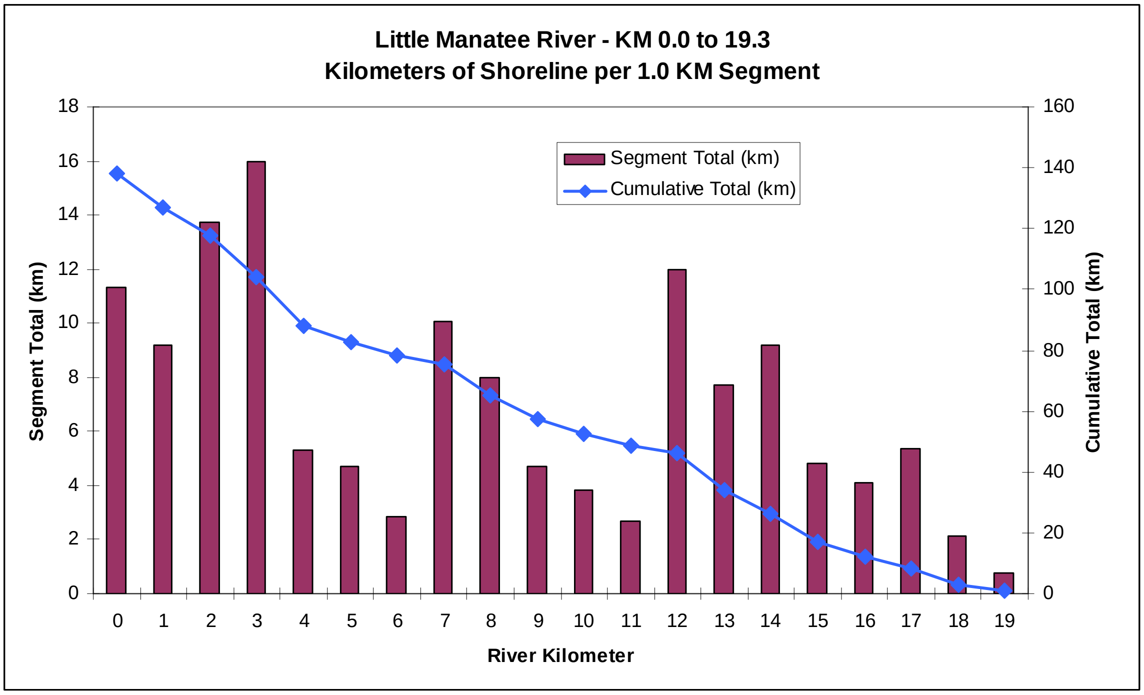

Little Manatee River - KM 0.0 to 19.4
Area of Upland Shoreline
Total Uplands Shorelines (hectares)
Cumulative Area (hectares)
River Kilometer
0
5
10
15
20
25
50
100
150
200
250
1
2
3
4
6
7
8
9
11
12
13
14
16
17
18

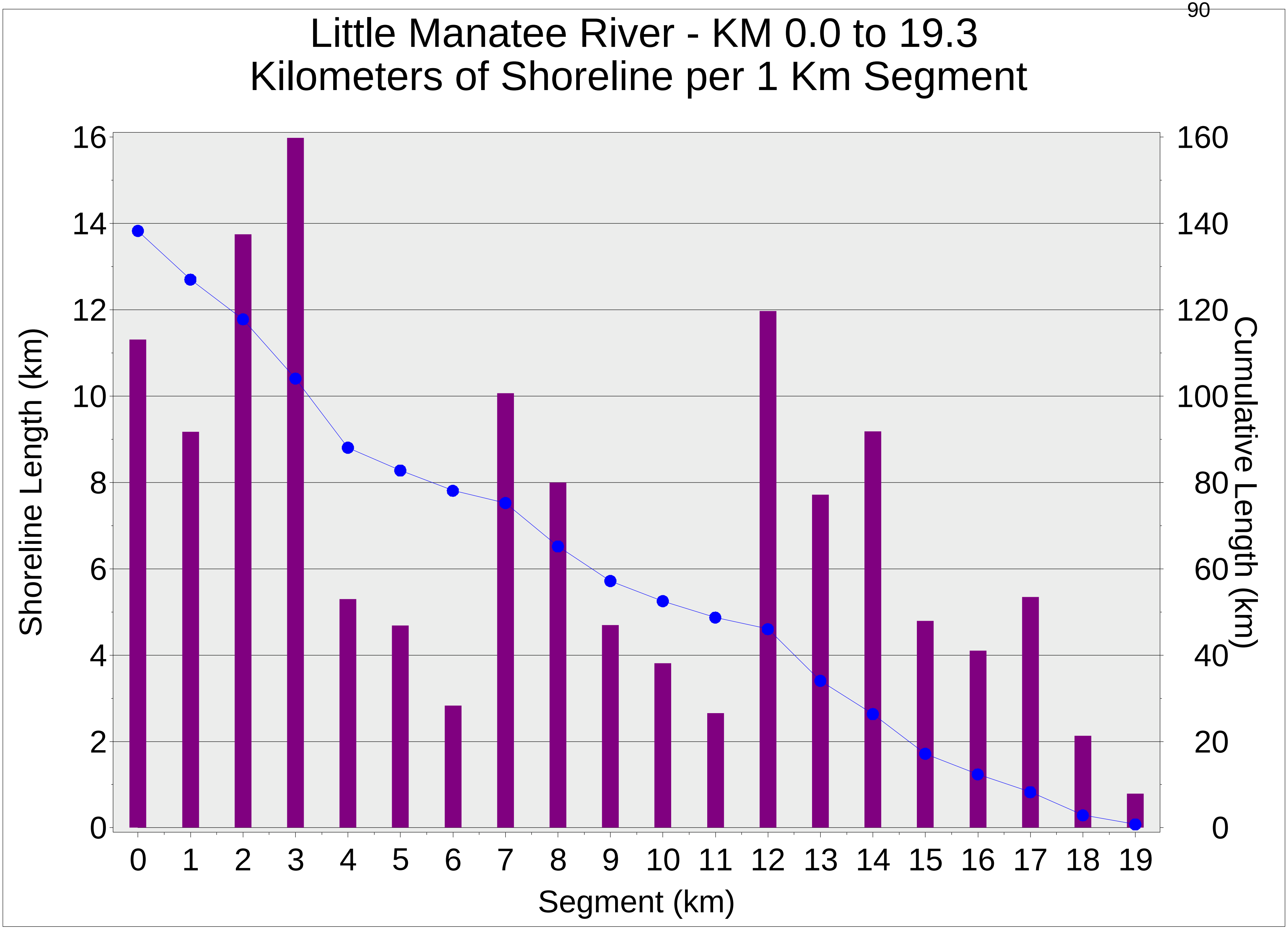

Little Manatee River - KM 0.0 to 19.4
Area of Wetland Shoreline
Total Wetlands Shorelines (hectares)
Cumulative Area (hectares)
River Kilometer
0
10
20
30
40
50
100
200
300
400
500
1
2
3
4
5
6
7
8
9
11
12
13
14
15
16
17
18
19

Area of Major Shoreline Plant Communities Along the Little Manatee River Shoreline

Species or Group	Area (hectares)	Percent of Total
Urban	267.63	25.6%
Bottomland Hardwoods	152.91	14.6%
Juncus romerianus(needlerush)	150.54	14.4%
Mangroves	107.64	10.3%
Agricultural	81.02	7.8%
Upland Forest	68.80	6.6%
Coastal Hammock	68.78	6.6%
Upland Conifers	47.21	4.5%
Freshwater Marsh	44.01	4.2%
Range	14.76	1.4%
Echinochloa	9.97	1.0%
Wetland Conifers	8.93	0.9%
Upland Hardwoods	5.29	0.5%
Marsh with Cladium (sawgrass)	4.56	0.4%
Typha (cattail)	3.38	0.3%
Leatherfern	2.35	0.2%
Juncus and Leatherfern	1.91	0.2%
Tidal Flat	1.65	0.2%
Wetland Marsh	0.88	0.1%
Cladium (sawgrass)	0.72	0.1%
Saltmarsh	0.48	0.0%
Sabal Palmetto	0.47	0.0%
Utilities	0.39	0.0%
Wet Prairie	0.06	0.0%


Little Manatee River - KM 0.0 to 19.9
Distribution of Man-Made Shoreline
Man-Made Shoreline (meters)
0
1000
2000
3000
4000
5000
6000
7000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Kilometers of Shoreline per 1.0 KM Segment
Segment Total (km)
Cumulative Total (km)
River Kilometer
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
0
2
4
6
8
10
12
14
16
18
20
40
60
80
100
120
140
160


Little Manatee River - KM 0.0 to 19.3
Kilometers of Shoreline per 1 Km Segment
Shoreline Length (km)
Cumulative Length (km)
Segment (km)
0
2
4
6
8
10
12
14
16
20
40
60
80
100
120
140
160
1
3
5
7
9
11
13
15
17
18
19

December 13, 2021

Request and questions about Little Manatee River EFF modeling

Hello Kym and Doug,

I have request for a report, selected model output, and have a few questions about the Environmental Favorability Function (EFF) modeling results presented in the minimum flows report for the Little Manatee River. If the District could address these requests when it is convenient, it would be greatly appreciated.

The references for report I am asking for is below, taken from page 186 in the minimum flows report.

Wessel, M. 2011. Defining the Fish-Flow Relationship in Support of Establishing Minimum Flows and Levels for Southwest Florida Tidal Rivers: Building on the Toolbox of Analytical Techniques. Report prepared by Janicki Environmental Inc. for the Southwest Florida Management District

I would also like to receive output from the Environmental Favorability Function modeling that was done for fish species in the lower river. In particular, I am requesting daily output for the amount of favorable habitat for the fish species listed on pages 146 to 149 of the minimum flows report, except for Sheepshead, for the baseline and the 15, 20, 25 and 30% flow reduction scenarios. If it saves time, my request could be limited to the Sailfin Molly, Naked and Clown Gobies, Eastern Mosquitofish, Rainwater Killifish, small gobies and Common Snook. I would also like to receive the flows at the USGS streamflow gage near Wimauma for these flow scenarios for the years 2015 to 2019, the results for which are presented on pages 146 to 149.

The questions I have are about the EFF analyses are listed below.

1. Figure 6-11 on page 147 in the minimum flow report shows average percent reductions in favorable habitat for 10 species. How were the average percent change values calculated for each flow reduction scenario. Were simple arithmetic averages of favorable habitat calculated from all days for the baseline scenario and each flow reduction scenario, then the average for the flow reduction scenario divided by the baseline average value, or was some other method used?

Similarly, in Tables 6-5 to 6-7, were the percent reduction in favorable habitat values calculated as averages for each flow reduction scenario as described above, within flow blocks, or was some other method used to calculate the percent reduction values?

2. The report about nekton in the river collected by the FFWCC that was prepared for the District (MacDonald et al., 2007) divided the stages of many species into size classes for certain analyses. For the species that were assessed for the EFF modeling, were all size classes combined for the modeling of flow reduction effects?

The following questions pertain to the habitat factor that is included in the logistic regression equation that is shown on page 129 of the minimum flows report with the intercept adjustment on page 130. Information on the EFF model is also presented in the report included as Appendix E the minimum flows report, which is draft minimum flows analysis submitted by Janicki Environmental (JEI) in June 2018. The questions below pertain to Appendix E. If these factors are no longer applicable or have been updated, please let me know.

3. On page 4-21, Appendix E says that for the refined model, the habitat levels were collapsed to the following categories: mangroves, emergent (marshes), structure and freshwater habitats, with tree, terrestrial grasses, and bare sand group as a single category. Are these the categories that remained in the final EFF model used to determine the minimum flows?

Also, this page shows a map of the dominant shore types assigned by FFWCC as part of their seine collections. Were the shoreline classifications assigned by FFWCC categories used as the source data to create the collapsed shore habitat types used in the EFF modeling, or was some other source used to determine the shore habitat types?

The map of page 4-21 of Appendix E shows the distribution of dominant shore types identified FFWCC as part of their sampling. It is interesting to note that the map shows 'freshwater" shore types that are located fairly far downstream, sometimes in the mesohaline reach of the river. I wonder what the FFWCC was using to classify the shore type. Were they looking at the vegetation on the upland next to the shoreline? For fish sampling, I would suggest that the shore type should be classified based on habitats and vegetation within the inter-tidal range of the river, but I don't really know what FFWCC used to classify shore types. Does the District or JEI have any information on that?

Also, the FFWCC sampling generally did not extend upstream of approximately kilometer 14. Again, what source data was used to assign habitat types, was something other that data for FFWCC data used? What was applied upstream of kilometer 14?

In general, how was favorable shore habitat determined and applied in the EFF model? I am assuming that shore type was what used to determine shore habitat. Is that correct? Was a separate analysis conducted on the frequency of occurrence of fish species in various shore habitats conducted to determine favorable shore habitats, then the quantity of those shore habitats in various river reaches applied in the EFF modeling? Or, did the EFF modeling itself derive what the favorable shore habitats were for each species? More explanation of how favorable shore habitats were determined and applied in the model would be helpful.

For example, could a species have more than one favorable shore habitat? From looking at the map on page 4-21, I would think that combined emergent marsh and freshwater would make sense.

The figure on page 4-25 for favorable habitat predictions for the striped mojarra (*Eugerre plumieiri*) using the EFDC and the LOESS model is interesting. Does it incorporate both the salinity predictions and favorable habitat factors or is it just based on salinity? On this date (December 6, 2003), it appears that salinity distribution had much to do with favorable habitat being upstream of approximately kilometer 10, as the flow at the gage on that date was 53 cfs.

I would assume on a day with higher flow, the favorable habitat would extend farther downstream. If that were the case, does the EFF analysis also incorporate data from within the bayous and Ruskin Inlet? Page 169 in MacDonald et al. (2007) shows that the striped mojarra had higher geometric mean abundance values in the bayous than in the river channel during that period of data collection (1996-2006).

Thanks for whatever information you can provide to these questions. I expect you are very busy with the holidays approaching, so whenever you can address these if fine, with after Christmas or sometime thereafter being fine.

Thanks again and Happy Holidays!

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]

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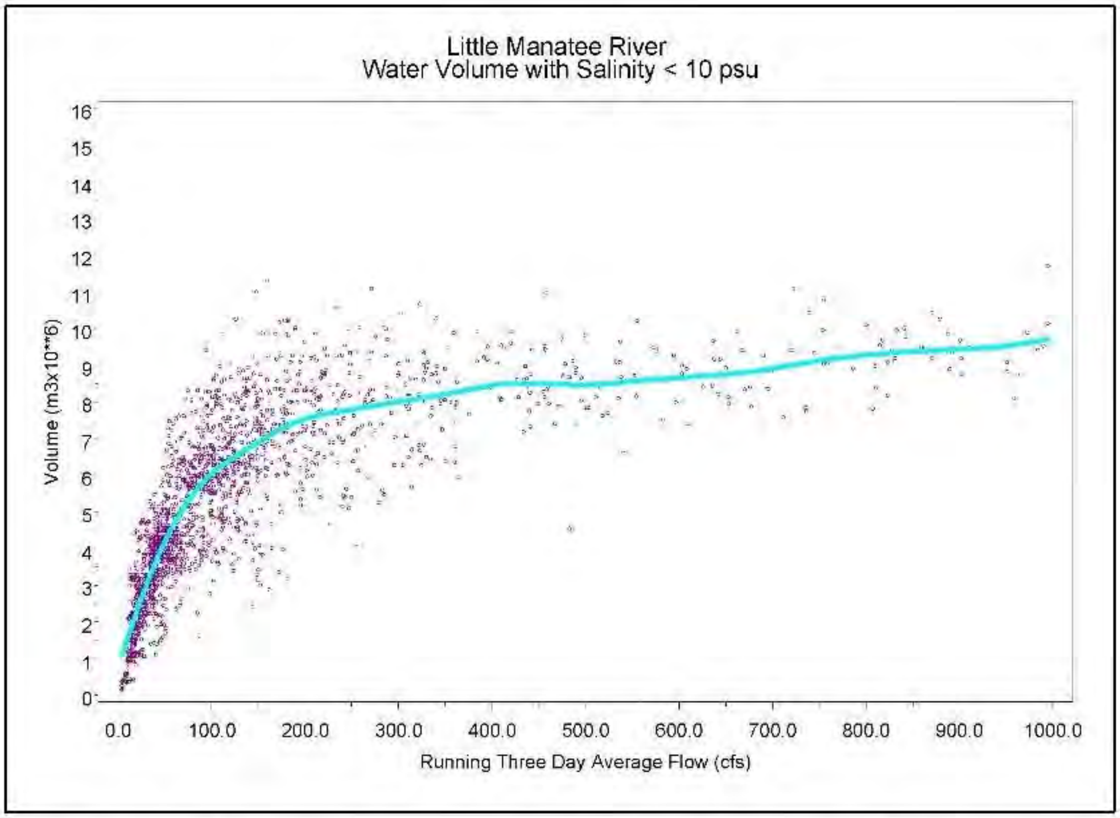
[2] *University of South Florida, College of Marine Science, 140 Seventh Avenue South, St. Petersburg, Florida 33701*
[3] *PBS&J, Inc., 5300 West Cypress Street, Suite 300, Tampa, Florida 33606*

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.

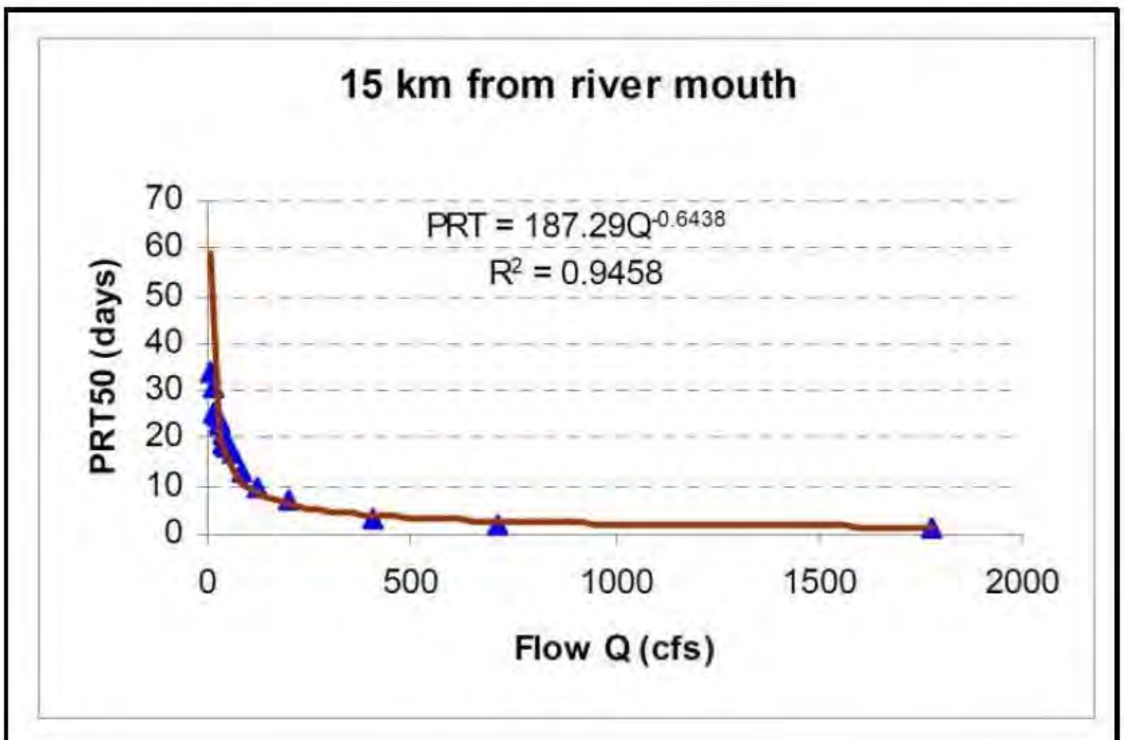
Introduction

Stream ecologists have emphasized the importance of natural flow regimes for maintaining the

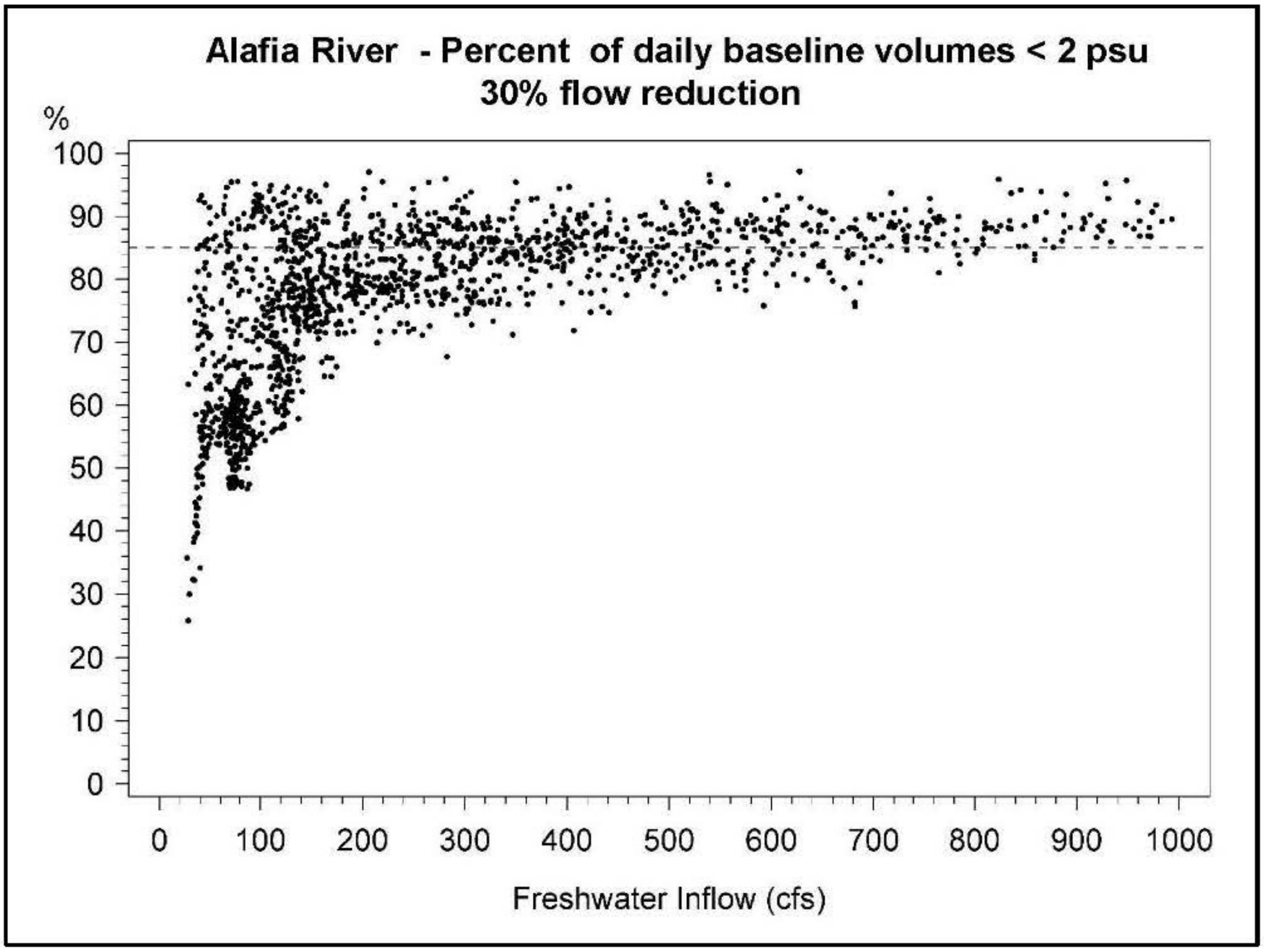
ceding freshwater inflow terms calculated over 2-mo or 3-mo intervals, indicating that the seasonality of inflow can have a significant effect on fish



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

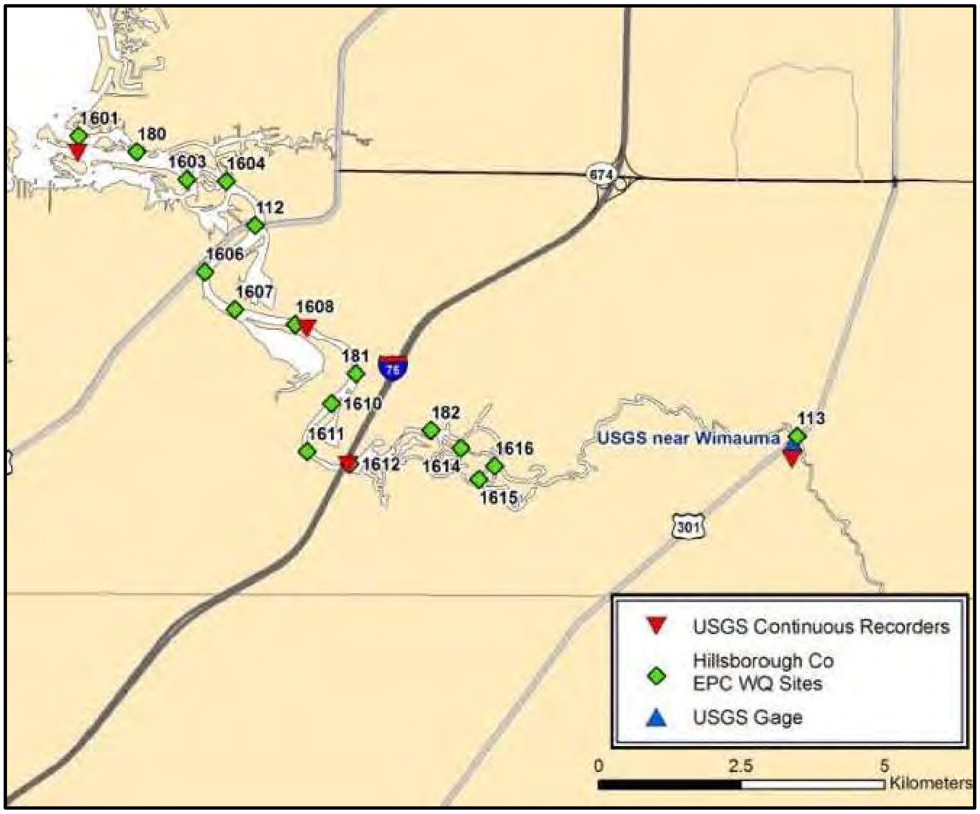


Figure A. USGS salinity recorders and EPCHC vertical profile stations in the lower river.

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

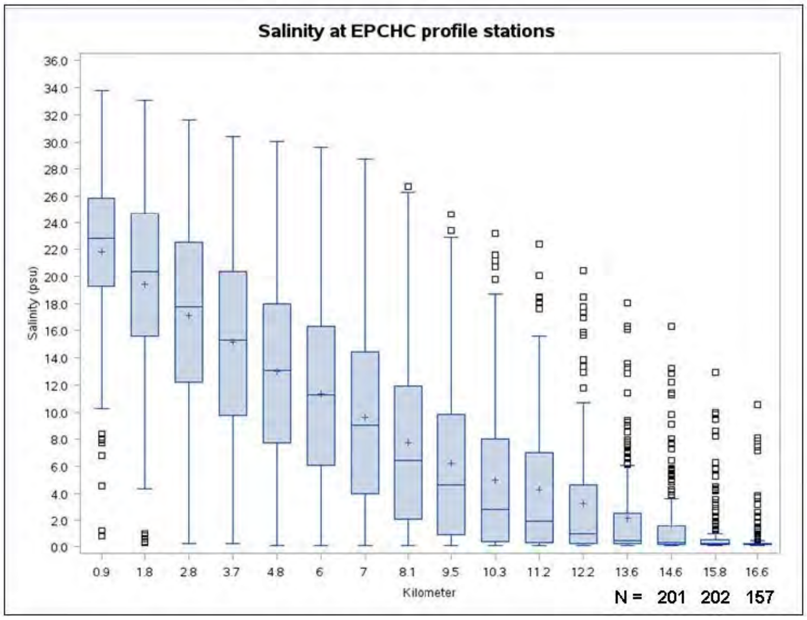


Figure C. Box plot of mean water column salinity values for vertical profiles measured in the lower river by the EPCHC from 12/14/2000 to 10/2/2006 and 01/26/2009 to 08/17/2001. N values for three upstream stations are the number of dates each station was sampled.

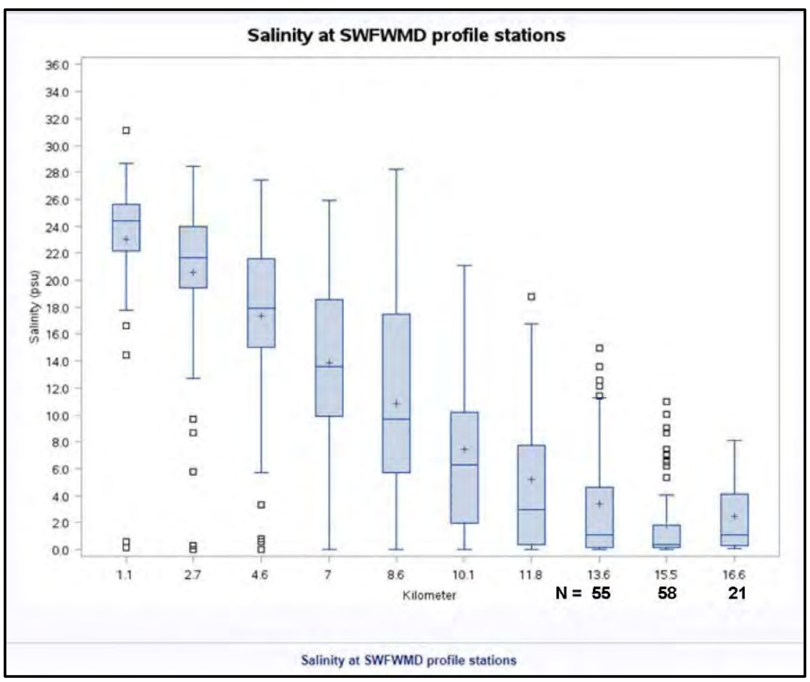


Figure D. Box plot of mean water column salinity values for vertical profiles measured in the lower river by the SWFWMD from 1985 to 1989. N values for three upstream stations are the number of dates each station was sampled.

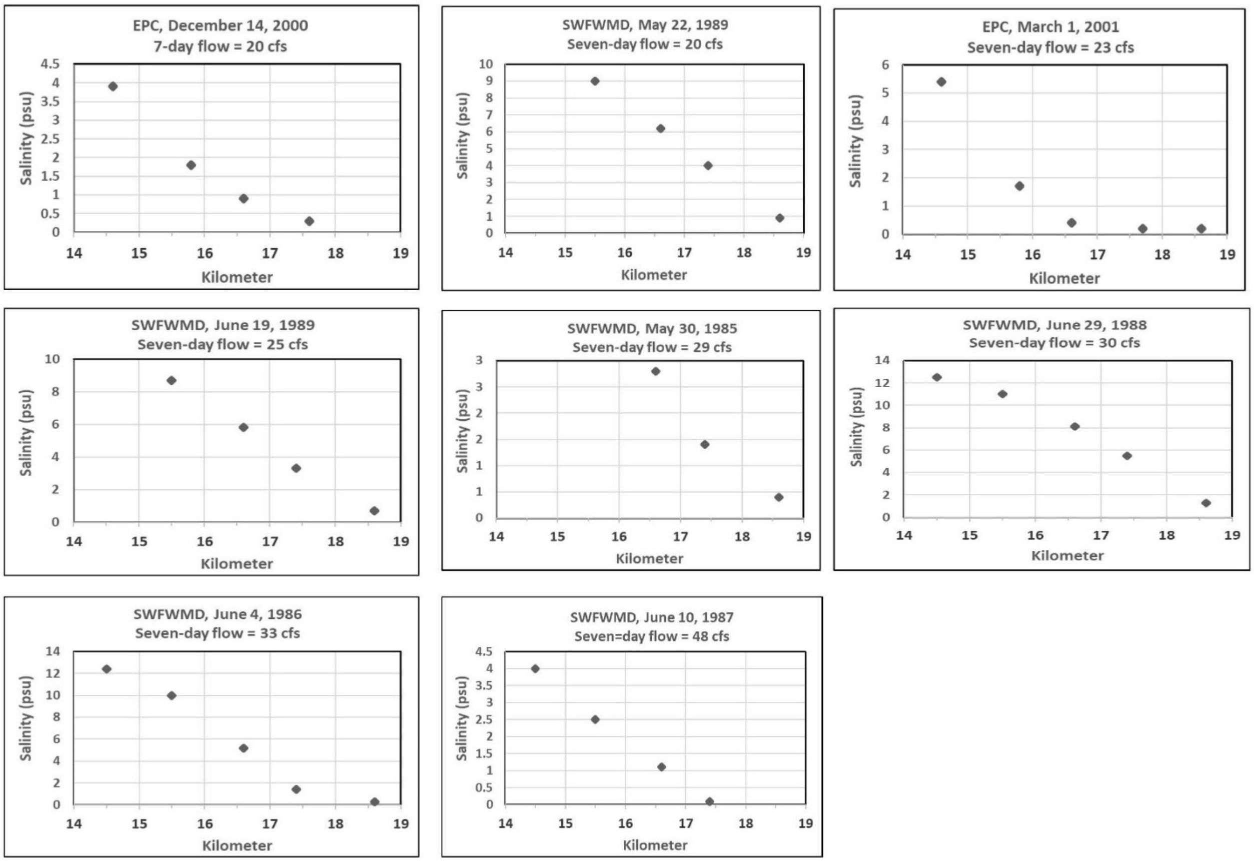


Figure E. Mean salinity values at stations in the upper reaches of the lower river on days when sampling by the EPCHC or the SWFWMD extended upstream of kilometer 16.6

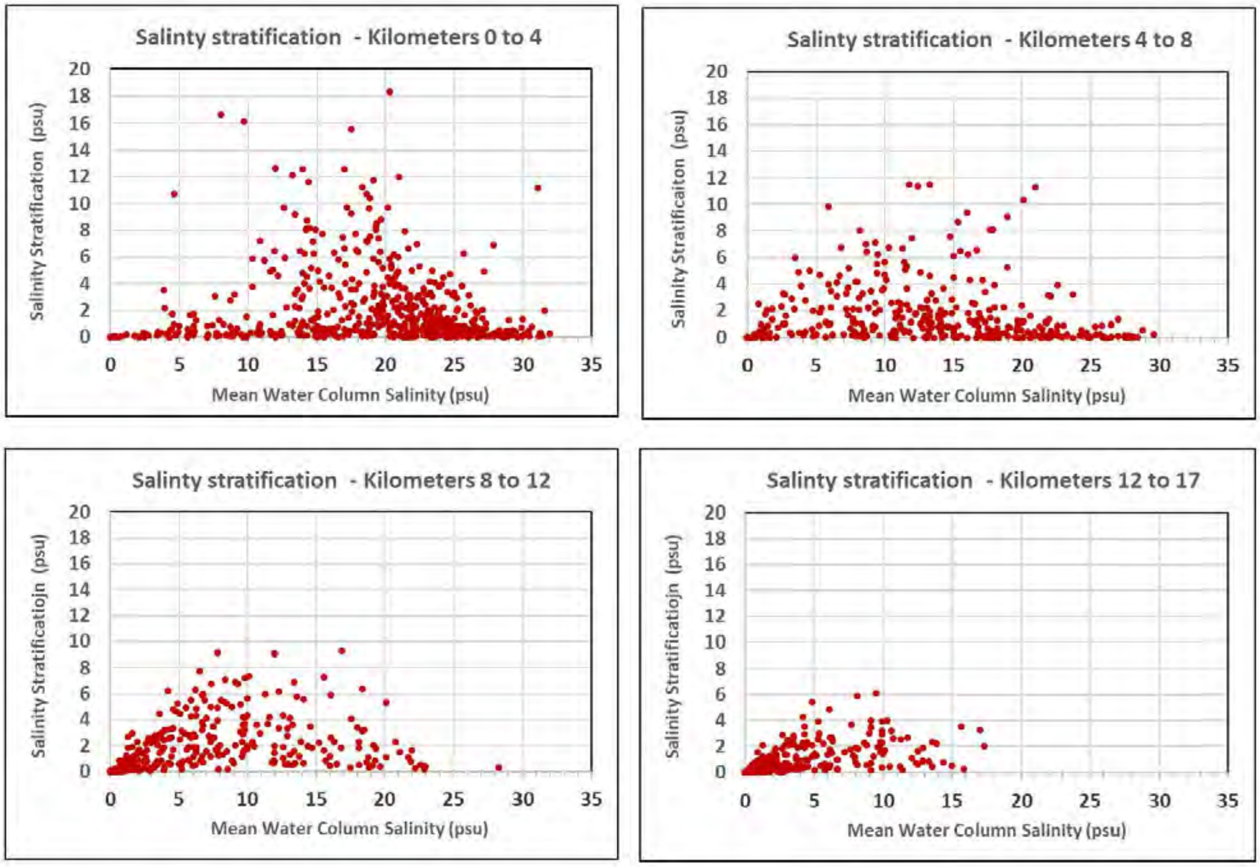


Figure F. Salinity stratification in four reaches of the lower river vs. mean water column salinity for stations that were two meters deep or greater. Stratification was calculated by subtracting the surface salinity value from the bottom salinity value.

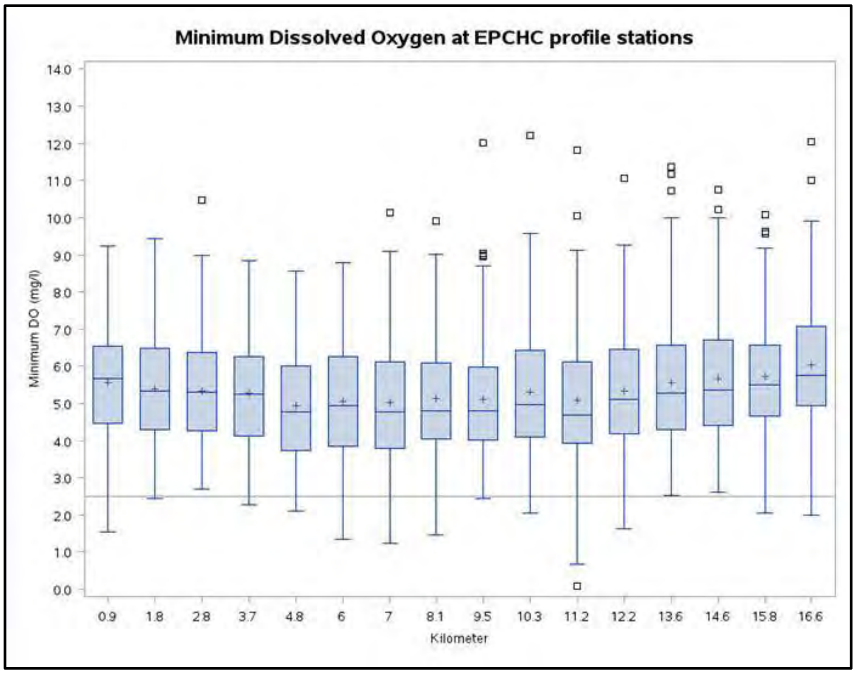


Figure G. Box plot of minimum dissolved oxygen concentrations a stations in the lower river monitored by the EPCHC. Whiskers are 1.5 times sssssssss.

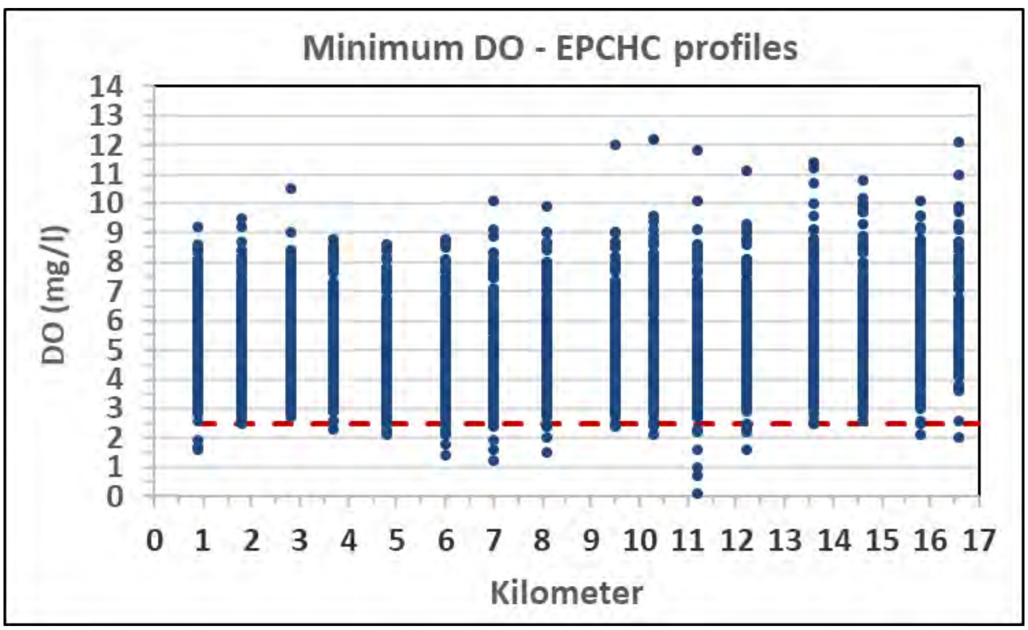


Figure G. Minimum dissolved oxygen concentrations at EPCHC vertical profile stations.

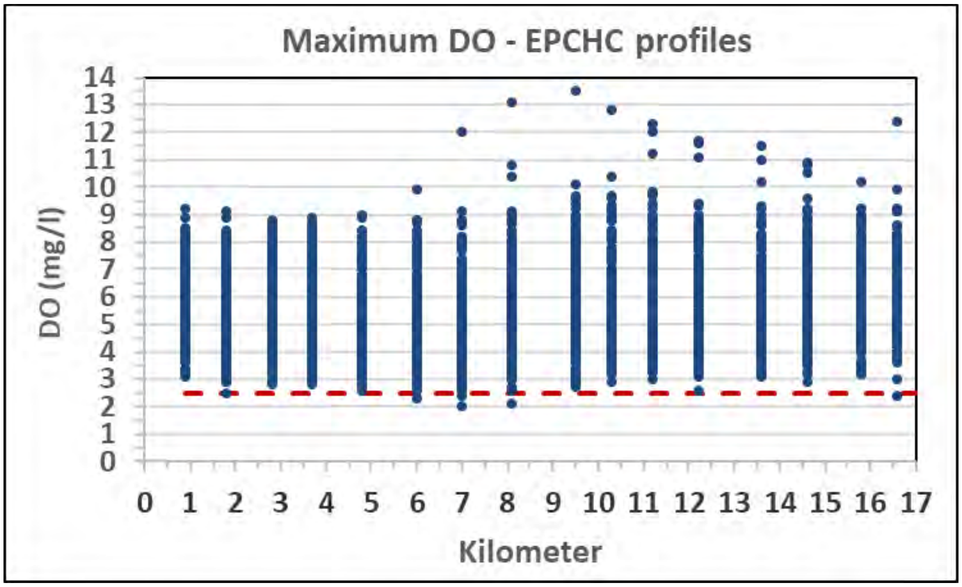


Figure H. Maximum dissolved oxygen concentrations at EPCHC vertical profile stations.

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*	2,126	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	Bleniid	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

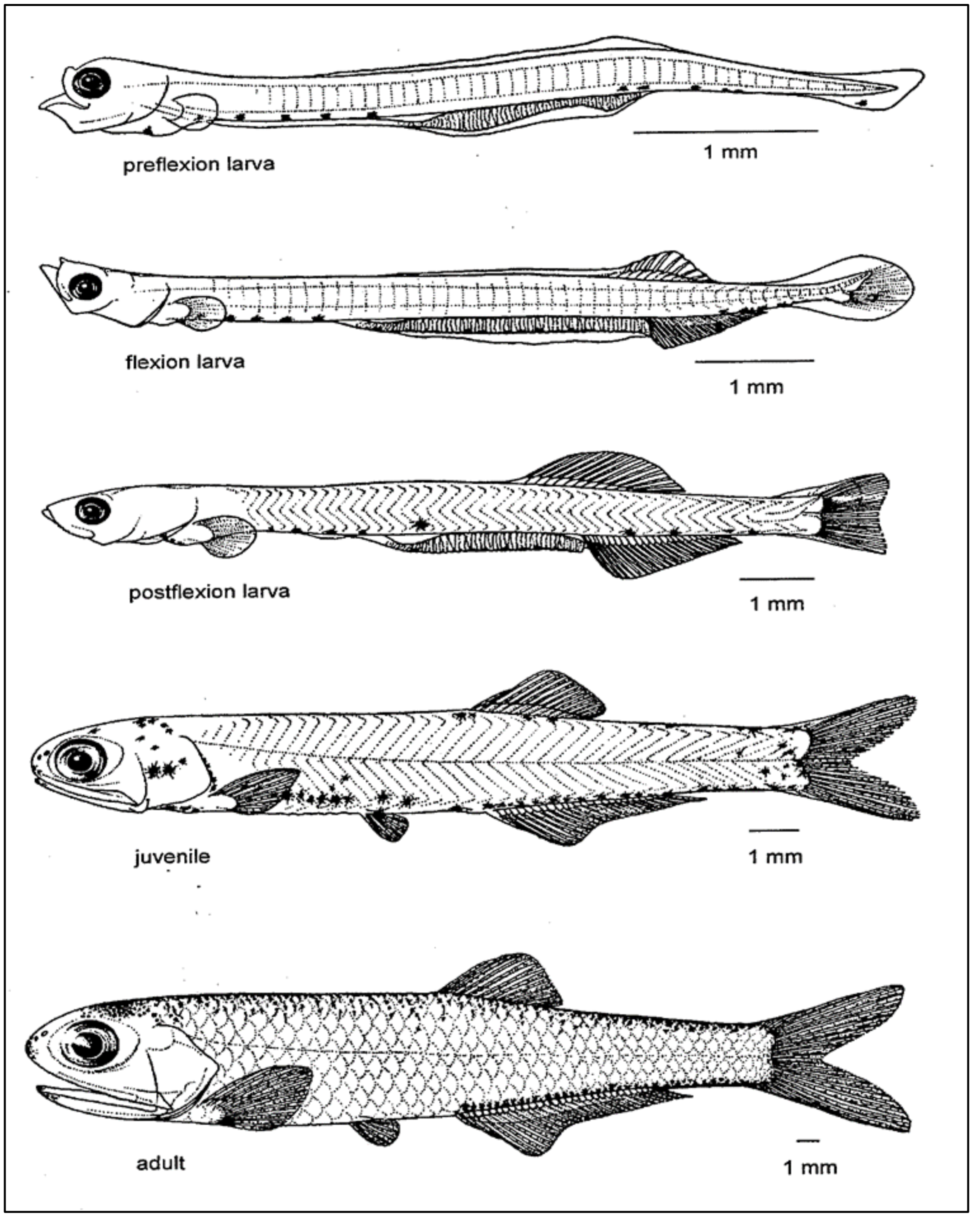


Figure I. Development stages of the bay anchovy (*Anchoa mitchilli*) collected from the Lower Little Manatee River and Tampa Bay, measuring 4.6, 7.0, 10,5, 16 and 31 mm standard length.

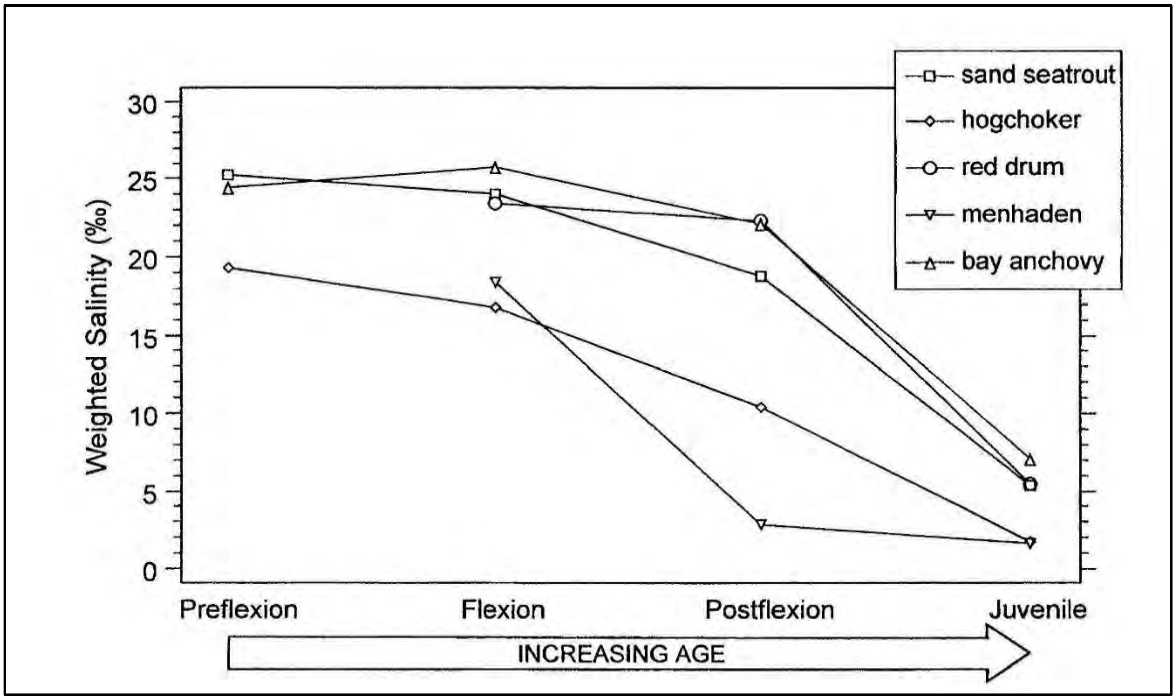
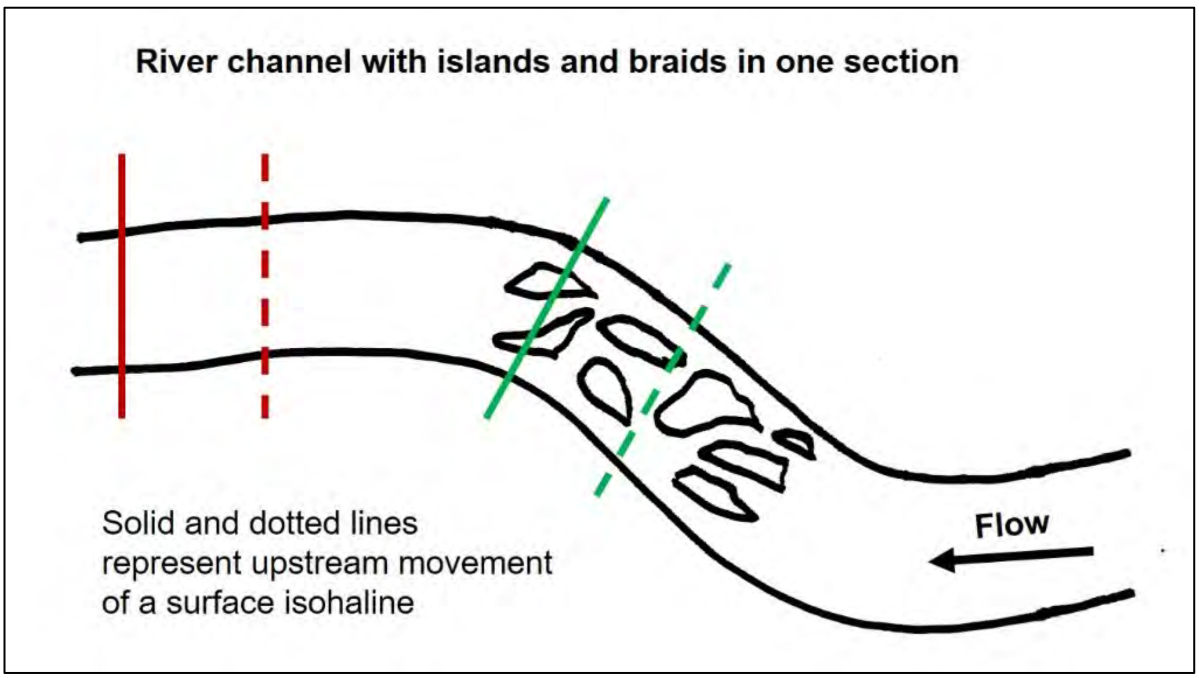


Figure J. Examples of decreasing mean salinity at capture with fish development. See Figure I for illustrations of these stages for the bay anchovy (*Anchoa mitchilli*).

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, 2022

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.

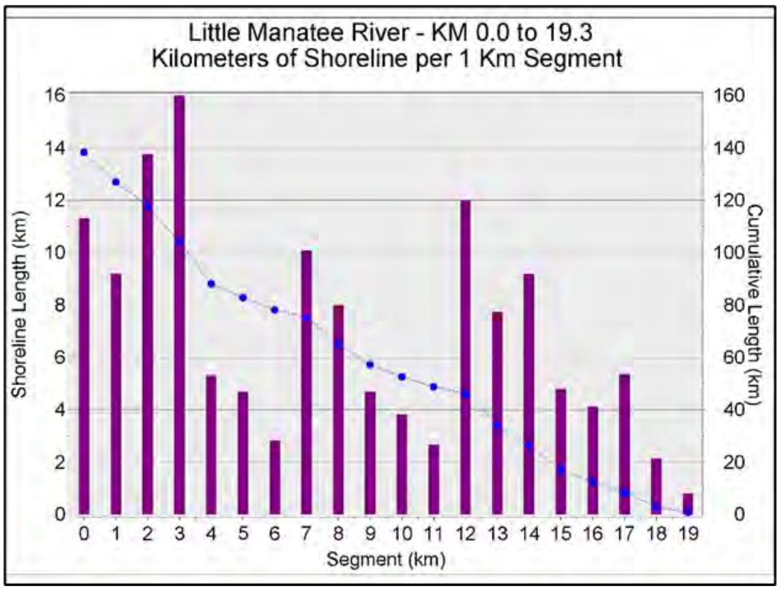
Conversely, there will be a much greater reduction in shoreline length associated with the green lines as there is a much greater quantity of shoreline length in that zone. The differences in these changes will also be reflected in percent reductions in total area and shoreline length upstream of these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

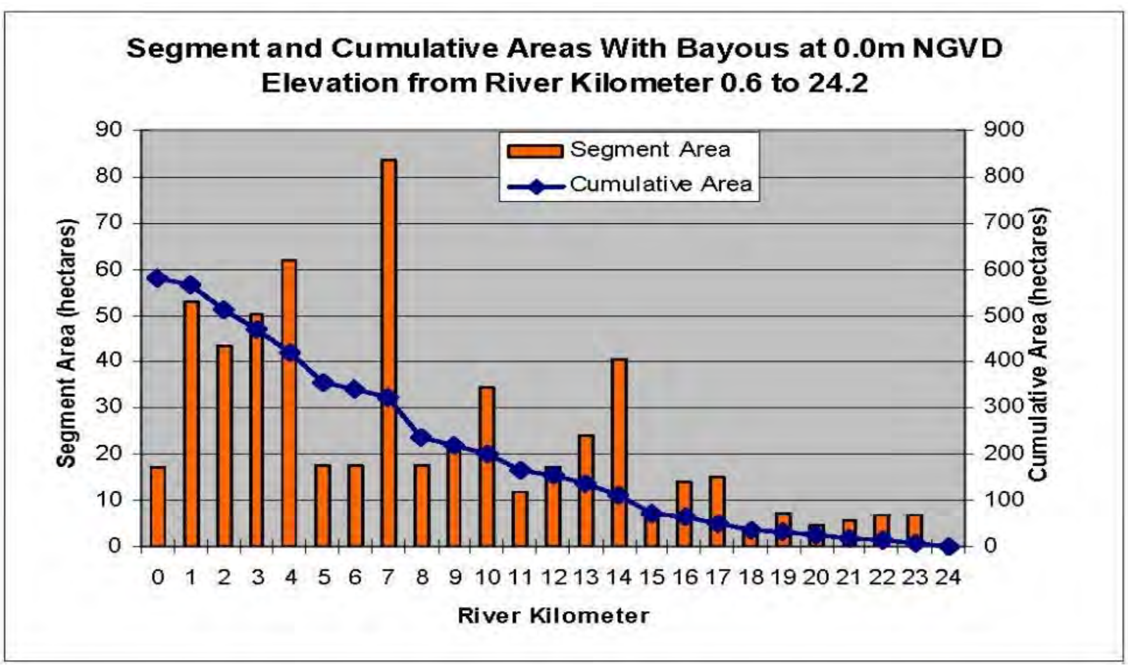


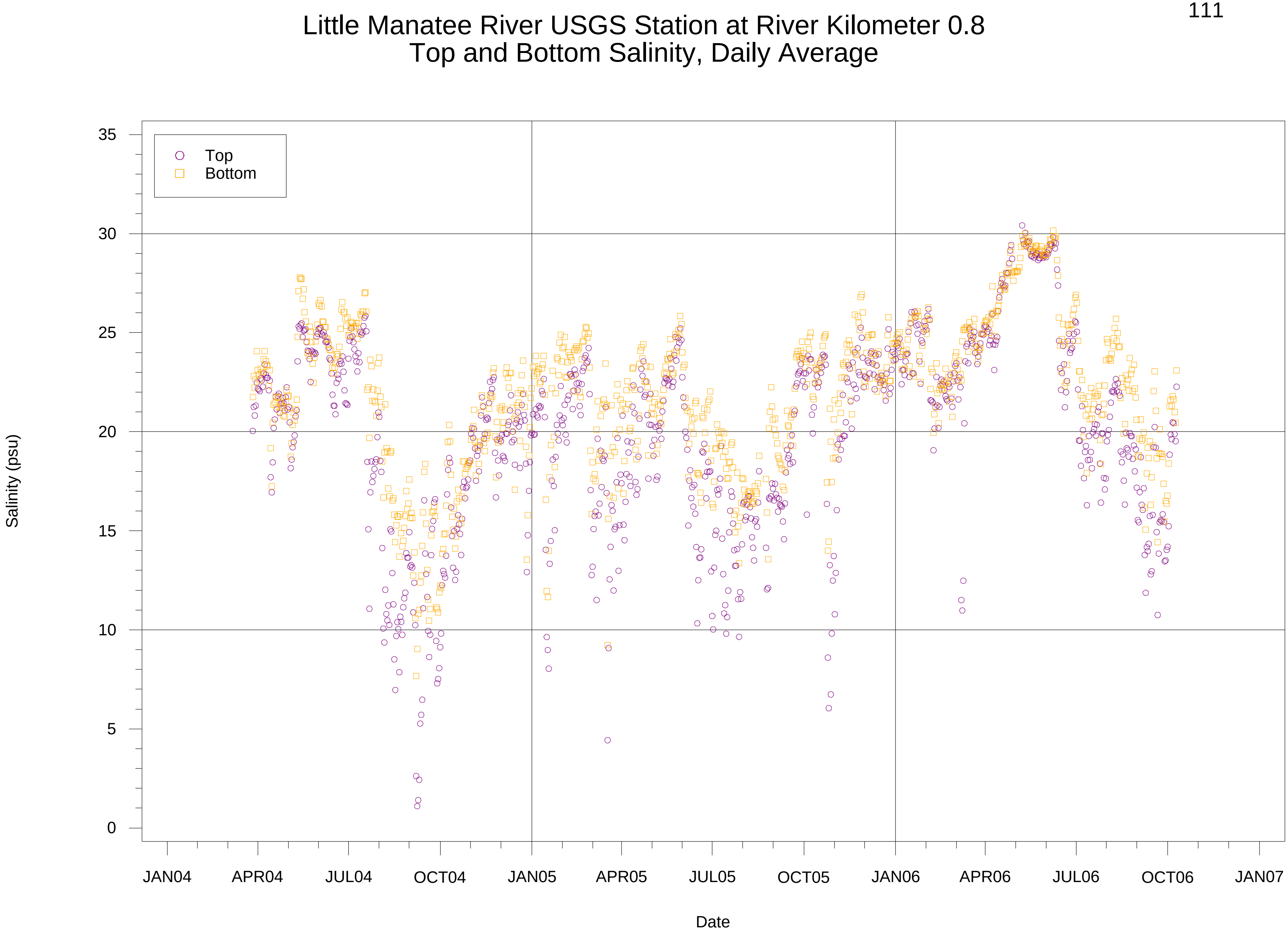
See next page for graphs from the Little Manatee

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.

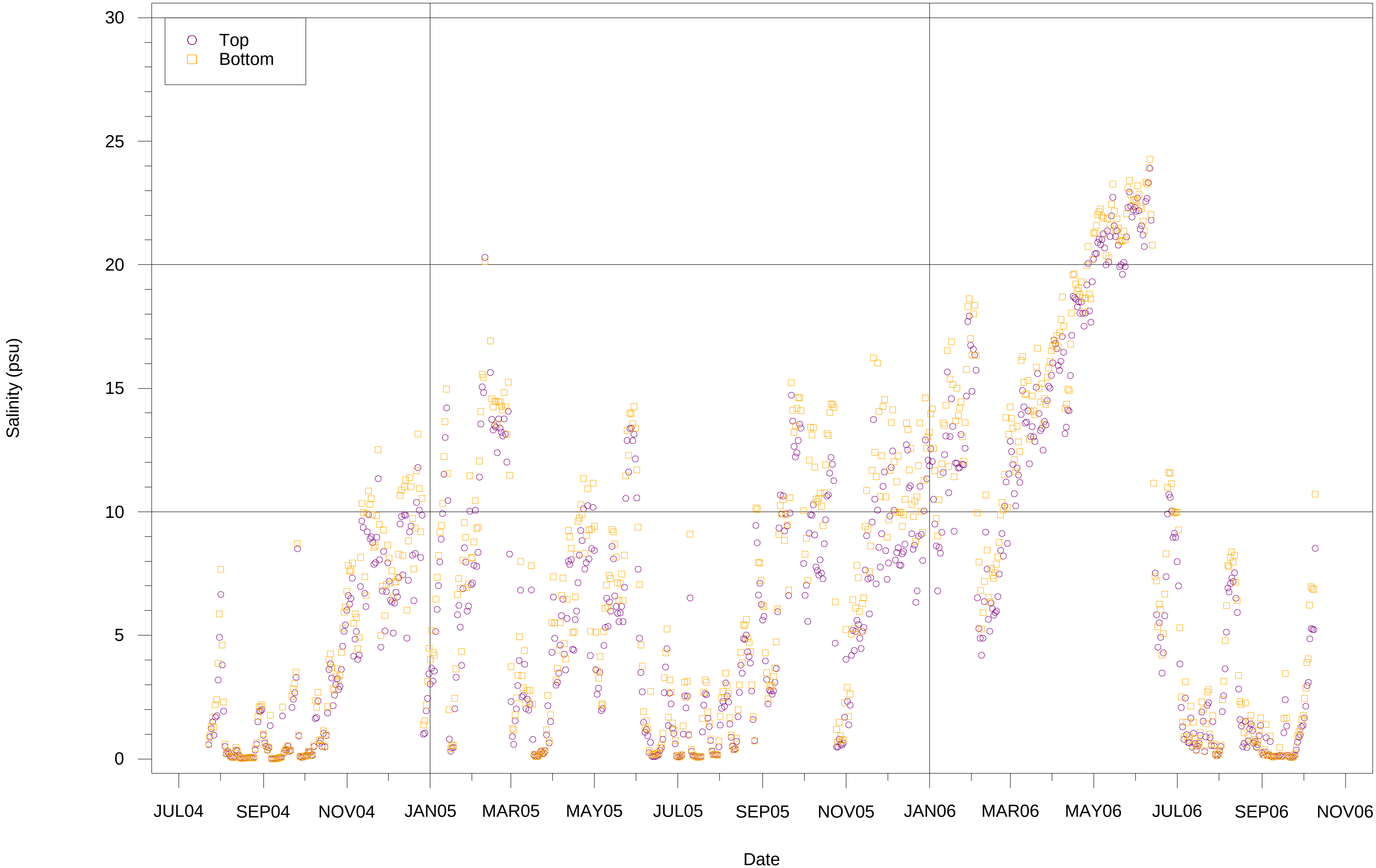
The Little Manatee has extensive oligohaline and freshwater marshes in the braided zone upstream of Interstate 75 near kilometer 12 that are susceptible to the effects of increased salinity. As such, the quantification of changes in shoreline length below a given salinity concentration (2 or 4 psu) are 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.

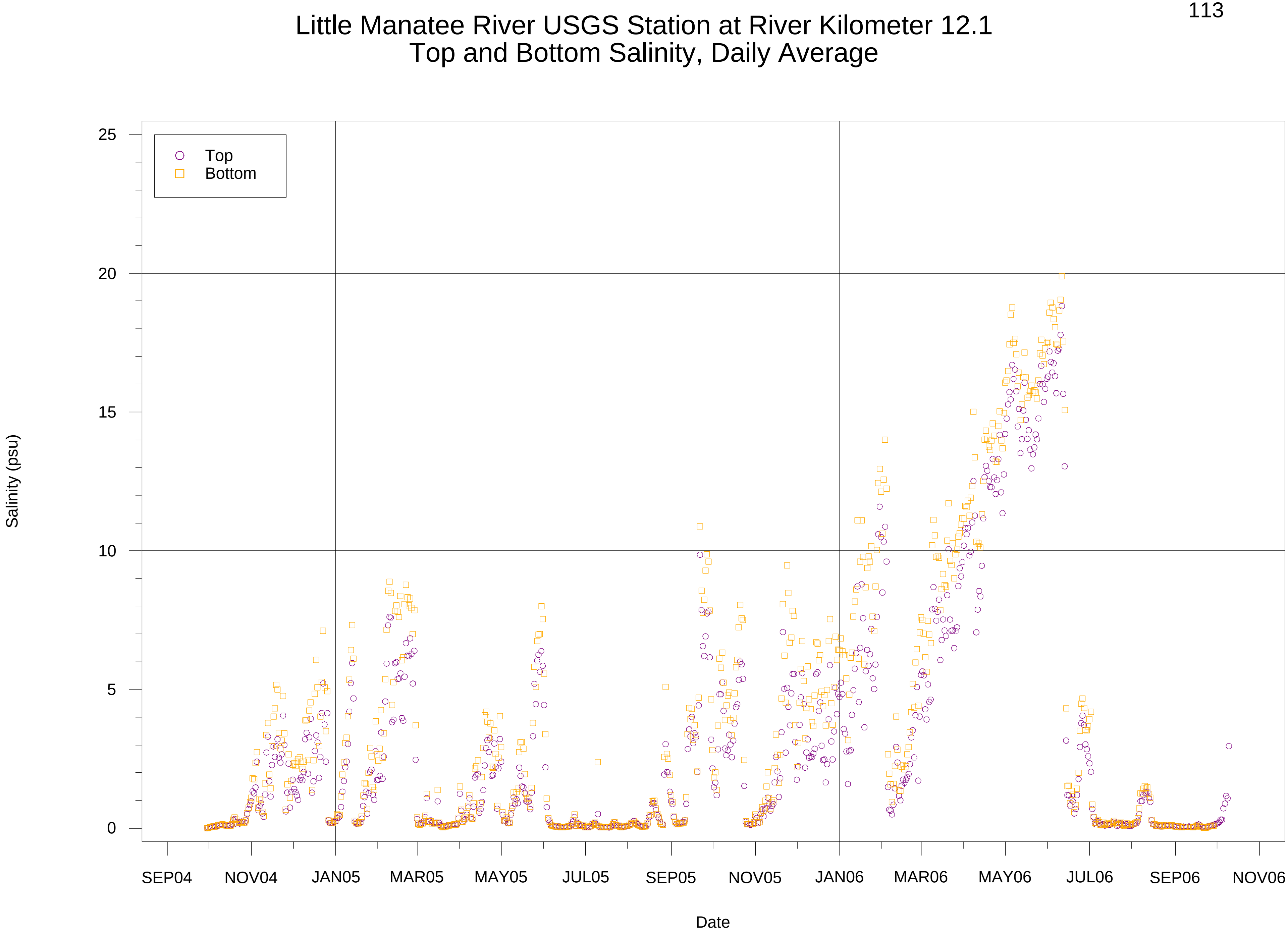





Little Manatee River USGS Station at River Kilometer 0.8
Top and Bottom Salinity, Daily Average
Top
Bottom
Salinity (psu)
0
5
10
15
20
25
30
35
JAN04
APR04
JUL04
OCT04
JAN05
APR05
JUL05
OCT05
JAN06
APR06
JUL06
OCT06
JAN07
Date

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
Top
Bottom
Salinity (psu)
0
5
10
15
20
25
SEP04
NOV04
JAN05
MAR05
MAY05
JUL05
SEP05
NOV05
JAN06
MAR06
MAY06
JUL06
SEP06
NOV06
Date

September 7, 2022

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.

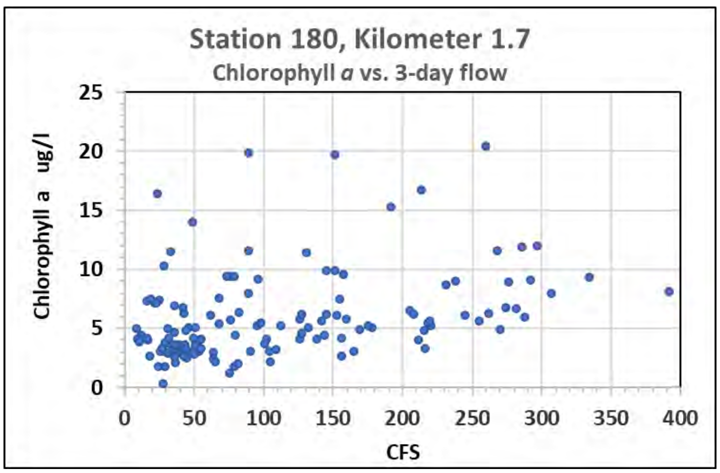
These studies have shown that the spatial distribution of chlorophyll *a* concentrations in tidal rivers is strongly affected by a number of factors, including nutrient loading, light penetration, and residence time. In turn, all of these factors are strongly affected by the rate and volume of freshwater 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.

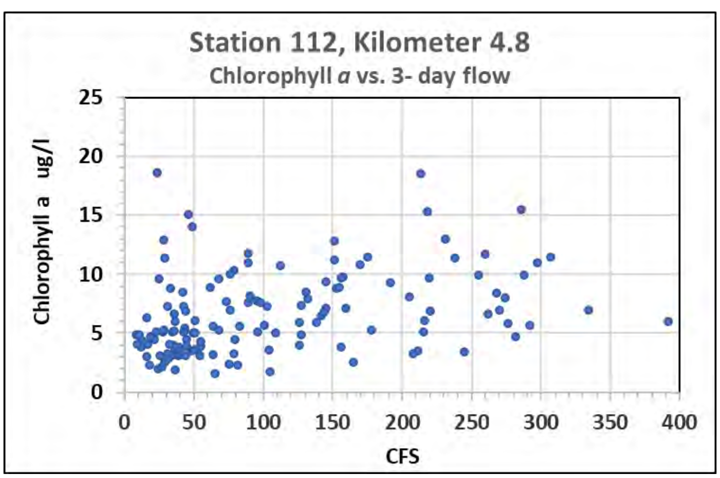
Table 2. Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers, adapted from Vargo et al. (2004).

		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.



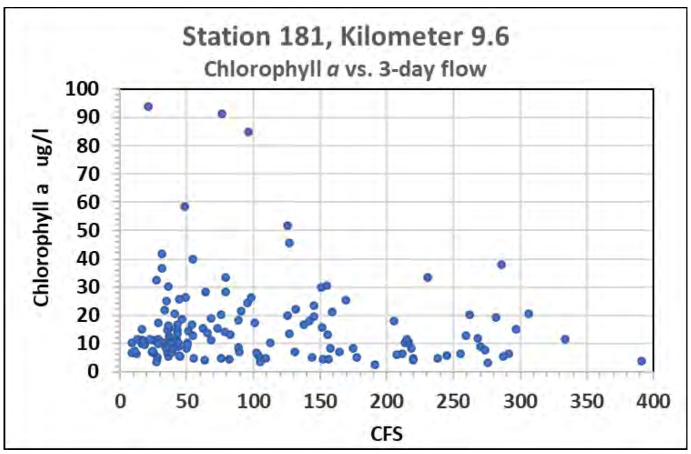


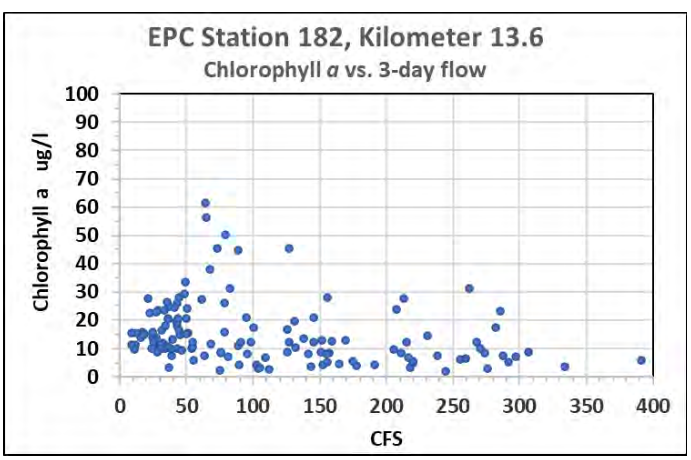
Figures 1 and 2. Chlorophyll *a* concentrations at EPCHC stations at kilometers 1.7 and 4.8 in the Lower Little Manatee River vs. the preceding three-day average flow at the US 301 gage.

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.

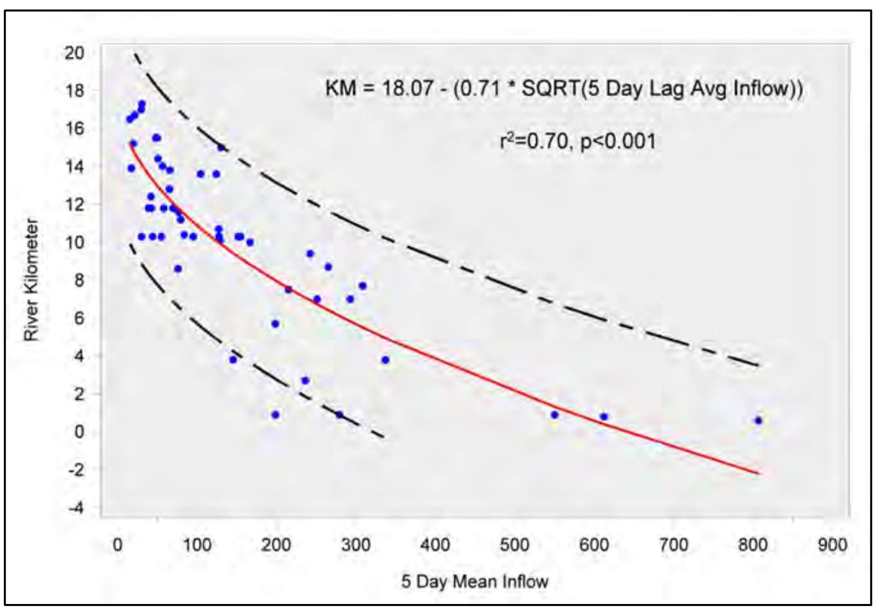


Figure 5. Scatter plot and regression of the location of maximum chlorophyll *a* concentrations measured among four moving salinity-based stations in the Lower Little Manatee River vs. the preceding five-day average inflow for each sampling date.

* **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.

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April 11, 2022

Doug Leeper
Southwest Florida Water Management District
Springs and Environmental Flows Section
2379 Broad Street
Brooksville, FL 34604
Doug.Leeper@WaterMatters.org

RE: Recommended Minimum Flows for the Little Manatee River Draft Report, Southwest Florida Water Management District, Hillsborough and Manatee Counties

Dear Mr. Leeper:

Florida Fish and Wildlife Conservation Commission (FWC) staff have reviewed the above referenced minimum flows and levels (MFL) report and appendices for the Little Manatee River. The following comments and recommendations are provided as technical assistance during your review of the draft MFL under Chapter 373, Florida Statutes (FS), and in accordance with FWC's authorities under Chapter 379, FS.

Executive Summary

The Southwest Florida Water Management District (SWFWMD) has completed the *Recommended Minimum Flows for the Little Manatee River Draft Report* (draft report, (2021) which summarizes minimum flows developed for the Little Manatee River, including both the freshwater and estuarine portions of the river. For purposes of minimum flows development, the freshwater portion or Upper Little Manatee River starts at the headwaters near Fort Lonesome in southeastern Hillsborough County and extends to the U.S. Highway 301 bridge, where the U.S. Geological Survey (USGS) "Little Manatee River at U.S. 301 near Wimauma, FL" (No. 02300500) gage is located. The estuarine portion or Lower Little Manatee River begins at the U.S. Highway 301 bridge and ends where the river flows into Tampa Bay.

The Little Manatee River is one of the most pristine blackwater rivers in Southwest Florida. The watershed of the Little Manatee River is in southern Hillsborough County and the northern portion of Manatee County; it includes the City of Palmetto and the communities of Parrish, Ruskin, Sun City, Wimauma, and Terra Ceia. The Little Manatee River flows west about 40 miles (64 km) from its headwaters east of Fort Lonesome before emptying into Tampa Bay near Ruskin.

The recommended minimum flows for the Little Manatee River were developed as required by Section 373.042, Florida Statutes and were based on relevant environmental values identified in the Florida Water Resource Implementation Rule (Chapter 62-40, Florida Administrative Code). The SWFWMD's approach for developing minimum flows is habitat-based, and because the Little Manatee River includes a great variety of aquatic and wetland habitats that support diverse biological communities, key ecological resources were identified for the development of minimum flows. The resource management goals that were the focus of the technical analyses for the development of minimum flows for the Little Manatee River included the following:

- Determination of a low-flow threshold to provide protection for ecological resources and
  recreational use of the Little Manatee River during critical low-flow periods.
- Maintenance of seasonal hydrologic connections between the Upper Little Manatee River
  channel and floodplain to ensure the persistence of floodplain structure and function.
- Maintenance of available instream habitat for fish and benthic macroinvertebrates in the
  Upper Little Manatee River.
- Maintenance of biologically relevant salinities that protect the distribution of fish species, benthic macroinvertebrates, and shoreline vegetation communities in the Lower Little Manatee River.
- Maintenance of available estuarine habitat for fish in the Lower Little Manatee River.

The criteria used for minimum flows development in the Little Manatee River addressed maintenance of 85% of the most sensitive criterion associated with the resource management goals using flow-based blocks. In addition, a low-flow threshold specific to surface water withdrawals and applicable to all blocks were identified to ensure flow continuity for environmental and human-use values. Finally, assessments were conducted to ensure all relevant environmental values that must be considered when establishing minimum flows would be protected by the minimum flows proposed for the Little Manatee River.

For the Upper Little Manatee River, the recommended minimum flows for Block 1 and Block 2 are based on maintaining available instream habitat. The minimum flows for Block 3 are based on maintaining floodplain inundation. For all flow-based blocks, the most sensitive criterion for the Lower Little Manatee River minimum flows development was the maintenance of available estuarine fish habitat, and the recommended minimum flows were established based on preserving 85% of the available estuarine fish habitat. The recommended minimum flows for the Upper and Lower Little Manatee River are based on flows for the previous day at the USGS U.S. 301 near Wimauma (No. 02300500) gage adjusted for upstream withdrawals.

An adaptive management approach will be used by the SWFWMD to monitor and assess the status of minimum flows established for the Little Manatee River. Changes in the Little Manatee River watershed related to multiple factors, including climate change, could potentially affect flow and additional information relevant to minimum flows development may become available. The draft report states that the SWFWMD is committed to periodic evaluation and, if necessary, revision of minimum flows established for the Little Manatee River.

Comments and Recommendations

FWC staff appreciates the SWFWMD's evaluation of the recommended minimum flows and levels for the Little Manatee River. Specific comments pertaining to current research and fish and wildlife habitat are provided below as technical assistance.

- The FWC's Fish and Wildlife Research Institute (FWRI) has a long history of research and development of techniques to support science-based decision making regarding freshwater inflow effects on fish and macroinvertebrates in southwestern and west-central Florida (Tsou and Matheson 2002, Greenwood 2007; Greenwood et al. 2007; Peebles and Greenwood 2009; Flaherty and Guenther 2011; Stevens et al. 2010, 2013; Olin et al. 2013, 2015; Whaley et al. 2016). FWC staff recommends incorporation of the historical record of work completed in the Little Manatee River in this and subsequent MFL assessments. This review should include reports on historical sampling (Haddad et al. 1989, 1990; Peebles et al. 1991; MacAulay et al. 1993), a thorough discussion of relationships between freshwater inflow and populations of fish and selected macroinvertebrates in the Little Manatee River (MacDonald et al. 2007), and other published studies pertaining to the Little Manatee River (Rydene and Matheson 2003, Ley and Rolls 2018, Trotter et al. 2021). FWC staff recommends that more text be dedicated to the findings of this work (as was done in Janicki Environmental Inc. 2011) as the findings are directly applicable to establishing MFLs for the Little Manatee River.

- The Little Manatee River contains important nursery habitat for several economically important fishery species such as red drum (Whaley et al. 2016) and blue crab (MacDonald et al. 2007; Flaherty and Guenther 2011). Whaley et al. (2016) estimated that during the period from 1996 to 2008, the Little Manatee River contained 10 – 47% of the annual juvenile population of red drum surviving to the larger juvenile stage (50 – 100mm standard length) within the Tampa Bay estuary and adjacent rivers. FWRI's Fisheries-Independent Monitoring (FIM) program has abundant biological data (24-years of data collected monthly, 1996-2019) describing spatiotemporal distribution patterns of numerous fish and invertebrate species inhabiting the estuarine portions of the Little Manatee River, and the characterization of the lower river fish community could be greatly improved by a more thorough analysis of these taxa over the complete time record, instead of focusing on data collected from the most recent year of sampling (2019, p. 92 and Tables 4.8 and 4.9), a period of heavy inflow conditions. For example, it is standard practice to examine annual variation in fish abundance in terms of mean catch-per-unit-effort (number/net, number/unit area) instead of total numbers collected (Figures 4-9, 4-10), and annual patterns in young-of-the-year recruitment for selected species should be discussed in more detail (Figure 4-11).

- The assessment of significant harm (habitat reductions greater than 15%) appears to be solely determined using the Environmental Favorability Function (EFF) modelling to assess changes in favorable habitat. However, the final presentation of this modelling effort concentrated on species data from 2015 – 2019, a period of generally high freshwater inflow conditions. It is not clear in the draft report whether other time periods were also assessed by the model, but not presented. If that is the case, those results should be discussed with a rationale as to why 2015-2019 was used in this report. The examination of percentage reduction in species habitat that may occur during dry periods appears to be missing in the report or the analyses. Species-inflow relationships can be non-linear, and a percent reduction in species habitat under wet conditions will not likely have the same magnitude during dry conditions. Previously published research has shown that abundance of juvenile red drum in the Little Manatee River varies greatly in wet versus dry periods (Whaley et al. 2016). In addition, the Little Manatee River is the least impacted major river system in the Tampa Bay watershed, so withdrawals from this system should be made carefully and include the full complement of data associated with the system, including major end points (1998/1999 El Nino and 2007/2008 severe drought) and perturbations (e.g., cold events such as in 2010, red tide events such as in 2005, 2018; Flaherty and Landsberg 2011, Stevens et al. 2016, Schrandt and MacDonald 2020) that may impact nekton communities, fish recruitment, and mortality.

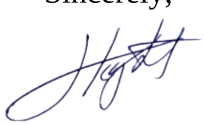
- The magnitude that freshwater inflow modifications may have on the food web of the Little Manatee River does not appear to be addressed in this report. The relationships among freshwater inflow, nutrients, and distribution and abundance of phytoplankton are well established (Peebles 2002; Olin et al. 2013; Stevens et al. 2013). Phytoplankton concentrations are closely related to the distribution and abundance of bay anchovy (Peebles 2002, Olin et al. 2013), a dominant nekton species in the lower rivers, and an important component of the food web (Hollander and Peebles, 2004). In addition, a lower volume of freshwater can affect inundation and nekton use of important riverine floodplains, such as marshes, along the shoreline of the river (see reviews by Robins et al. 2005 and Gillson 2011). These marshes typically provide abundant benthic food sources as well as protection from predation for many nekton species, including some fishery species (Beck et al. 2001 and references therein). Addressing the influence of freshwater flow reduction on the food web (planktonic and benthic pathways) would be helpful in the analysis and report.

- Spatial species modelling regarding minimum flows, such as the EFF modeling by Janicki Environmental Inc. (2011, 2018, SWFWMD 2021), could be improved by consulting with FWRI staff in the FIM program and Center for Spatial Analysis. FWRI staff have related fish populations to flow and other habitat variables in several rivers along the Gulf coast (e.g., Alafia, Anclote, Chassahowtizka, Crystal, Hillsborough, Homosassa, Manatee, Myakka, Peace, and Weeki Wachee Rivers) including the Little Manatee River (MacDonald et al. 2007), so these methods should be investigated and applied as appropriate for each individual river system. For example, in the Alafia River just north of the Little Manatee River, FWRI identified freshwater resident and transient species that recruit into the river from the estuary and offshore as potential indicators of the impacts of differing flow regimes (Flaherty et al. 2013, MacDonald et al. 2013, Matheson et al. 2013). There are also species that tend to focus on a particular river section and others that move up and down the river that could be used to determine impacts of different flow regimes. The transport of juveniles related to flow (not just water level or salinity regime) within the estuarine portions of rivers should also be considered (Norcross and Shaw 1984). In addition, although the conservation of the oligohaline zone is important for nekton, it is unclear why the goal is to maintain the 1-2 practical salinity unit (psu) habitat conditions (river km ~15-19; as noted in the initial peer review report) even though many of the species mentioned were not abundant in the 1-2 psu range. Other research on salinity zones in southwest Florida suggest that the 0.1-1 psu range corresponds with relatively large changes in nekton communities (Greenwood 2007), and several marine species tend to use the lower river as nursery habitat. Furthermore, the report mentions Schireiber and Gill's (1995) three-tiered classification system for assessing important fish habitats, where the tidal freshwater zone of this system would correspond with Greenwood's (2007) findings, but it does not give a rationale as to why the three-tiered system was not used for the nekton. In other MFLs nationwide, the low salinity zone is targeted for management with the assumption that the salinity gradient downstream is maintained. If this is the case here, then it could be stated more explicitly. Also, the reader should be made aware that much of the nursery habitat for estuarine and marine species occurs in the lower river. In general, FWC staff recommends the report more clearly describe how and why these rivers are important to estuarine/marine species and what the effects of reduced freshwater inflow are likely to be.

In summary, given the breadth of the longstanding fisheries data for the Little Manatee River, FWC staff believes the information above should be more clearly described or examined further in the final version of the report.

FWC staff appreciates the early coordination with the SWFWMD staff during the data collection and technical analysis phases of MFL evaluations and looks forward to working through fish and wildlife habitat concerns throughout the final approval process for this MFL. For specific technical questions regarding the content of this letter, please contact Michelle Sempsrott at (407) 452-1995 or by email at Michelle.Sempsrott@MyFWC.com. All other inquiries may be sent to ConservationPlanningServices@MyFWC.com.

Sincerely,



Jason Hight, Director
Office of Conservation Planning Services

jh/ms
Little Manatee River MFL Update_46722_04112022

cc: Kym Holzwart, Southwest Florida Water Management District, Kym.Holzwart@swfwmd.state.fl.us

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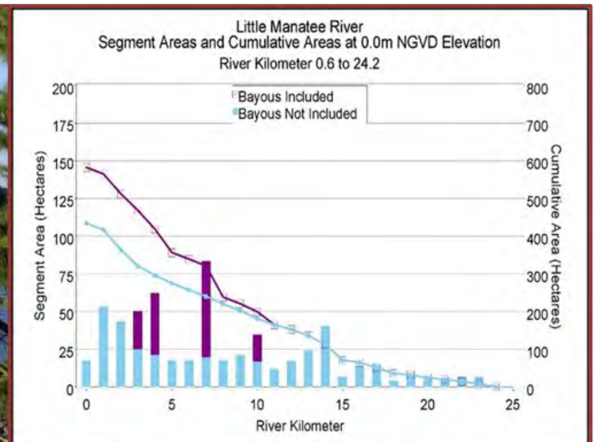
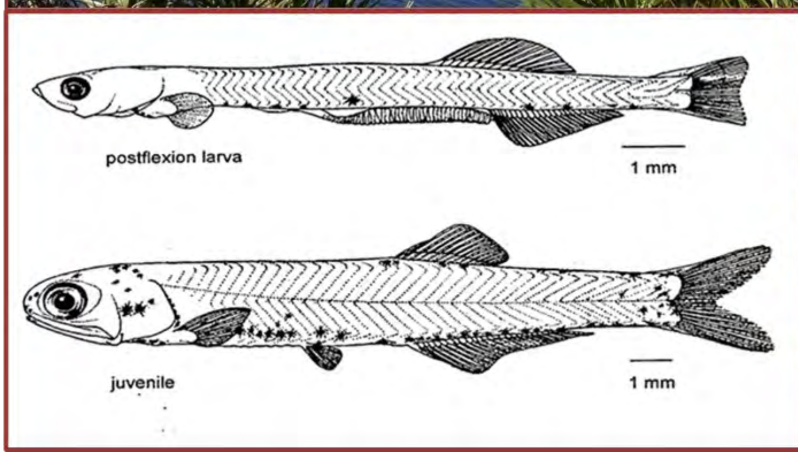
Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows for the Little Manatee River





January 2022

(with corrections and minor revisions in June 2023)

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 for the Little Manatee River

This document is based on a review of the draft minimum flows report for the Little Manatee River published by the SWFWMD in September 2021. Many of these points have since been addressed by the District in a revised minimum flows report published in June 2023, but some significant points have not. Regardless, this document describes important characteristics of the Little Manatee River that I suggest be addressed in the determination of minimum flow for the lower tidal section of 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 of 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 in a separate evaluation of 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 EFF fish habitat modeling 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 5 to 7 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 are 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. These results can also be used to assess appropriate flow blocks for the lower river. *(These analyses were not performed as I did not receive output for the revised EFDC and EFF models).*

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 the medium flow to high flow blocks that designate a change in the allowable percent flow

reductions. Material is also presented to support a strong recommendation that flow blocks need to be evaluated separately for the lower river.

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). *(Much of this was not submitted due to my not receiving the revised EFDC and EFF modeling output for the lower river. However, the subject of revisiting nekton abundance with flow has been addressed through subsequent interactions between the District's consultant and the Florida Fish and Wildlife Conservation Commission.*

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.

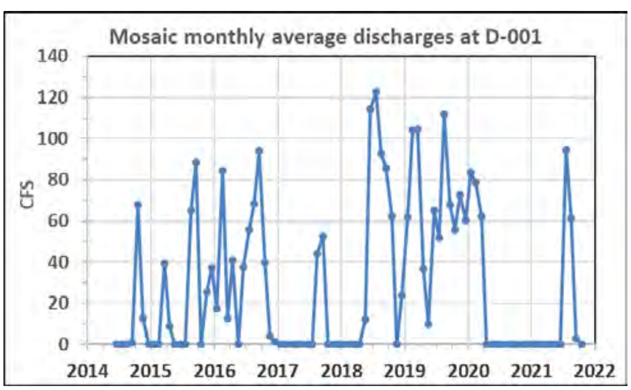
- Text resumes on next page –

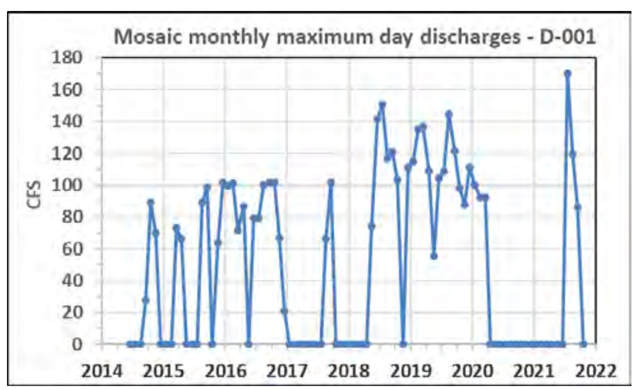
1. Recent point source discharges from the Mosaic Company Four Corners mine and status of phosphate mining in the Little Manatee River watershed.

The Mosaic Company mines phosphate ore in the upper reaches of the Little Manatee River watershed. Associated with this mining is a 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 (Figures 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.

**** The revised 2023 minimum flows report also identifies a smaller point source discharge (D003) that flows to Howards Prairie Branch in the Little Manatee River watershed***

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.

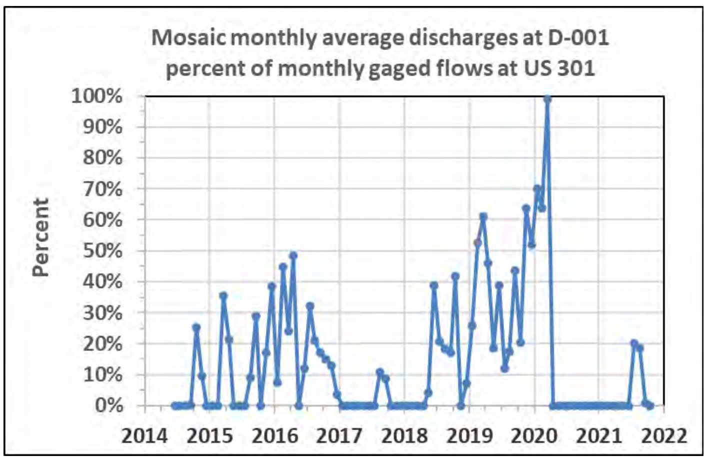


Figure 3. Percentage of average monthly gaged flows at the Little Manatee River at US 301 near Wimauma comprised of average monthly discharges at Mosaic Site D-001

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.

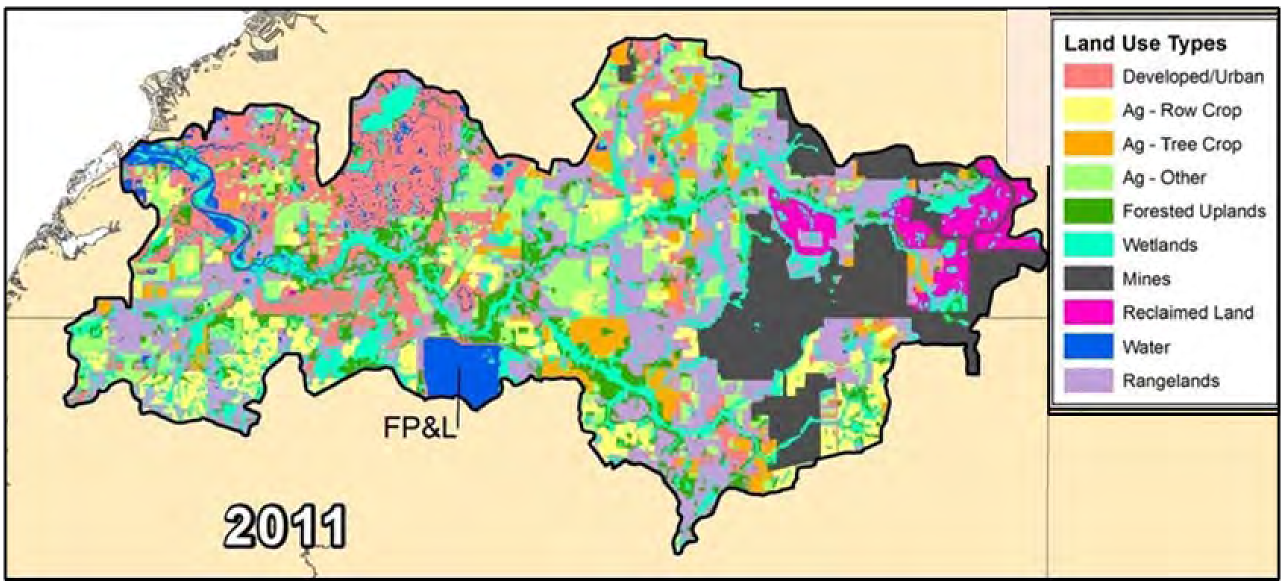


Figure 4. Land/Use cover map in the Little Manatee River Watershed for 2011, adapted from Figure 2-5 in JEI (2018a, Appendix C) and Figure 2-6 in JEI (2018b, Appendix E).

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.

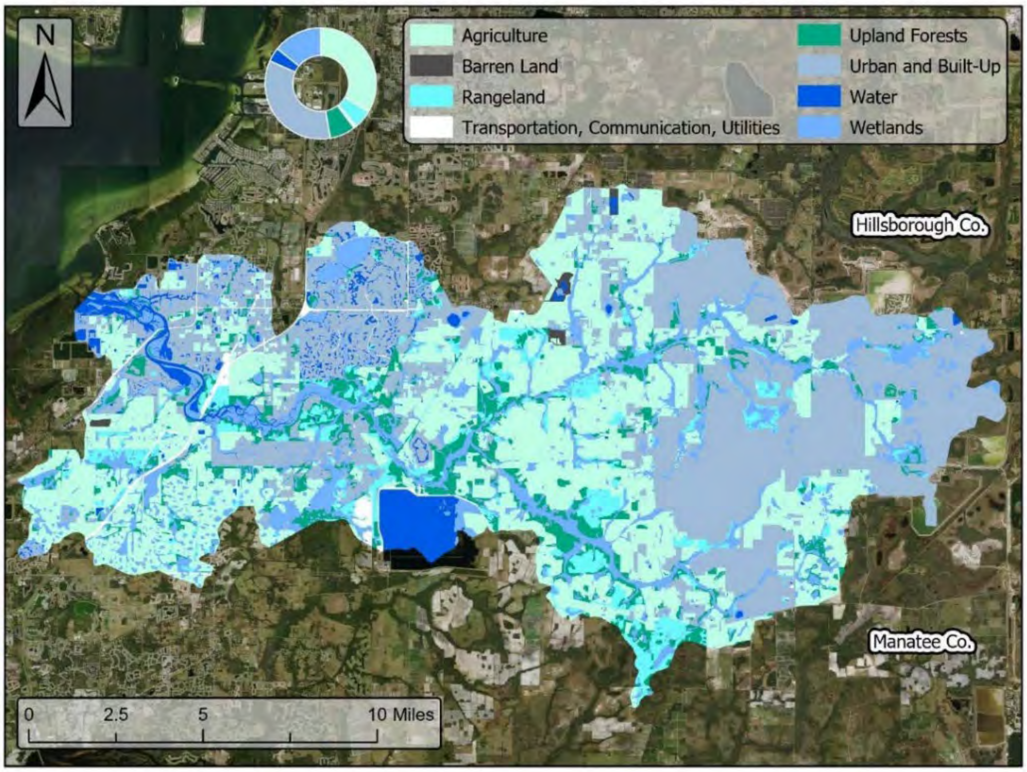


Figure 5. The 2017 Florida Land Use, Cover and Forms Classification System (Level 1) of the Little Manatee River watershed (SWFWMD 2019). Reprinted from 2021 draft minimum flows report.

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 the 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 the gaged flow of the river 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 gaged 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 of any five-year period 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 2, 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 2, the P50 for 2015-2019 was 105 cfs compared to range of 61 to 81 cfs in Table 2, the P75 for 2015-2019 was 243 cfs compared to a range of 145 to 167 cfs in Table 2, and the P90 for 2015 – 2019 below was 516 cfs compared to a range of 375 to 387 cfs in Table 2.

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.

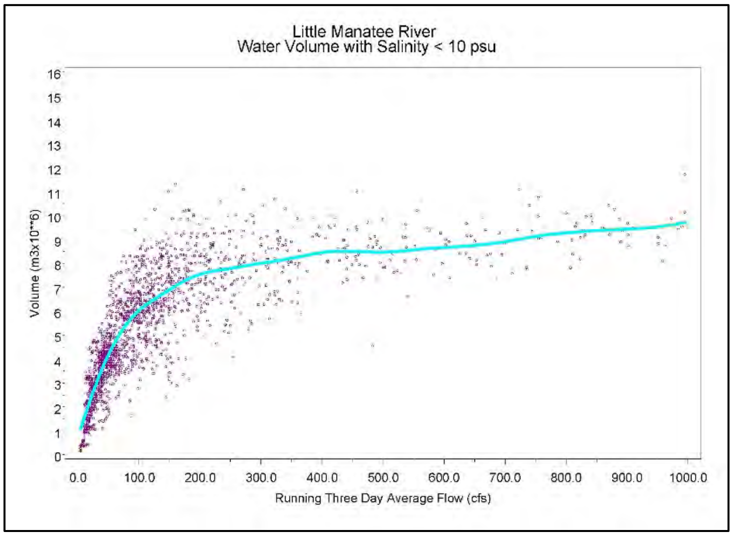


Figure 6. Water volume less than 10 psu salinity in the Lower Little Manatee River as a function of preceding three-day freshwater inflow as predicted by the EFDC model for the lower river.

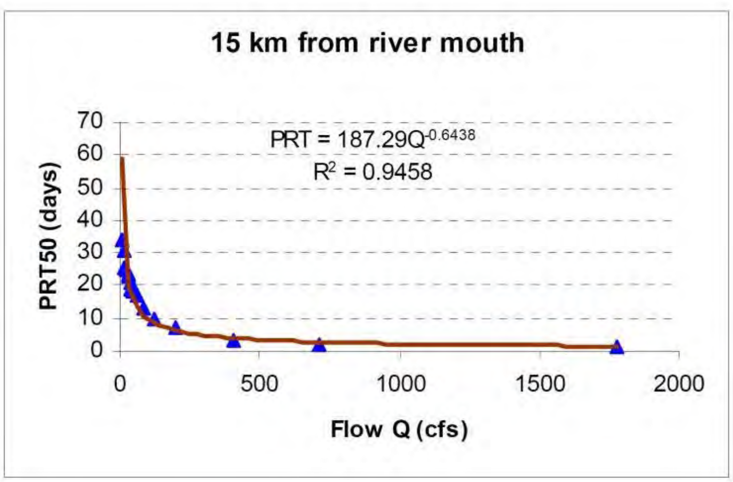


Figure 7. Pulse residence time versus freshwater inflow at a site 15 kilometers upstream from the mouth of the Little Manatee River, adapted from Figure 3-14 in JEI (2018b).

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.

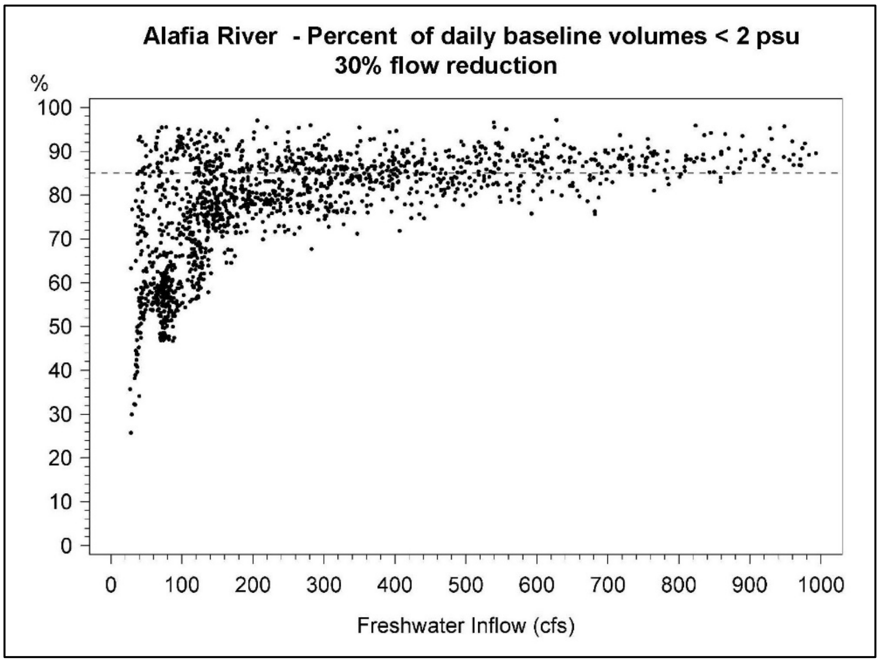


Figure 8. Percent of water volume less than 2 psu salinity relative to baseline for daily flow reductions of 30 percent vs. the rate of daily baseline flow for the Lower Alafia River with a reference line at 85 percent remaining habitat, equivalent to a 15% reduction in volume.

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 in Table 4 on page 19. Though not shown, the file contained values down to a maximum depth of between 15.0 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.

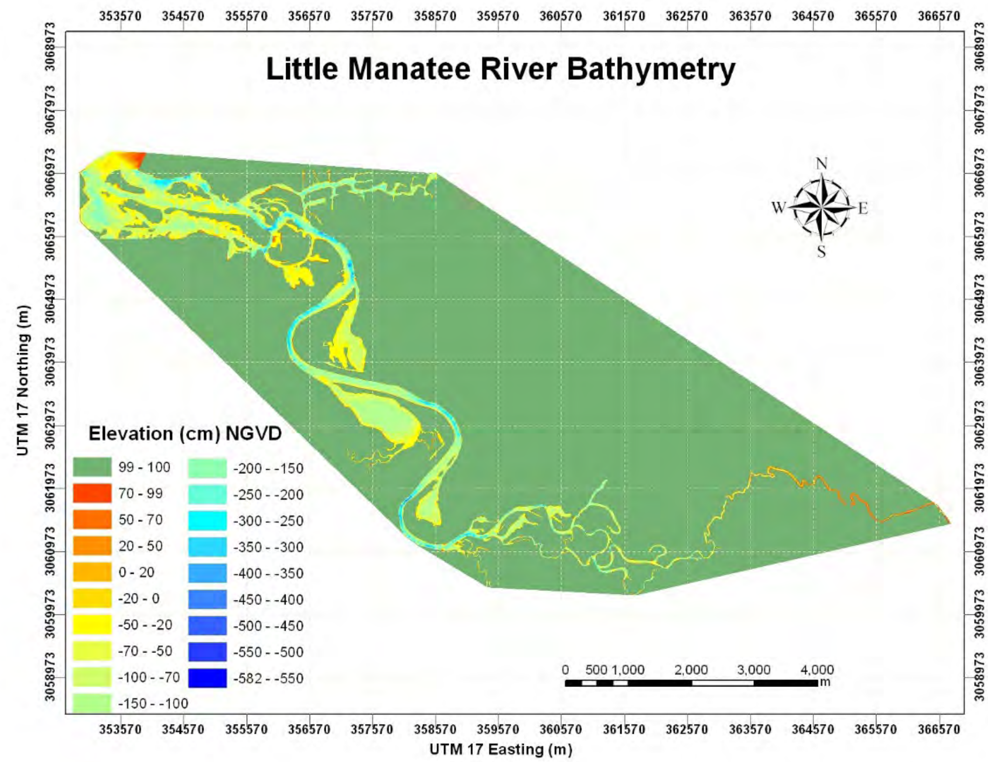


Figure 9. Bathymetric map of Little Manatee River generated from data from Wang (2006)

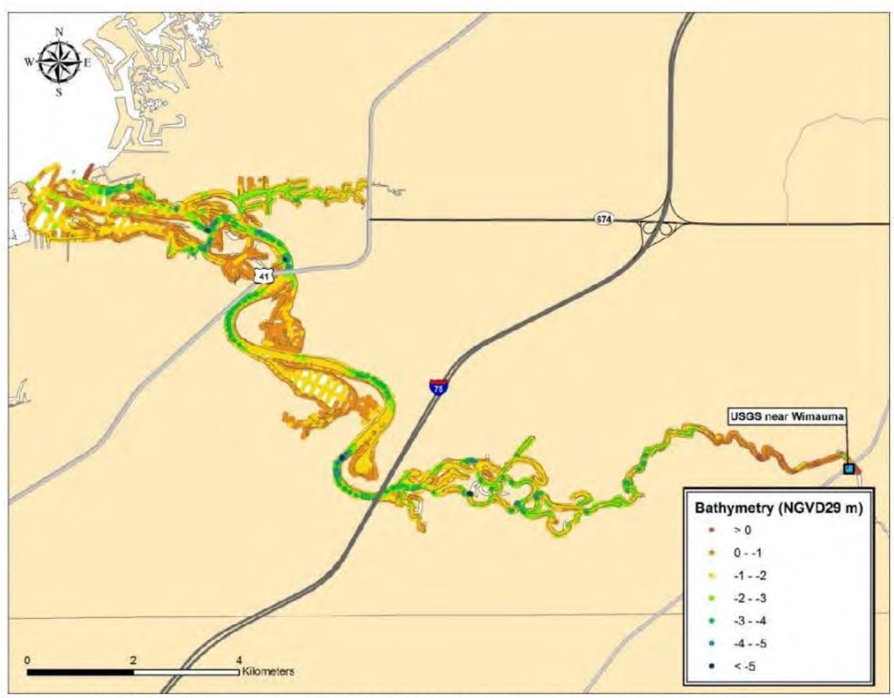


Figure 10. Bathymetric map reprinted from the first draft minimum flows report for the lower river (JEI 2018b)

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 15.0 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 dissolved 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.

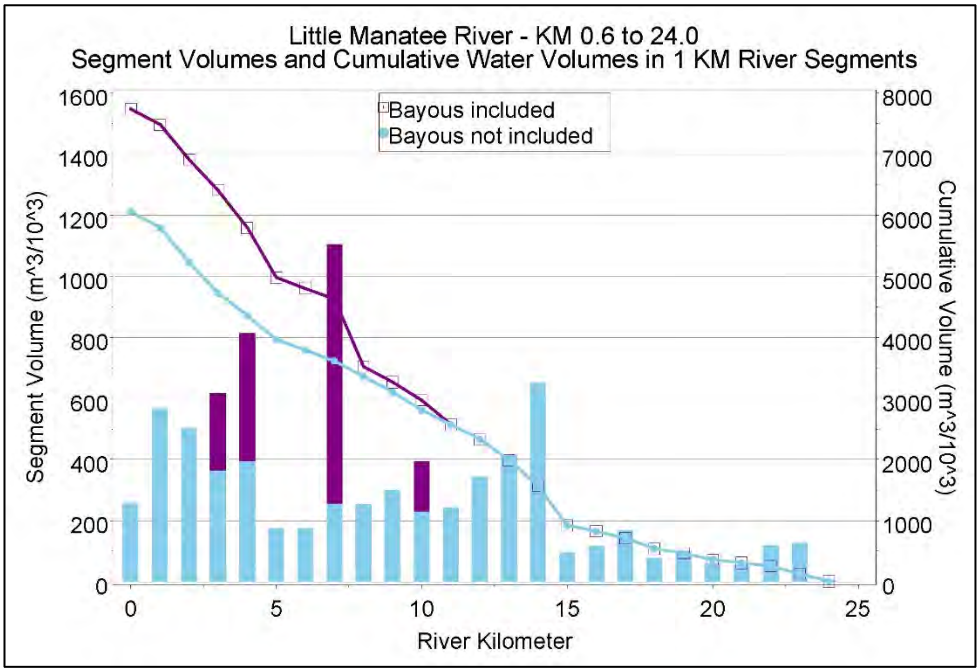


Figure 11. Volume of the Lower Little Manatee River in one-kilometer segments and cumulative volume increasing toward the river mouth from km 24 to km 0.6.

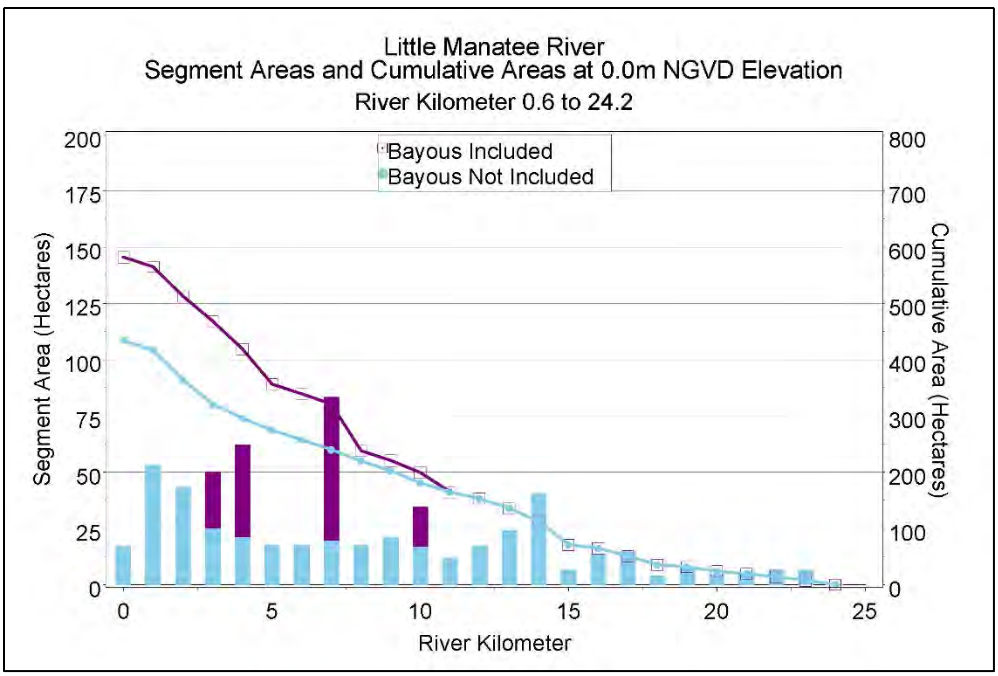


Figure 12. Area of the Lower Little Manatee River at an elevation of 0.0 meters NGVD1929 in one-kilometer segments and cumulative area increasing toward the river mouth from km 24 to km 0.6.

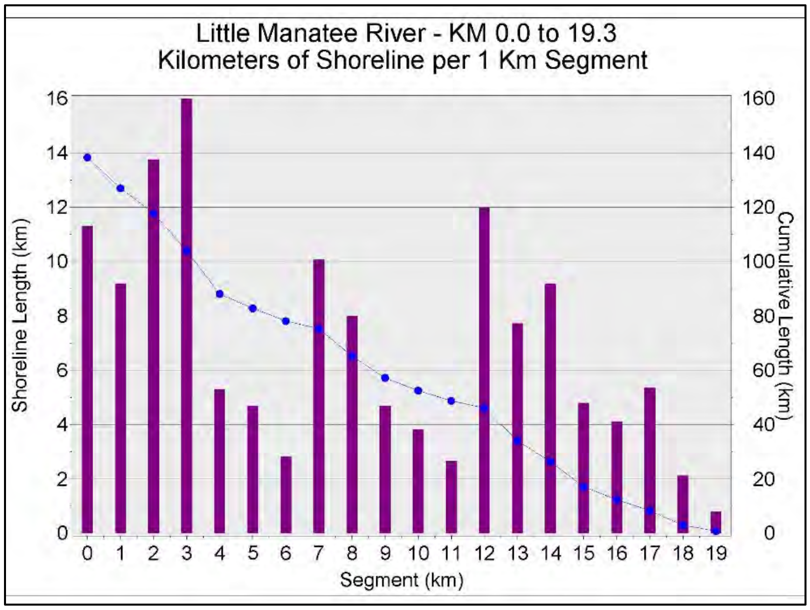


Figure 13. Shoreline lengths along the Lower Little Manatee River in one kilometer segments and cumulative shoreline length increasing toward the river mouth from km 19 to km 0.6

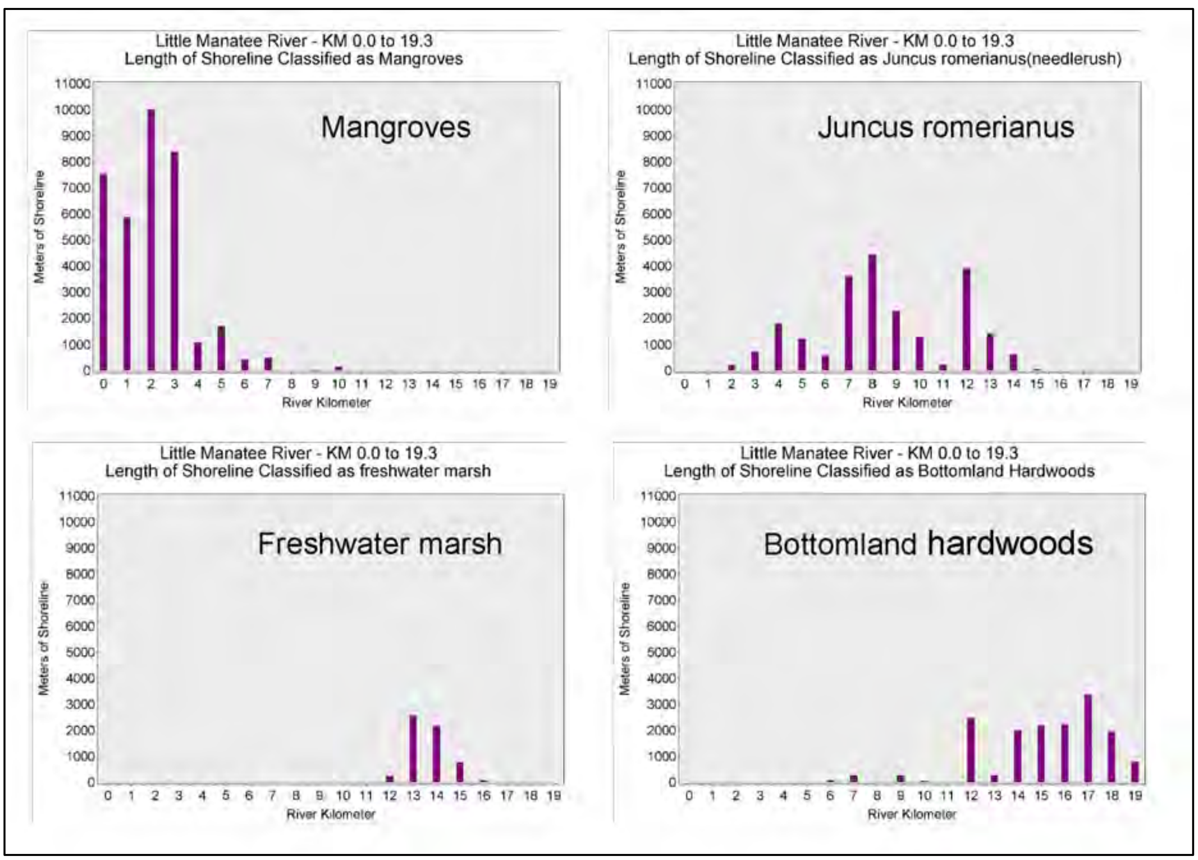


Figure 14. Shoreline lengths of mangroves, needle rush (*Juncus romerianus)*, freshwater marsh and bottomland hardwoods along the Little Manatee River from km 0.0 to km 19

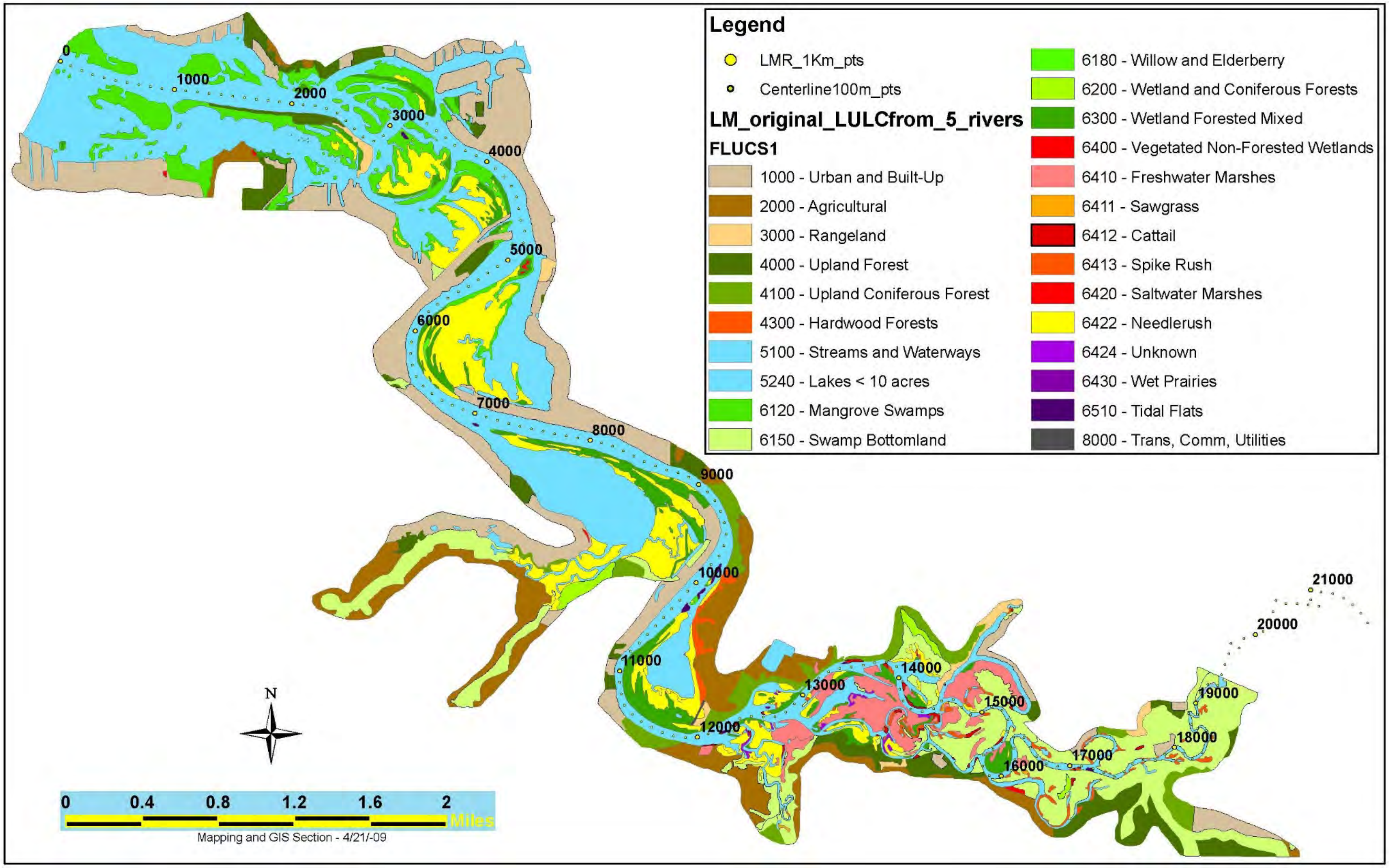


Figure 15. The distribution of major vegetation communities along the Lower Little Manatee River mapped by the Florida Marine Research Institute (1997).

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.

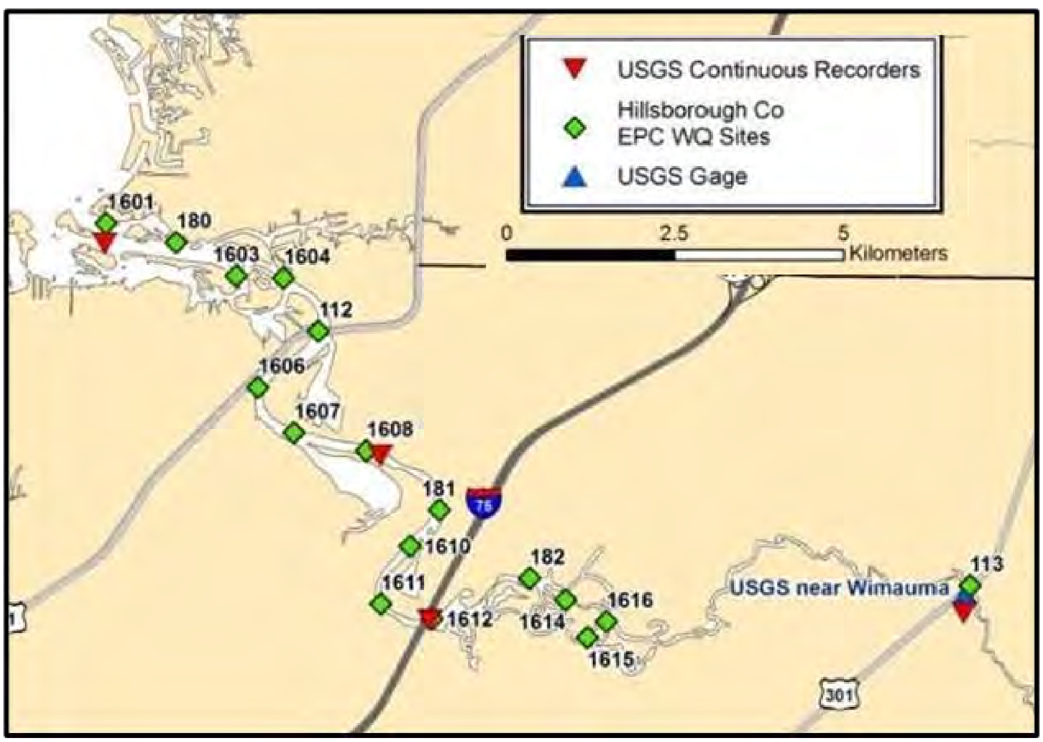


Figure 16. Location of vertical profile stations monitored in the lower river by the EPCHC, adapted from the first draft minimum flows report for the lower river (JEI 2018b).

*** *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.

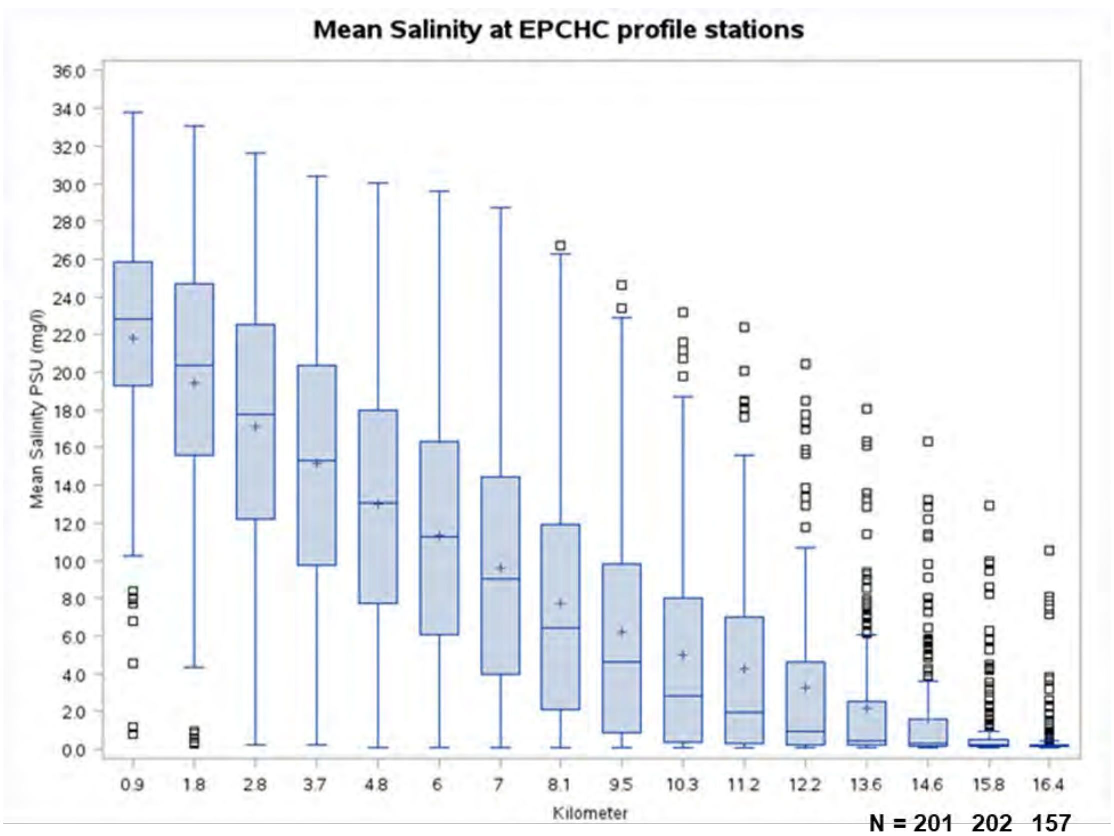


Figure 17. Box plot of mean water column salinity values at EPCHC vertical profile stations. The + symbols are means, the horizontal lines the medians, with the whiskers extending to 1.5 times the inter-quartile range. Outliers are shown for above the whiskers, but not below as freshwater outliers (<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.

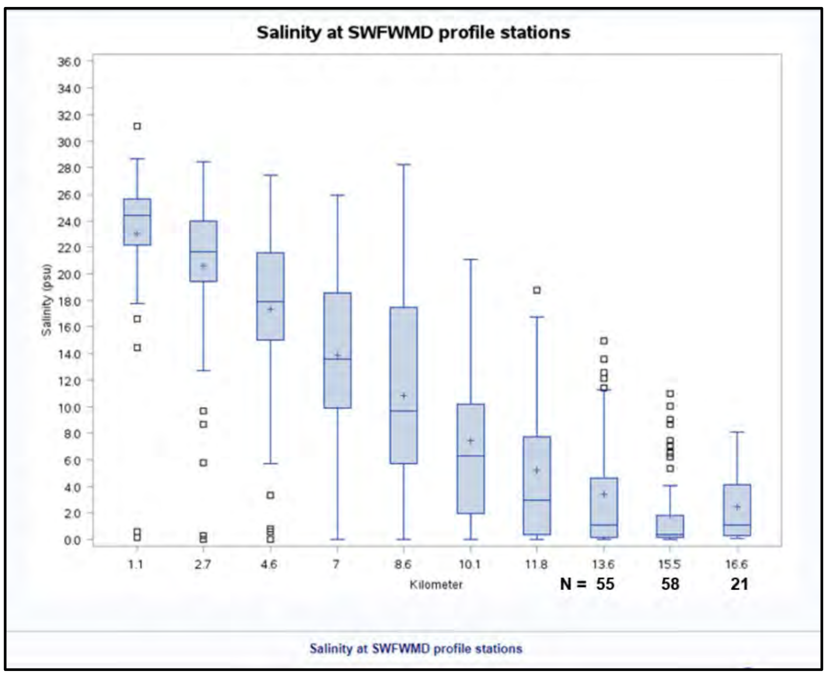


Figure 18. Box plot of mean water column salinity values at SWFWMD vertical profile stations.

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

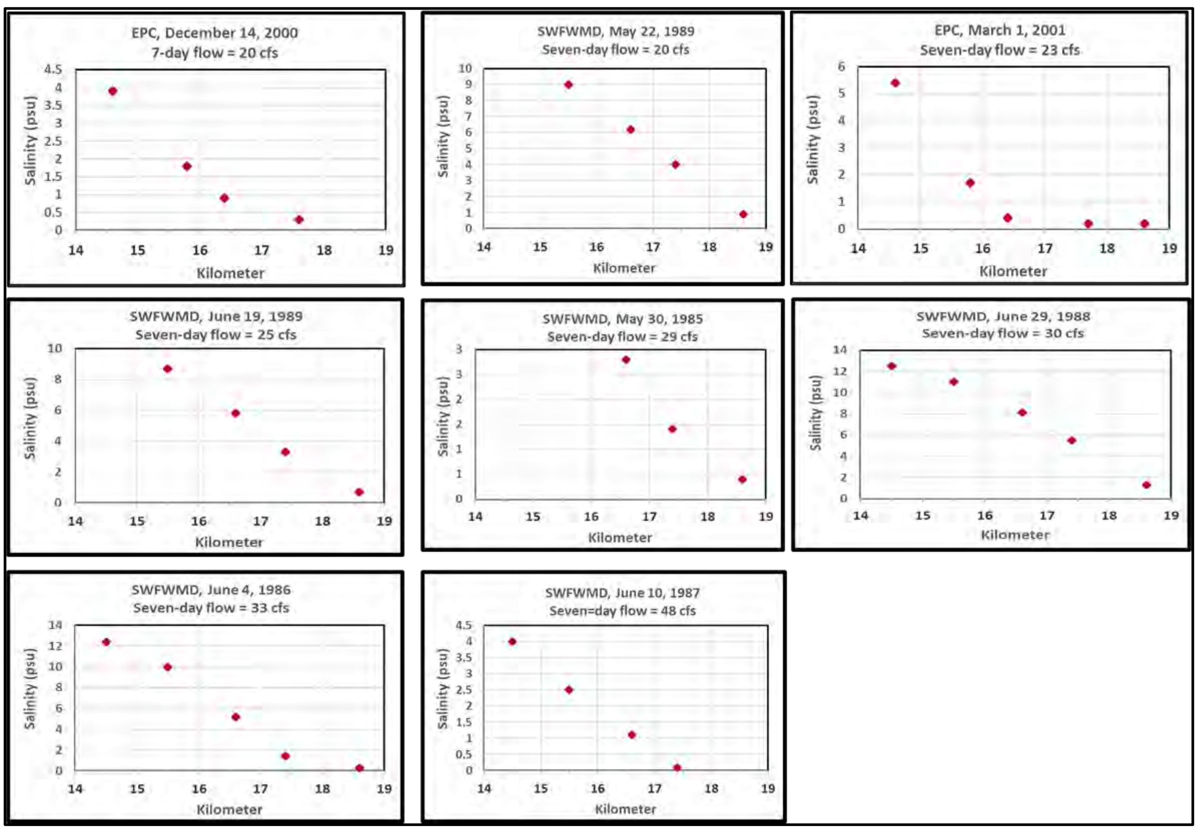


Figure 19. Mean water column salinity at upper stations in the lower river when sampling extended upstream of kilometer 16.6 by either the EPCHC or the District. The preceding seven-day average flow for each sampling date is listed on graphs.

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, Whigham 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 indicates 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.

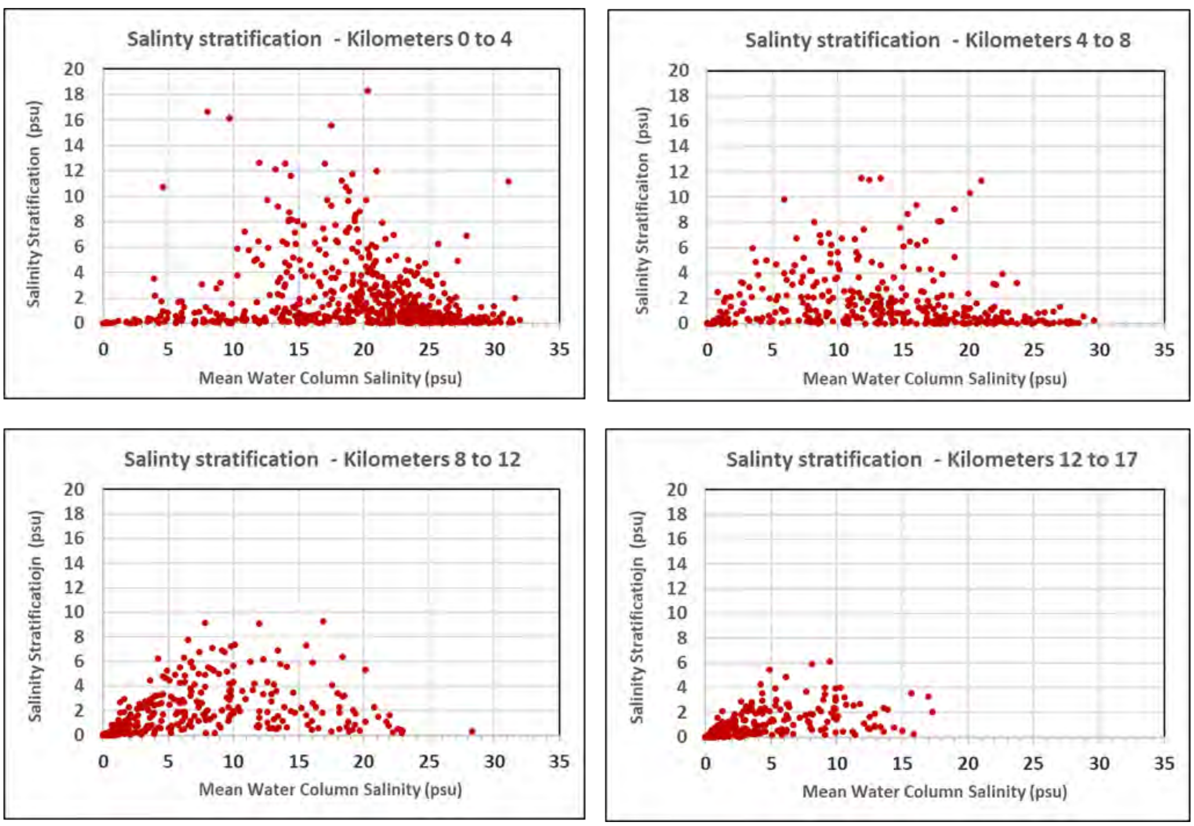


Figure 20. Salinity stratification (bottom minus surface) vs. mean water column salinity in four reaches of the Lower Little Manatee River as measured in vertical profiles taken by the EPCHC and SWFWMD.

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.

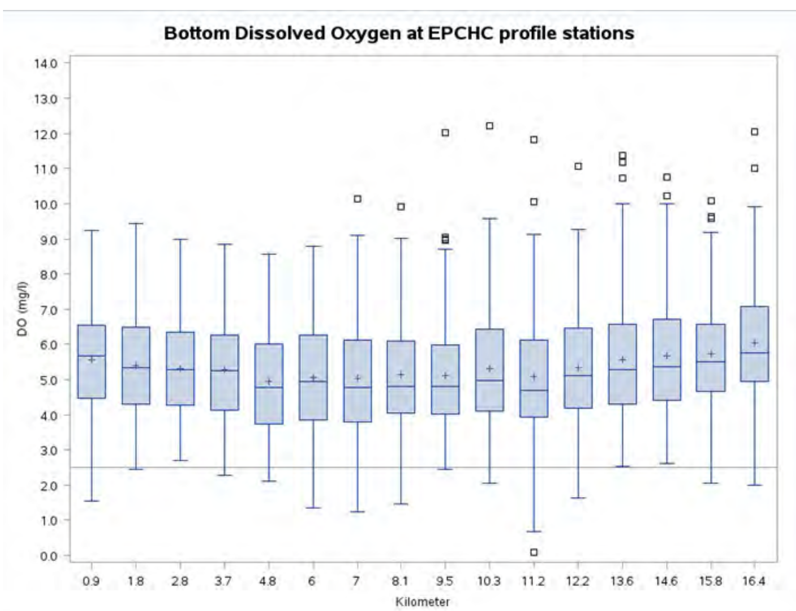


Figure 21. Box plot of bottom DO concentrations at EPCHC vertical profile stations, using same plotting conventions as Figure 17 on page 25.

Since individual outliers at low DO concentrations are not shown in Figure 21, 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.

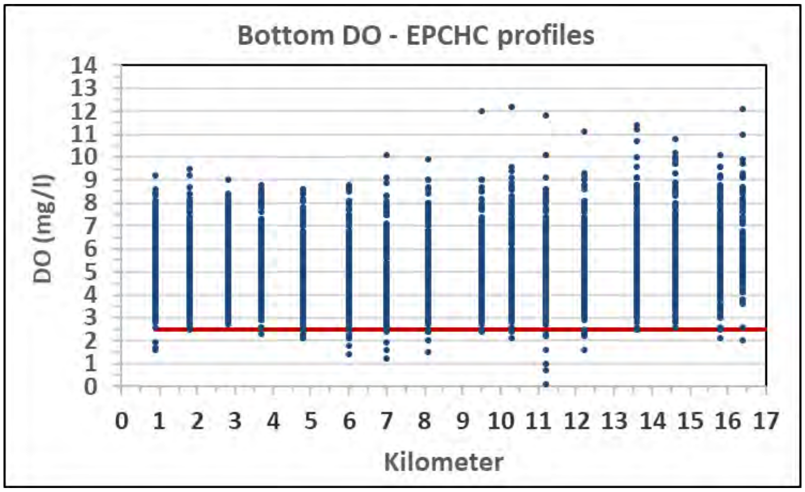


Figure 22. Individual bottom DO concentrations at EPCHC vertical profile stations

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.

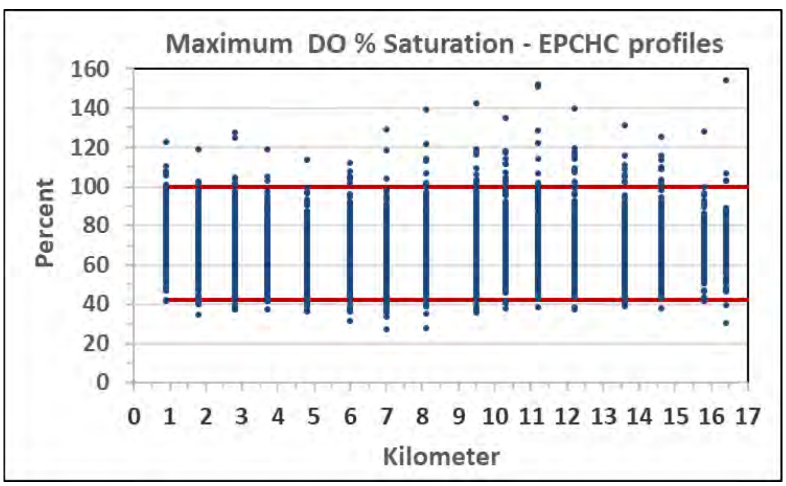


Figure 23. Maximum values of DO percent saturation at EPCHC vertical profile stations.

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.

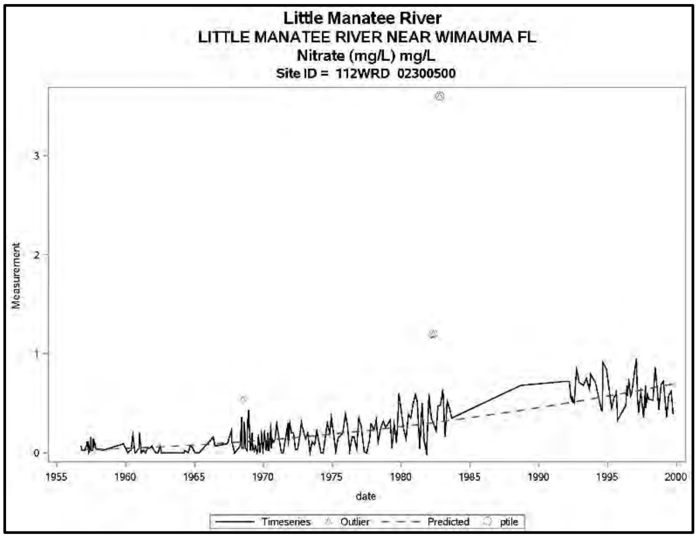
In determining what sites to use, the report limited their statistical analysis and interpretation to sites that has at least 60 observations in the EPCHC or Impaired Water Rule (IWR) data bases. Using the nonparametric Seasonal Kendall Tau test, trends all these sites to examined to determine if various 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.



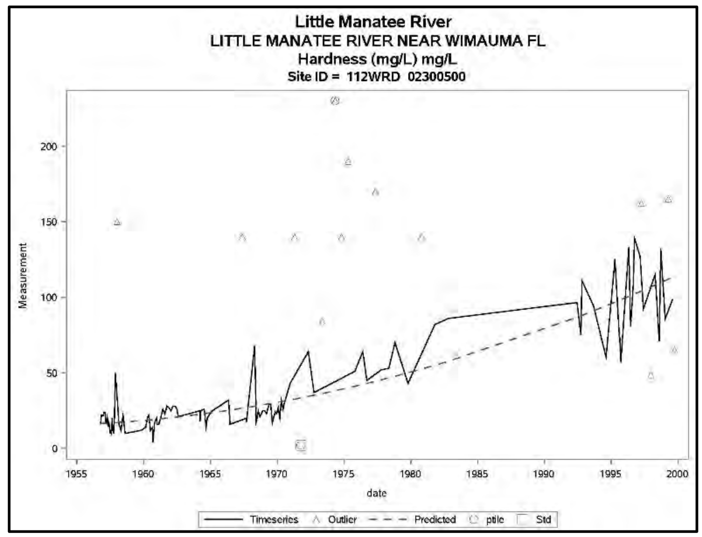


Figure 24. Concentrations of nitrate nitrogen and hardness, both as mg/l, for the USGS gage at US 301 Little Manatee River near Wimauma starting in the 1956 through 1999. Graphs taken from Appendix D-1 to the draft minimum flows report.

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.

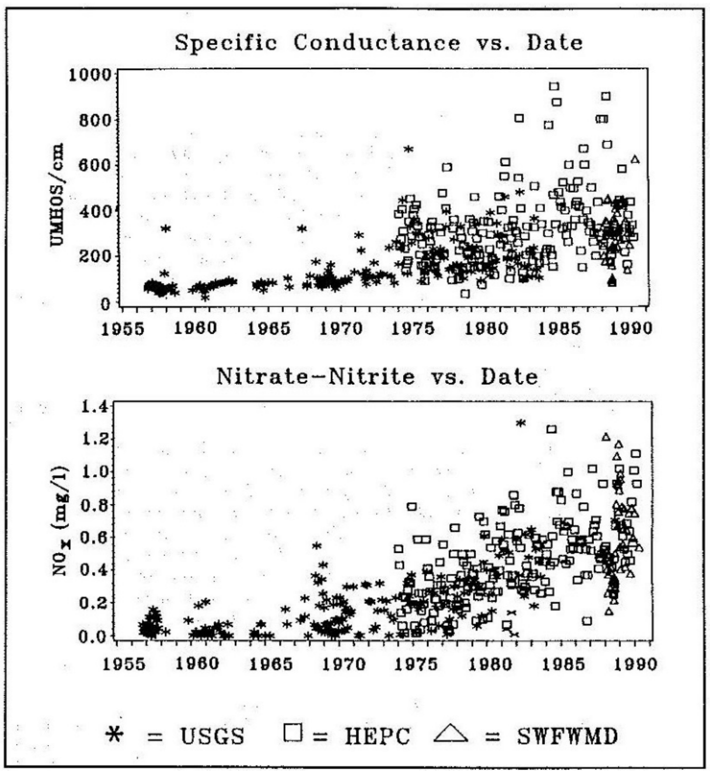


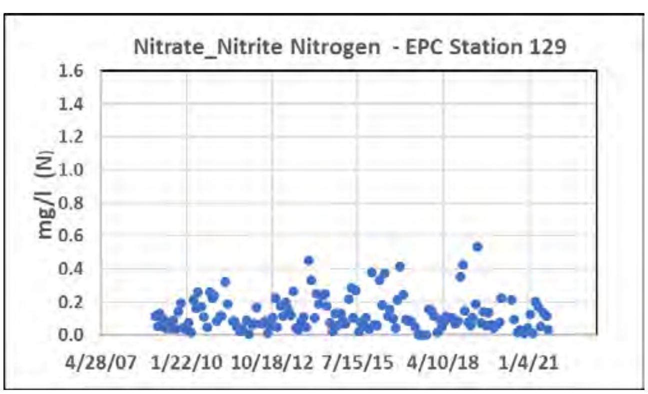
Figure 25. Time series plots of specific conductance and nitrate + nitrite nitrogen (as mg/l N) at the Little Manatee River near Wimauma at US 301 gage for 1956 through 1990 from three data sources: the USGS; the EPHCH (HEPC) and the District (SWFWMD). Reprinted from Flannery et al. (1991).

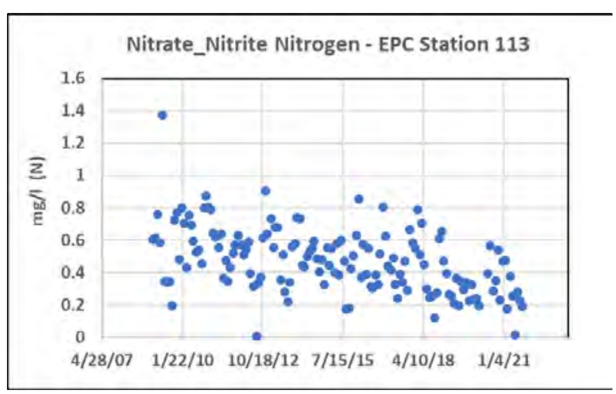
The comparison of constituent concentrations and flux rates from the watershed in this project is also informative. During the study, the most upstream site on the river at the site of the USGS gage near Ft. Lonesome was somewhat of a control site, as phosphate mining was largely inactive during the 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 5 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 5. 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 5 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 6 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 6 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 6, but that can be checked the values in Table 6 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 6. 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

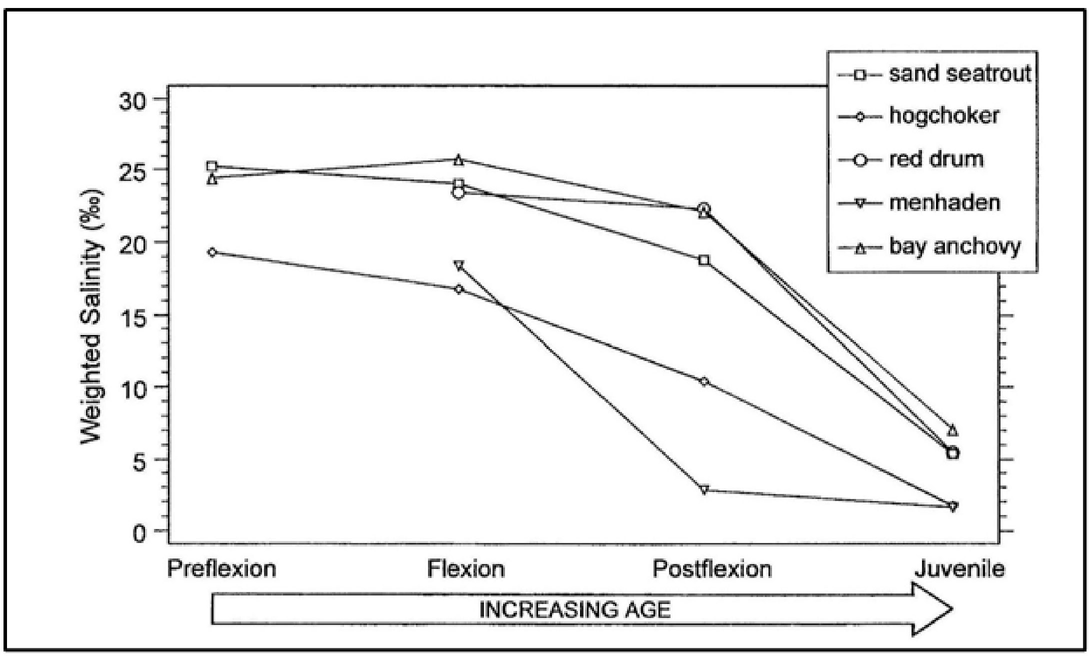


Figure 28. Decreasing mean salinity at capture with fish development for five species in the Little Manatee River. Reprinted from Peebles and Flannery (1992).

In addition to the taxa and stages listed in Table 6 on the previous page, in Table 7 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 7. The most common taxon/stages for fishes in 480 plankton tows listed in Table 4-10 in the minimum flows report with mean salinity at capture and center of abundance (KmU) added from Peebles (2008). (The taxon/stages in Table 6 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	Blenlid	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. 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.

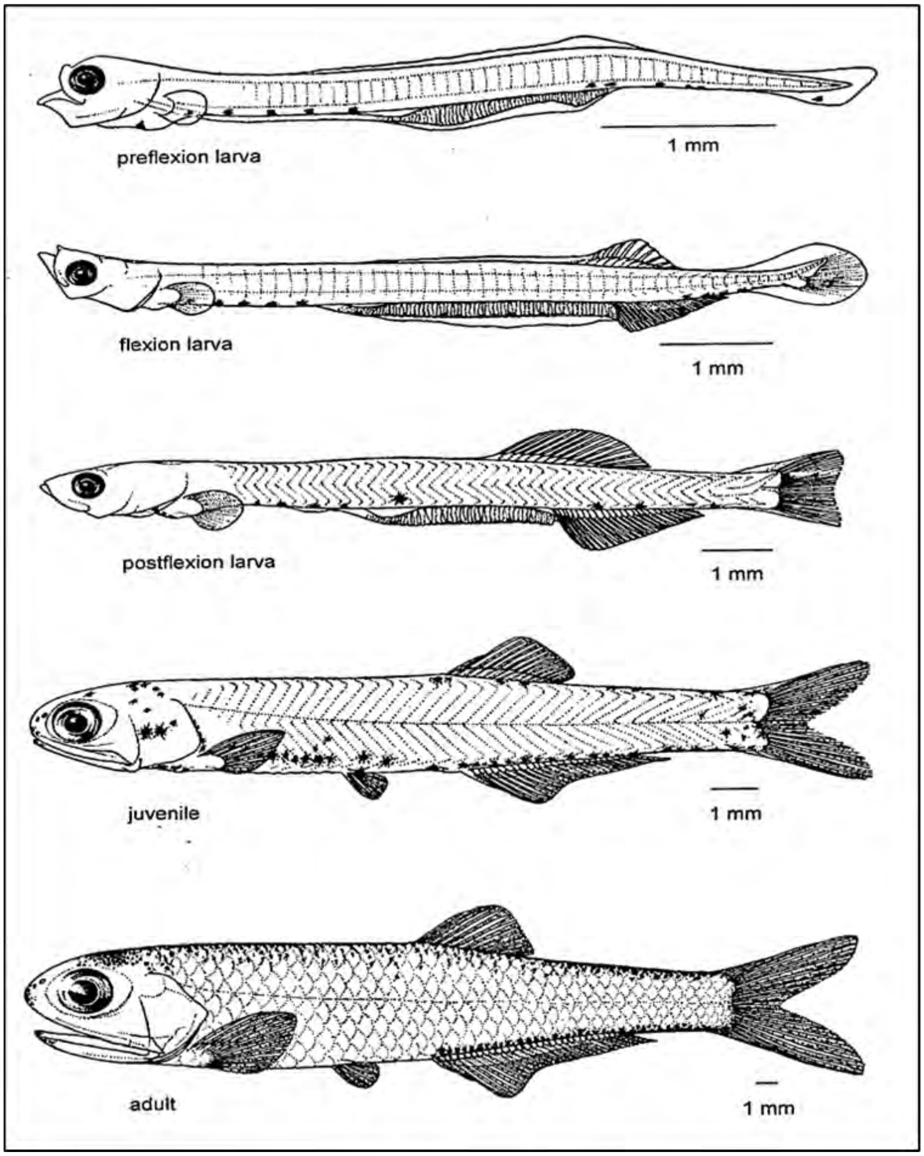


Figure 29. Development stages of the bay anchovy (*Anchoa mitchilli*) collected from the Lower Little Manatee River and Tampa Bay, measuring 4.6, 7.0, 10,5, 16 and 31 mm standard length. Reprinted from Peebles and Flannery (199

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 only 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 8 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 8. 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 9. 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 10. 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 30 on the following page with text for a new topic beginning on page 48

***Sciaenops ocellatus* (Red drum), Seines**

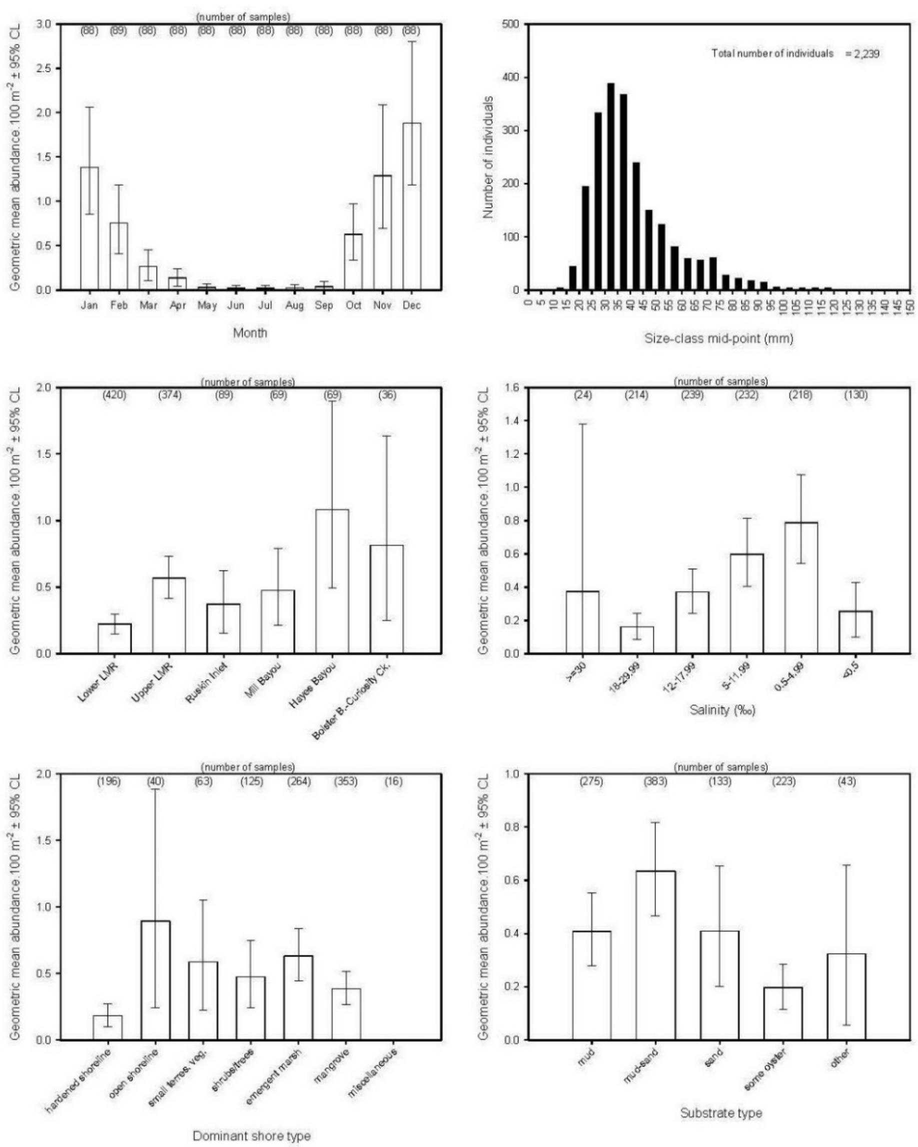


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

Figure 30. Graphics for the seine catch of red drum (*Sciaenops ocellatus*) 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.

Literature Cited on the following page

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From:	Sid Flannery
To:	Kym Holzwart
Cc:	Yonas Ghile; Xinjian Chen; Gabe I. Herrick; Kristina Deak; Jordan D. Miller; Doug Leeper; Chris Zajac; Randy Smith
Subject:	Three documents loaded to the Little Manatee River web forum
Date:	Monday, July 3, 2023 2:55:41 PM
Attachments:	Supplemental analyses, data presentations and clarifications related to Little Manatee River minimum flows, submitted by S. Flannery.pdf FFWCC letter to SWFWMD with comments on the 2021 draft minimum flows report for the Little Manatee River.pdf Compilation of various text, tables,and graphics sent by Sid Flannery to the SWFWMD regarding minimum flows for the Little Manatee River.pdf

Hello District staff,

I hope you are taking the day off.

Today (Monday), I loaded the three attached documents to the web forum for the Little Manatee River minimum flows. You can see by the title page of my supplemental analyses report that I made some corrections and minor revisions to the document I originally submitted to the District in January 2022.

Have a fine Independence Day,
Go Rays!

Sid

Documents added to minimum flows web forum (+ letter from FFWCC)

Text, tables, and graphics provided by Sid Flannery to the Southwest Florida Water Management District regarding review of the first draft Minimum Flows Report for the Little Manatee River (SWFWMD, 2021)

Content and Organization

This document complies various text, tables and graphics provided to the Southwest Florida Water Management District (the District) as part of a review of the draft minimum flows report for the Little Manatee River that was published in September 2021. These files were submitted to the District between Oct 2021 and September 2022. A revised draft minimum flows report for the Little Manatee River that addresses many of the topics identified in these files was published by the District in June 2023.

Other information not included

This document does not contain email correspondence with the District and miscellaneous files associated with that correspondence. Most notably, it also does not include analyses, results and discussion presented in an interpretive document provided to the District in January 2022 titled *Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows for the Little Manatee River (Flannery 2022)*, which can be provided upon request. Several technical points raised in that document were also addressed by the District in the revised draft minimum flow report.

This document also does not include a letter submitted to the District by the Florida Fish and Wildlife Conservation Commission (FFWCC) in April 2022 regarding nekton populations in the Little Manatee River and a review of the first draft minimum flows report. Similarly, many of the points raised by the FFWCC were also addressed in the revised draft minimum flows report for the Little Manatee River that was published in June 2023.

Next steps

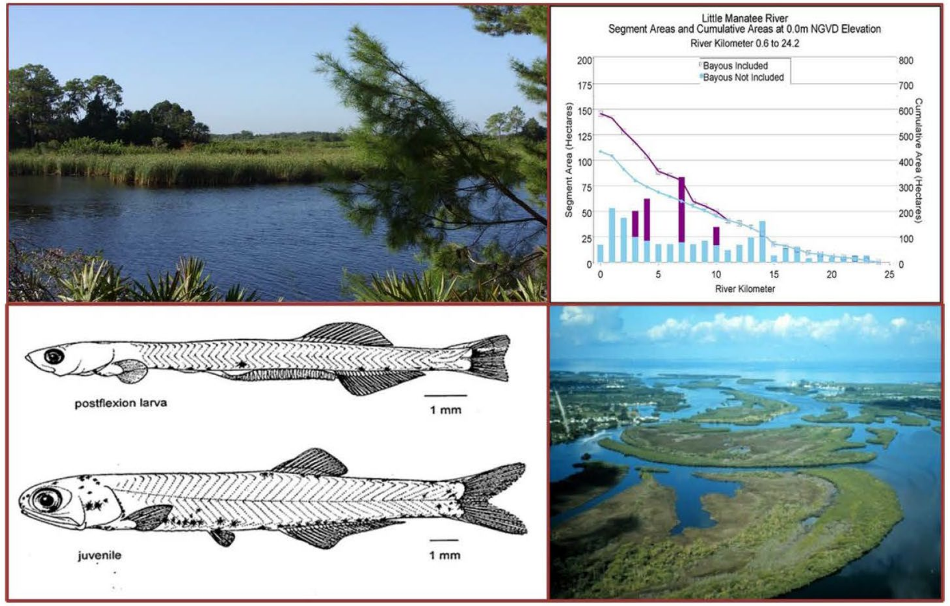
Although the District has done a commendable job of addressing many of the topics identified in both the aforementioned Supplemental Analysis report those described on the following pages in this document, I believe there are some topics that still need further attention.

Prepared by

Sid Flannery, retired, formerly Chief Environmental Scientist with the Southwest Florida Water Management District

June 28, 2023

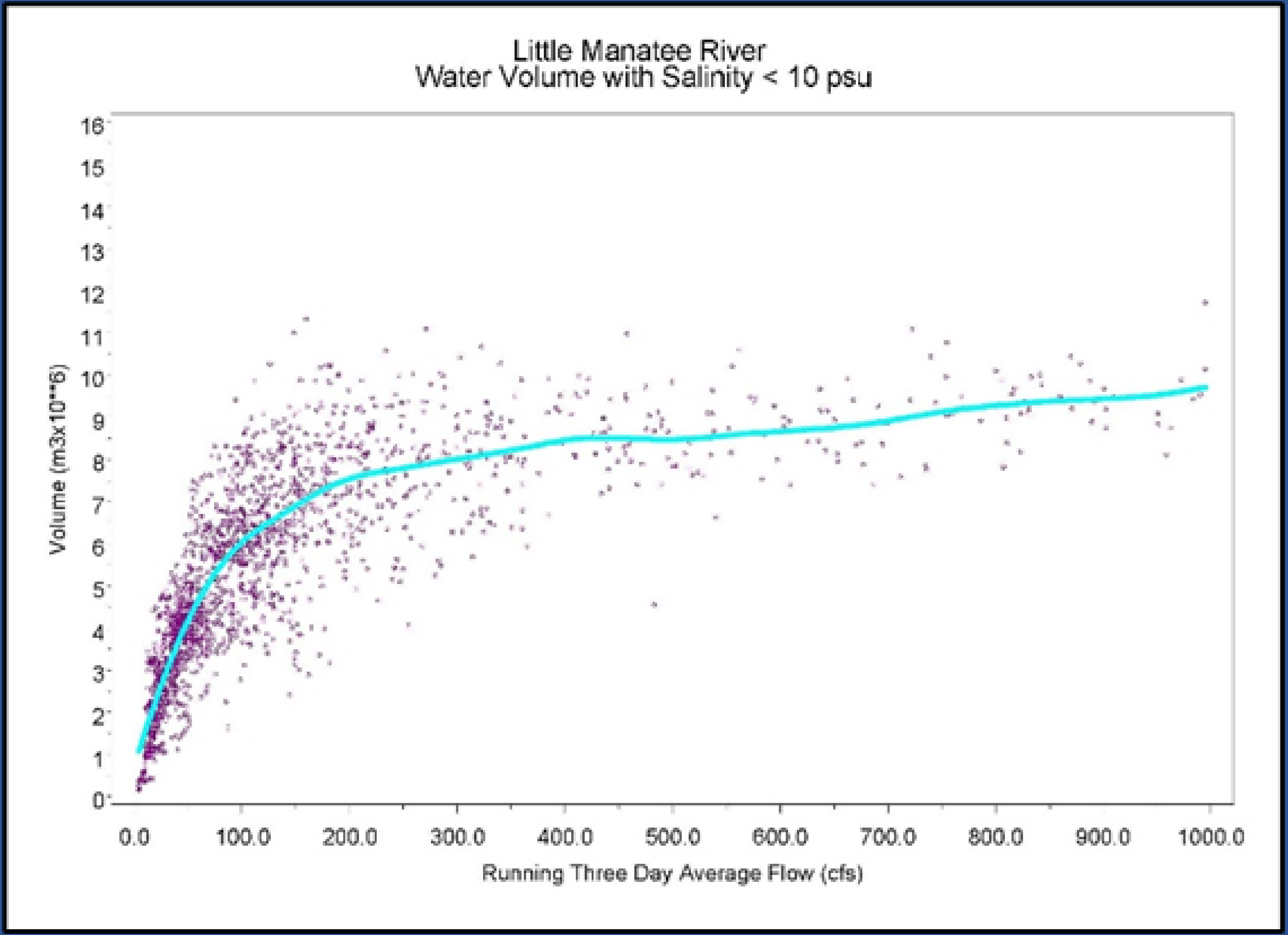
Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows for the Little Manatee River



January 2022
(with corrections and minor revisions in June 2023)

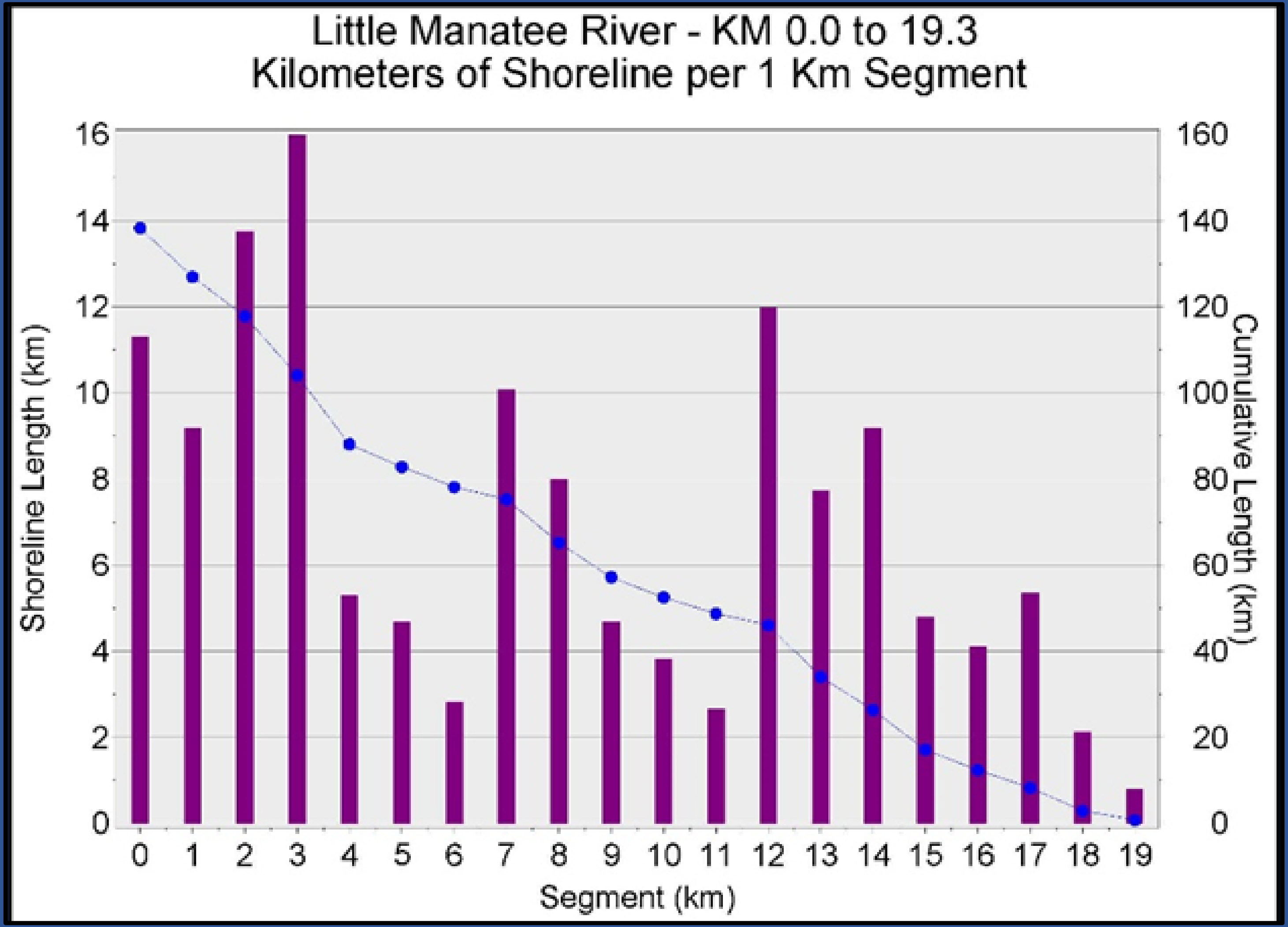
Prepared by Sid Flannery - Retired, formerly Chief Environmental Scientist with the SWFWMD minimum flows program

Volume of water less than <10 psu vs. flow (previous EFDC model)



Assess overlap of salinity zones with shoreline vegetative communities and fish habitat

(need to view four graphs: < 1, 2, 5 and 10 psu shoreline length vs. flow)



Percentile values of various flow thresholds
Gaged flows corrected for FPL withdrawals (1991 – 2020)

72 cfs	=	48^{th} percentile
96 cfs	=	58^{th} percentile
133 cfs	=	67^{th} percentile
178 cfs	=	75^{th} percentile

Percentile values of various LOW FLOW thresholds
Gaged flows corrected for FPL withdrawals (1991 – 2020)

40 cfs = 26th percentile (currently in effect for FPL)

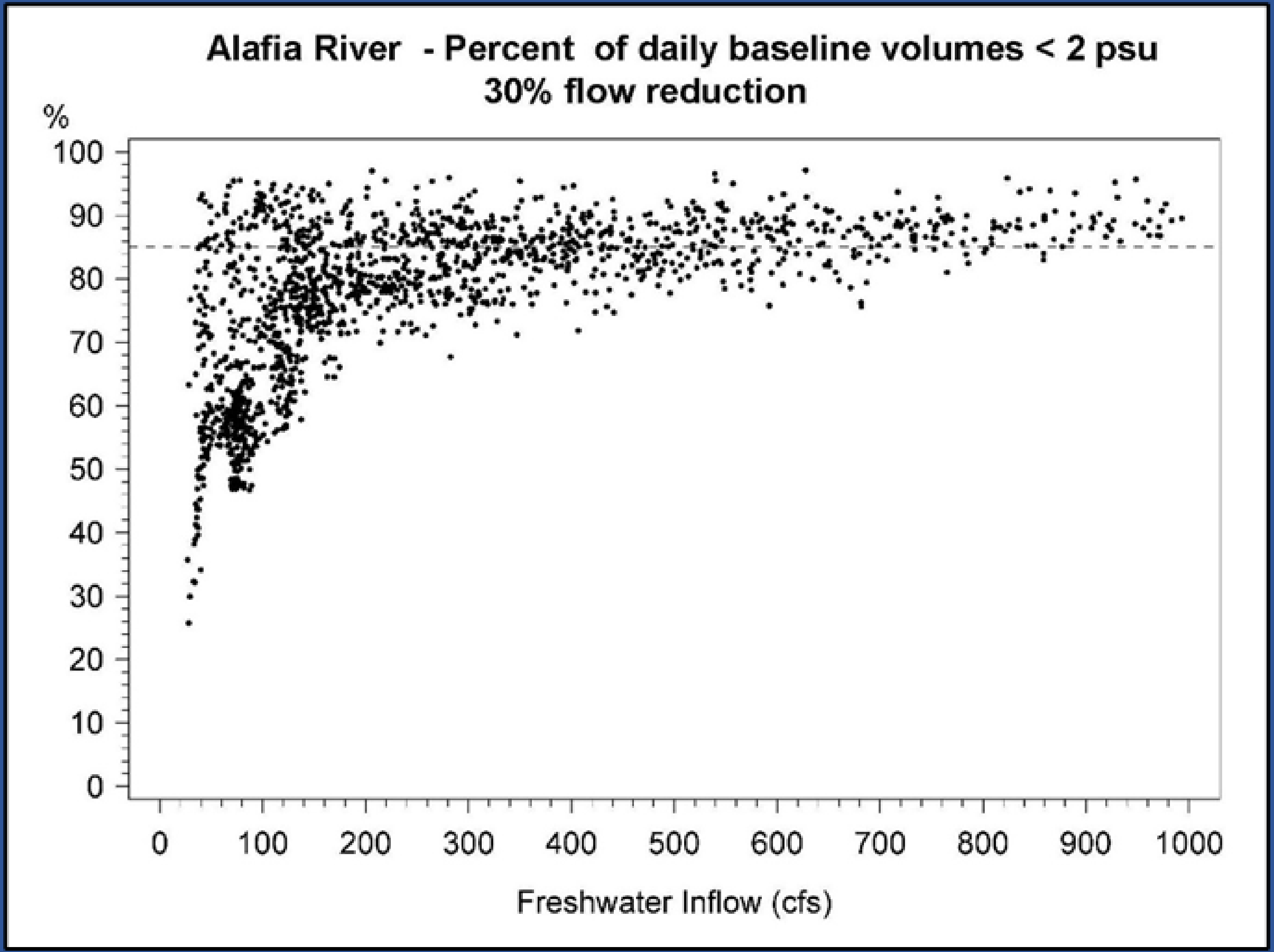
35 cfs = 21st percentile (previous draft report)

29 cfs = 13th percentile (revised draft report)

Lower Alafia River 120 cfs = 18th percentile

Lower Peace River 130 cfs = 16th percentile

Examine reductions in salinity zones and habitat as a function of flow for different percentage withdrawal rates



Estuaries Vol 25, No. 6B, p. 1319-1332, 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]

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[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.

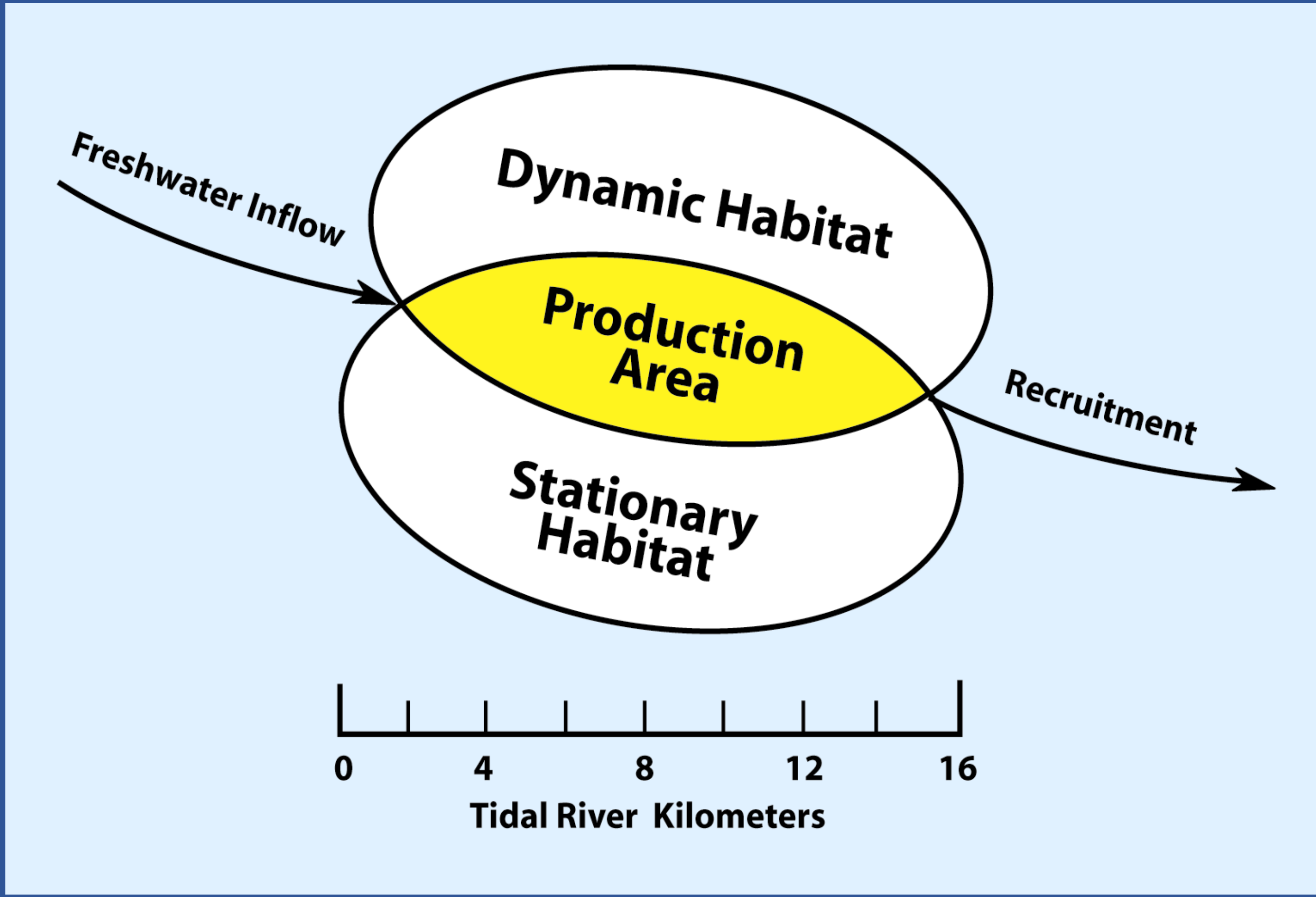
Introduction

Stream ecologists have emphasized the importance of natural flow regimes for maintaining the

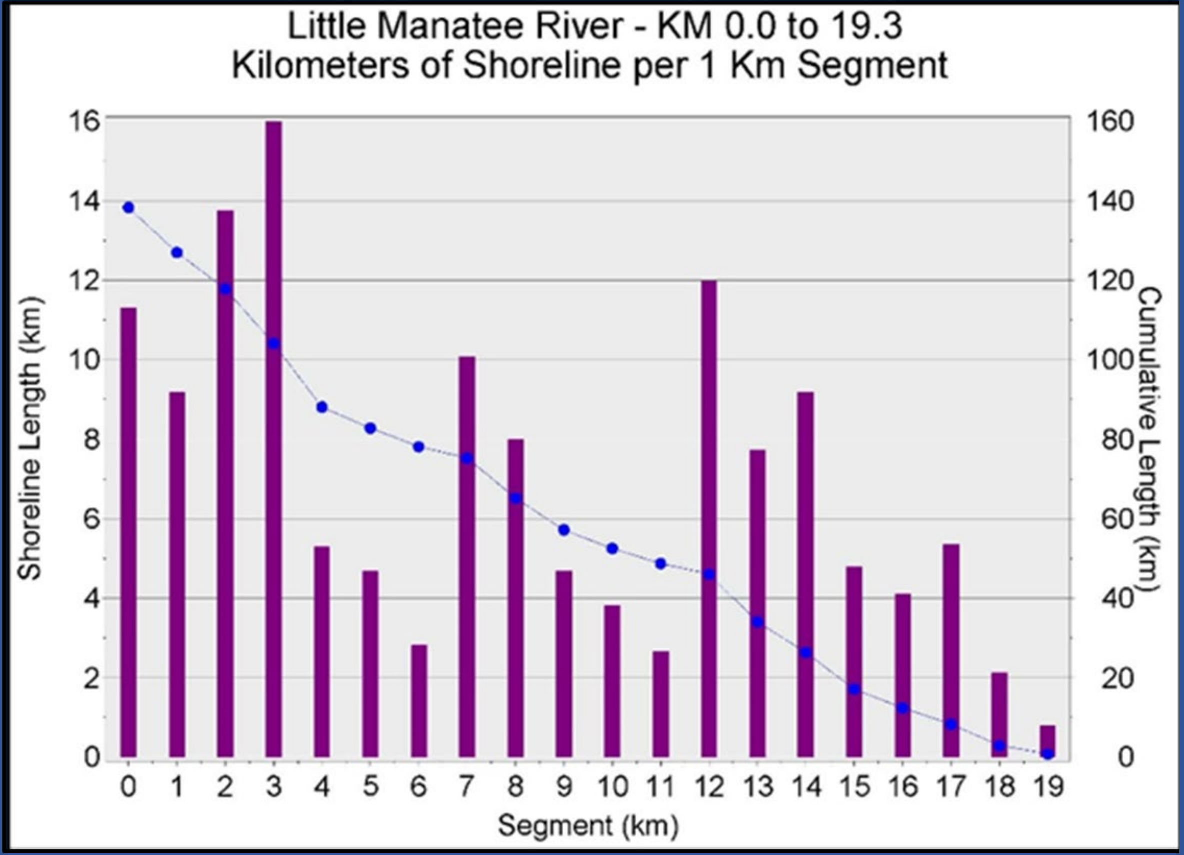
ceding freshwater inflow terms calculated over 2-mo or 3-mo intervals, indicating that the seasonality of inflow can have a significant effect on fish

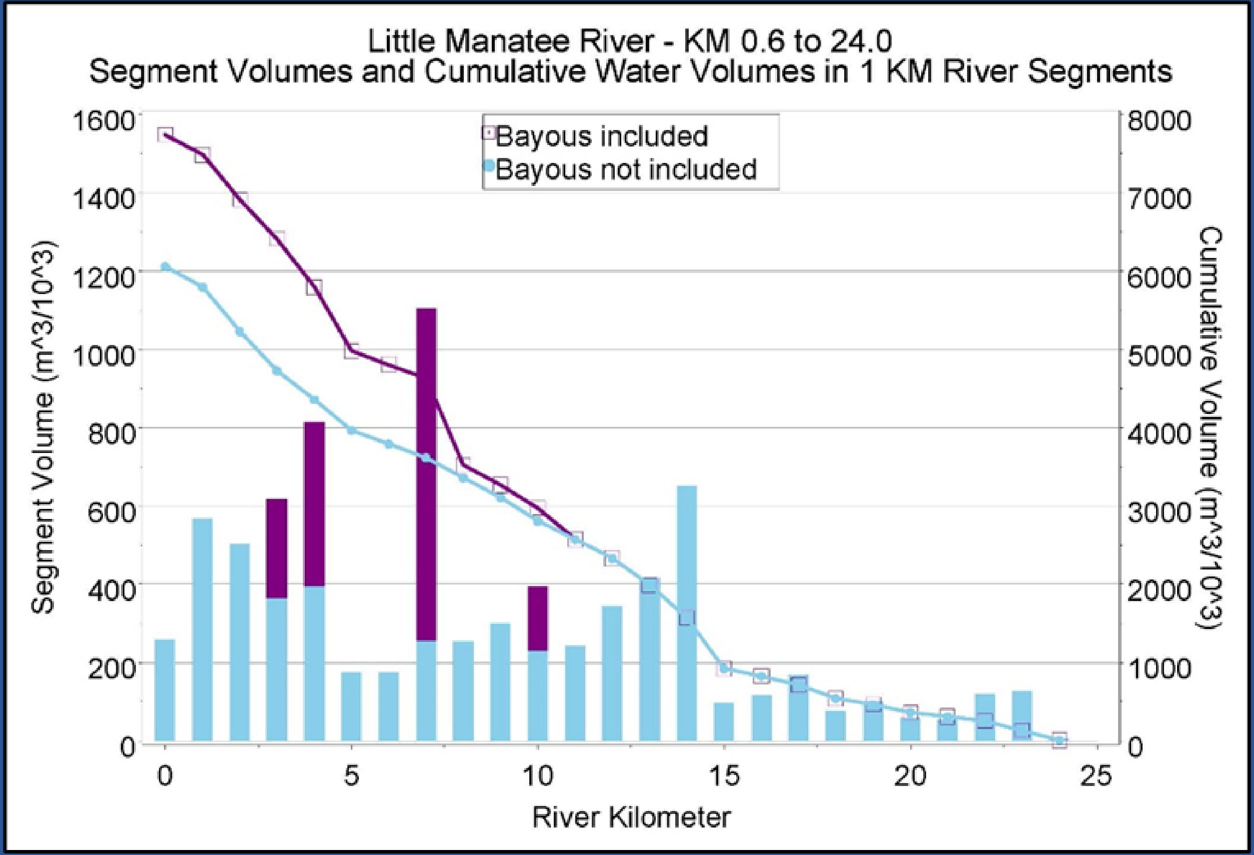
"Development of the percent-of-flow approach has emphasized the interaction of freshwater inflow with the overlap of stationary and dynamic habitat components in tidal river zones of larger estuarine systems"

Browder J. A. and D. Moore 1981. A new approach to determining quantitative relationship between fishery production and the flow of freshwater to estuaries. *In* Cross and Williams (eds). Proceedings of the National Symposium on Freshwater Inflow to estuaries.



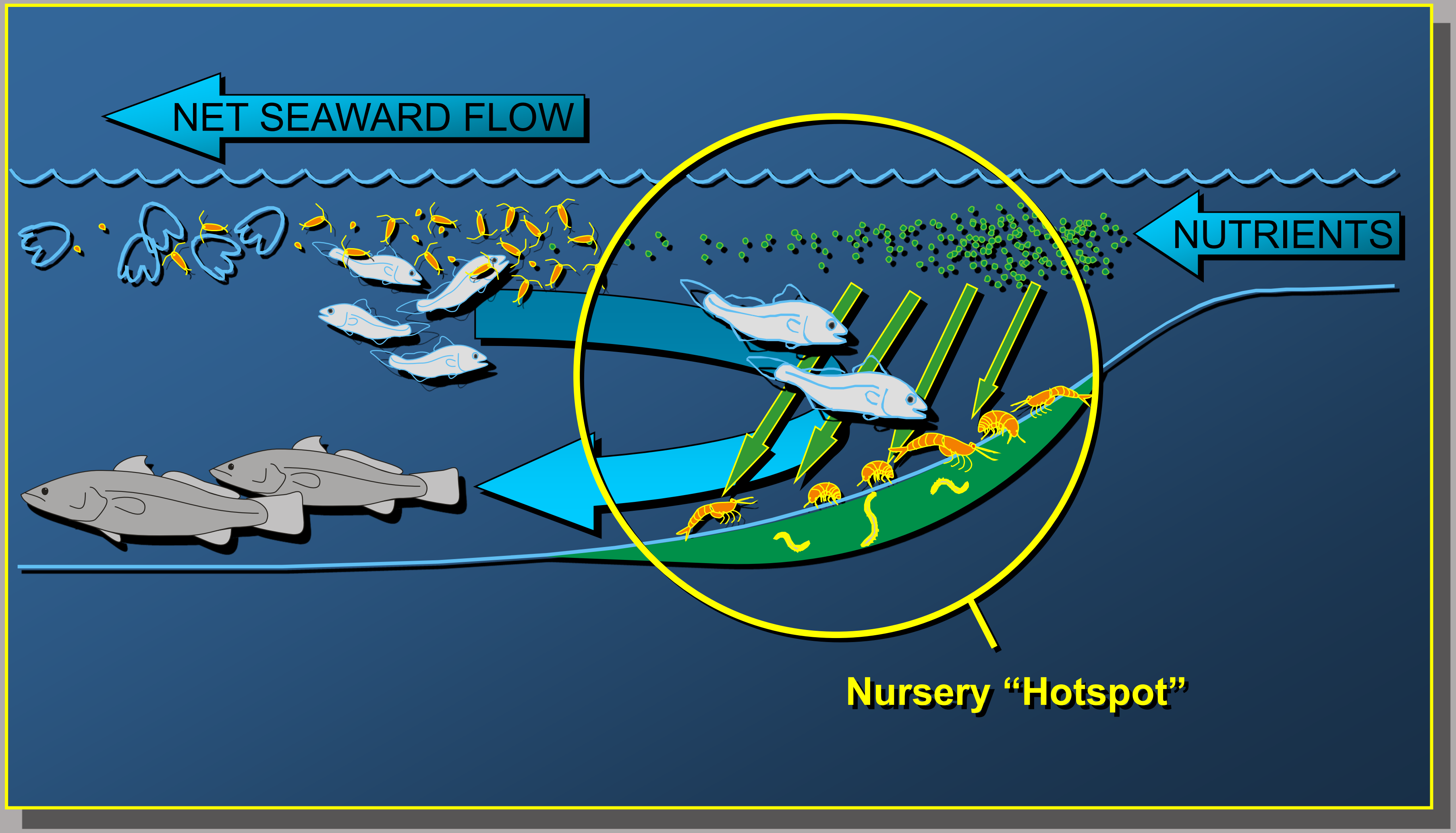
A handful of existing graphics are needed in the report to describe important physical and habitat characteristics of the Little Manatee River that are related to its biological organization and relationships with freshwater inflow





What ecological information needs to go into the minimum flows report?

Example - Fish nursery relationships and response to freshwater inflow



Initial Peer River Report (2021), Little Manatee River minimum flows, page 2-26

In the conclusions for this topic, it would be useful to summarize to 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.

USF Zooplankton Report for the District

(not mentioned nor cited in the minimum flows report)

Rast. J. P., M. E. Flock, T. T. Sutton and T. Hopkins . 1992. The zooplankton of the Little Manatee River Estuary: Species composition, distributions, and relationships with salinity and freshwater discharge. Report of the University of South Florida for the Southwest Florida Water Management District.

District funded USF studies of phytoplankton composition, production and relationships to freshwater inflow in the Little Manatee River (not mentioned nor cited in the minimum flows report)

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

Mean chlorophyll *a* concentrations at four salinity-based stations in three rivers				
	18 or 20 ppt	**12 ppt**	**6 ppt**	**0.5 ppt**
Little Manatee	4	9	14	**21**
Peace	8	**32**	22	9
Alafia	44	**96**	63	15

Fundamental hydrologic graphics not included in the minimum flows report

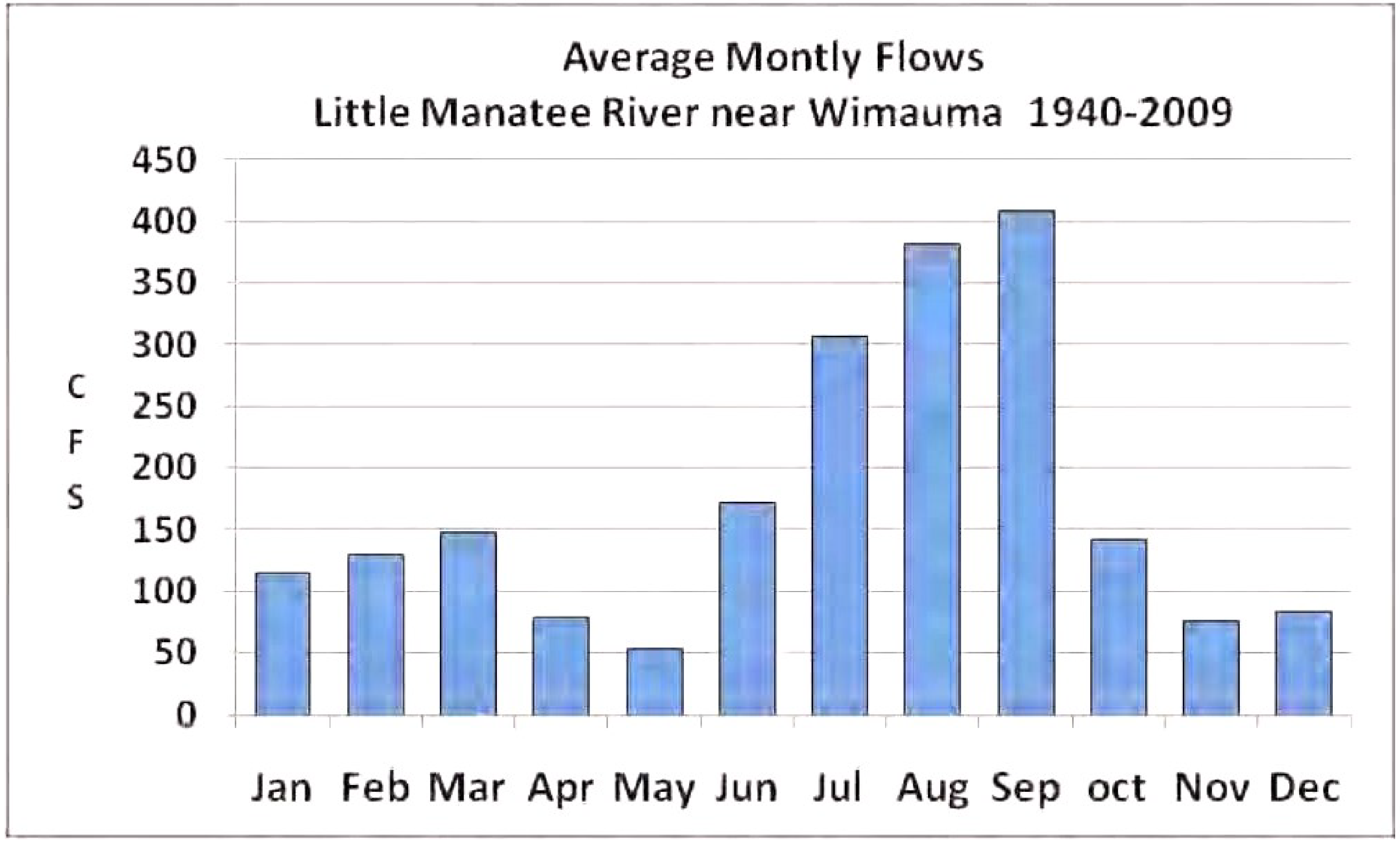


Figure 4-9. Average monthly rates of flow for the Little Manatee River near Wimauma for the years 1940-2009.

(From the 2011 draft freshwater minimum flow report)

Fundamental hydrologic graphics not included in the minimum flows report

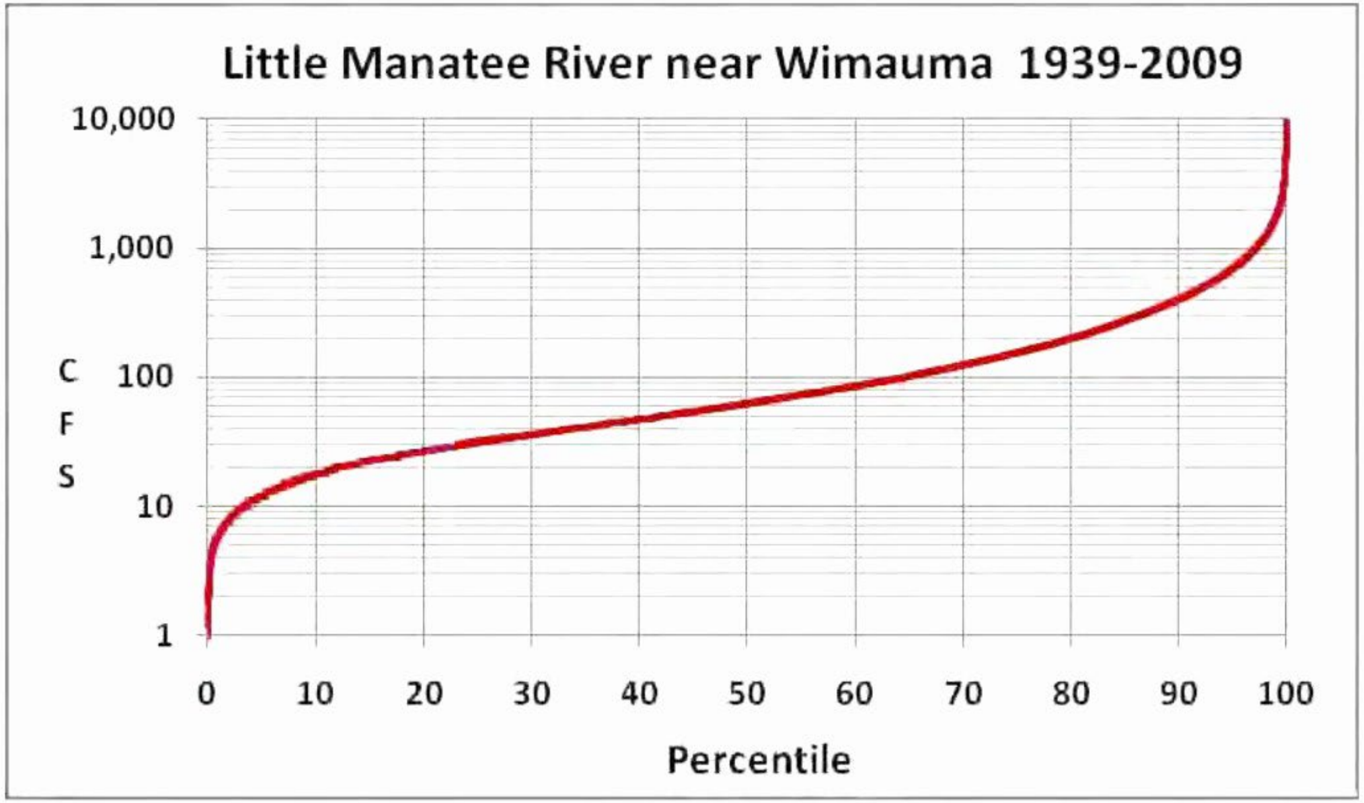
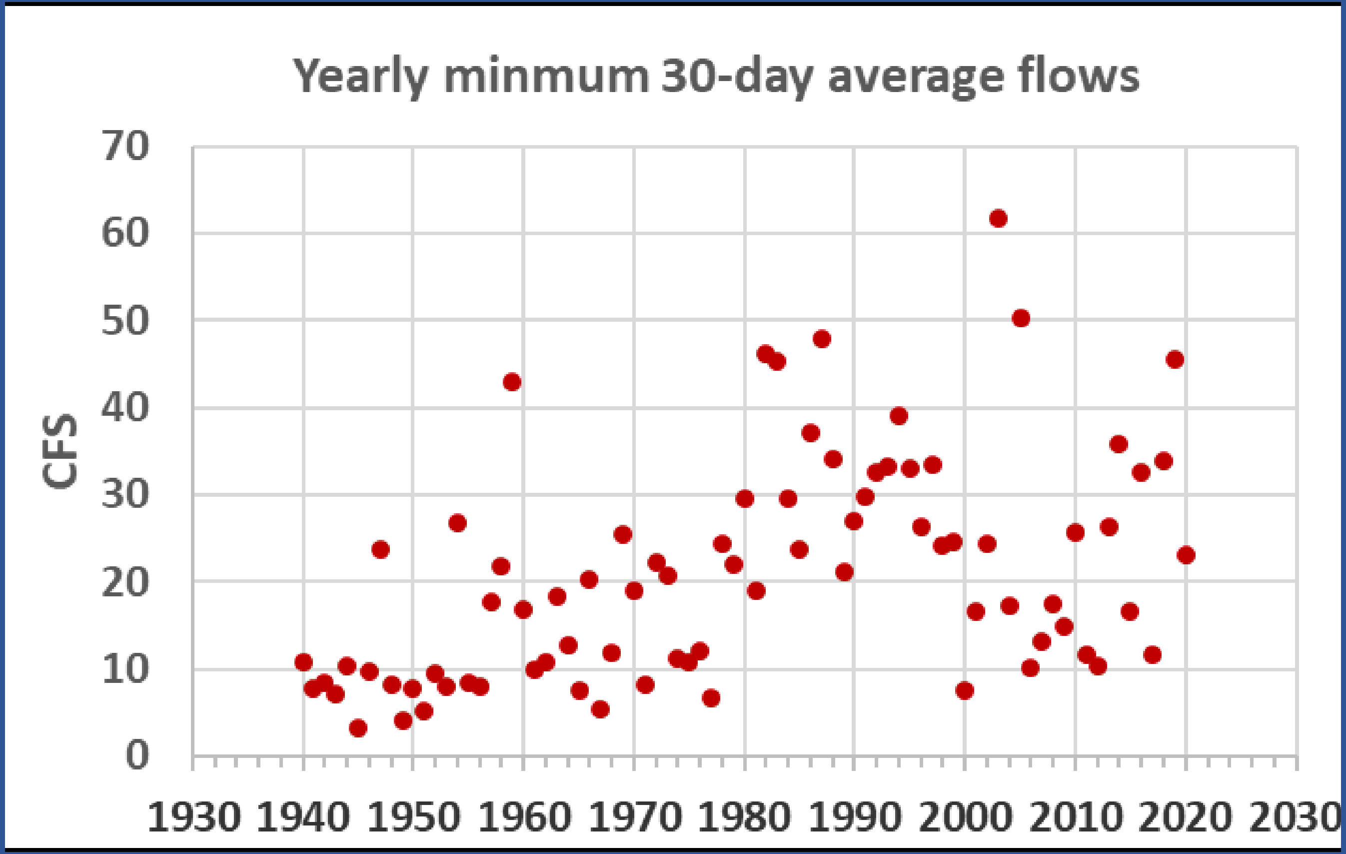


Figure 4-8. Cumulative Distribution curve of daily flows at the Little Manatee River near Wimauma gage for the period 1939-2009).

(From the 2011 draft freshwater minimum flow report)

Fundamental hydrologic graphics not included in the minimum flows report
Arithmetic scale on y axis is appropriate for many streamflow metrics



(From the draft 2011 freshwater minimum flow report updated through 2020)

Summary

1. Flow blocks for lower river need more assessment of existing EFDC and EFF model runs, with possible consideration of chlorophyll *a* relationships

2. A handful of existing graphics of the physical characteristics of the lower river need to be added

3. Previous ecological studies of the river need to be cited an briefly described

4. Some fundamental hydrologic statistics and graphics need to be added

Location of Peak chlorophyll *a* concentration in relation to freshwater inflow

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.

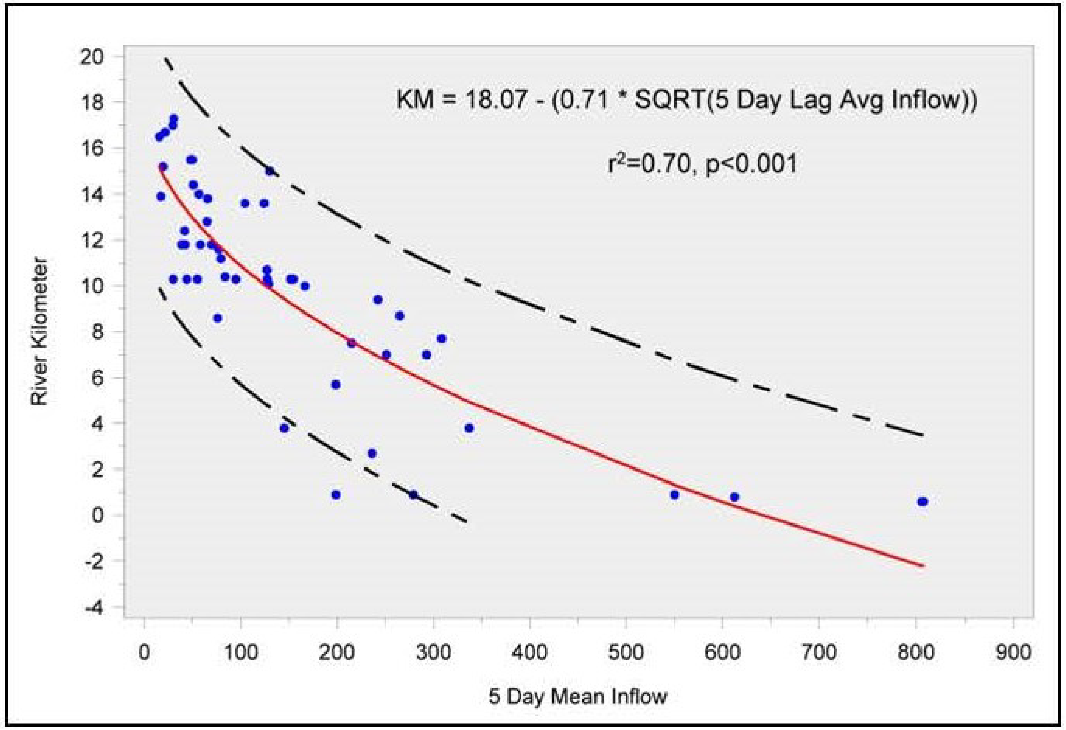


Figure 5. Scatter plot and regression of the location of maximum chlorophyll *a* concentrations measured among four moving salinity-based stations in the Lower Little Manatee River vs. the preceding five-day average inflow for each sampling date.

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Chris Zajac; Xinjian Chen; Gabe I. Herrick; Kristina Deak; Jordan D. Miller; Yonas Ghile
Subject:	My slides for today"s Little Manatee peer review meeting
Date:	Wednesday, July 12, 2023 7:12:17 AM
Attachments:	July 12 slides for Sid Flannery.pptx July 12 slides for Sid Flannery.pdf

Hello Kym and staff,

Attached is a powerpoint file and a pdf of the slides I would like to show at today's meeting of the Little Manatee River peer review panel.

As with last week, could you call this presentation up and advance the slides for me. It seems like using the powerpoint file might be the smoothest. After yesterday's Environmental Advisory Committee meeting, I tried sharing a powerpoint presentation but it did not go well - just technically challenged I suppose. The chairwoman of the EAC said that often happens at virtual public meetings and it is common for the moderator to share and change the slides.

Thanks much. See you virtually today at 1.

Sid

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Chris Zajac; Randy Smith; Jordan D. Miller; Kristina Deak; Xinjian Chen; Gabe I. Herrick; Yonas Ghile; Jennette Seachrist
Subject:	Request for EFDC and EFF model output
Date:	Friday, July 14, 2023 10:17:53 AM

[EXTERNAL SENDER] Use caution before opening.

Hello Kym,

As we have previously discussed, I would like to receive some selected output from the EFDC salinity and EFF fish habitat model runs for a few flow scenarios. I first made this request over a year ago, but in email communication with the District agreed to wait until the revised models were finished.

I think the District's consultant should be able to pull these files from previous model runs together pretty quickly. If results for these specific scenarios could be separated out that would be great, but I could work with larger data sets if the variables and scenarios I have identified are within them. To make sure I am identifying the variables correctly, I might want to briefly communicate with the consultant or could forward any clarification requests through you.

Requests for EFDC and EFF output are described below. In both cases, daily values would be desirable, but I can work with shorter time intervals if that is what is available. If the low flow cutoff of 29 cfs was applied in scenarios other than baseline that is preferable, but if the cutoff was not applied that is okay too. Either EXCEL or SAS files would be fine, with SAS preferable if that is what the data are in now.

The results I am requesting for the EFDC model are baseline flows and predicted area, volume and shoreline length for the <1, <2, <5 < 10 and < 15 ppt salinity values for the baseline, 15, 20, 25, and 30 percent withdrawal scenarios. I would like values for the entire period of record that was used for the minimum flows determination using the EFDC model.

For the EFF favorable habitat models I would like to receive baseline flows and favorable habitat values for the eastern mosquitofish, clown goby, striped mojarra, naked goby, hogchoker, common snook, red drum, and small gobies less than 20 mm. I would like to receive output for the baseline, 15, 20, 25, 30 and 35 percent withdrawal scenarios. I would like values for the entire period of record that was used for the minimum flows determination using the EFF model.

I would like to get my assessment of the results as soon as possible, so if the District could facilitate this I would appreciate it very much. Please let me know if any clarification is needed or if any of this should be identified to be pulled out and prioritized first.

Thanks as always,
Sid

DRAFT **July 21, 2023**

Plan of Study – Graphical analyses to evaluate flow blocks for minimum flows for the Lower Little Manatee River

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

As part of a public records request, the Southwest Florida Water Management District (the District) will provide to me files of predicted output values from the EFDC hydrodynamic model and EFF favorable fish habitat models for the Lower Little Manatee River. These files will be used to generate graphics to help evaluate suitable flow rates to serve as blocks to allow changes in allowable percent withdrawal rates for the lower river.

The District has estimated these files can be provided near the beginning of August, but the exact date of delivery may vary. I will begin to generate the graphics as soon as I receive the files and hope to produce a series of plots and a corresponding technical memorandum within a week or so. This memo could possibly suggest revised flow blocks for the lower river, or instead support the flow blocks of 29 and 96 cfs that are recommended in the revised draft minimum flows report.

The graphics that will be generated are fairly simple, but are very informative and have been used to evaluate flow blocks for tidal estuarine rivers in three previous minimum flow studies conducted by the District. Examples of these types of graphics and their utility were discussed in a supplemental analyses, data presentations, and clarifications report I submitted to the District in January 2002 and also shown in two slides I presented to the minimum flows peer review panel at their meeting on July 5, 2023.

In the case of the Little Manatee River, it is critical that relationships of favorable fish habitats to freshwater inflow be evaluated, as the minimum flows for the lower river were ultimately based on reductions in fish habitats as they generally provided more conservative results that reductions in salinity zones. Also, the EFF models fish habitats include both a salinity and shoreline type component, so the predicted values may show relationships with freshwater flow that are different than simple salinity zones because shoreline types change along the length of the lower river.

Plots of baseline values - The first type of graphics will be plots of daily values for the quantities of salinity zones and favorable fish habitats vs. baseline flows. The salinity zones that will be graphically evaluated will include bottom area, volume, and shoreline lengths below salinity values of <1, <2, <5, <10 and <15 psu. Similar plots of the amount of favorable fish habitats vs. baseline flows will be generated for eight taxa of fish analyzed in the minimum flows reports.

Plots of reductions in salinity zones and fish habitat v. baseline flows for various flow reduction scenarios. The second type of plots will show percent reductions in daily values for salinity zones and favorable fish habitats for a series percent flow reduction scenarios. Based on findings from previous minimum flow studies of other tidal estuarine rivers (lower reaches of the Peace, Alafia and Pithlachascotee Rivers), these types of graphics are very useful for evaluating flow blocks that allow increases in allowable percentage withdrawal rates.

*** *one of several with that job title at the District including another staff member in the minimum flows program at the time of my retirement***

Using output from the EFDC model, separate plots of daily values for percent reductions in the volume, bottom area, and shoreline lengths less than the aforementioned five salinity values vs. the corresponding rate of baseline flow will be produced for the flow reduction scenarios of 15, 20, 25 and 30 percent. Using output from the EFF models, plots of daily values for percent reductions in favorable fish habitats vs. the corresponding rate of baseline flow will be shown for eight fish taxa that were assessed in the minimum flows report for flow reductions of 15, 20, 25, 30 and 35 percent.

Data presentation and analysis

It is expected that a series of graphics will be provided for some, but not all, of these plots in a technical memorandum I will prepare with emphasis on those graphics that seem most critical to the evaluation of flow blocks for the lower river. Appendices containing of the total set of graphics can be provided upon request.

As previously mentioned, the findings of this assessment may either support the 29 and 96 cfs thresholds for flow blocks for the lower river recommended in the draft minimum flows report, or instead may recommend revisions to the flow blocks. If revisions to the flow blocks are recommended, the memo will statistically analyze the percent reductions of salinity zones and favorable fish habitats within each of those flow blocks.

As a separate effort, graphics and analyses of the response of the chlorophyll *a* in the lower river may also be submitted to the District and the peer review panel if they provide useful findings related to evaluation of flow blocks that are based on salinity zones and favorable fish habitats.

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Chris Zajac; Randy Smith; Jennette Seachrist; Jordan D. Miller; Gabe I. Herrick; Yonas Ghile; Kristina Deak; Xinjian Chen
Subject:	Notify Little Manatee River minimum flows review panel of upcoming post to web board
Date:	Friday, July 21, 2023 6:22:31 AM
Attachments:	DRAFT - Plan of study for graphical assessment of flow blocks for the lower LIttle Manatee River.docx

Hello Kym and District staff,

Attached is a draft plan of study that describes the graphics I will generate once I receive the output from the EFDC and EFF models for the Little Manatee River that were part of the recent public records request.   I am happy with it, but if anyone has any comments it is labeled draft for now.

Once I receive the files, which should be near August 2 according to the email I received from public records, I will generate the graphics and associated technical memorandum as soon as possible, which should take about a week or so.

At this time, I think it would be best to inform the peer review panel that I will be doing this work.   My understanding from the last meeting is that Kym can send an email to the panel informing them that something has been posted to the minimum flows web board.   I suggest that would be a good approach here, as I can send a brief explanatory email to Kym which she could forward to the panel with an introduction by her.   If that is okay, before the email is forwarded I would post to the web board my plan of study and also a slide showing a related regression of the location of the chlorophyll maximum in the river as a function of flow. In the text field that goes with posts, I would provide a few sentences similar to the email below.

Please let me know if this approach is okay with the District? If so, when can the District forward such an email be sent to the panel? I can load my files to the web board at any time. A draft of my email is below.

Sid

---------------------   draft email to be forwarded to the review panel ---------------------------------------

Hello peer review panel for the Little Manatee River minimum flows report,

On July x, I loaded to the minimum flows web board a plan of study I will use to prepare graphics of daily quantities of various salinity zones and favorable fish habitats vs. freshwater inflow using values predicted by the

EFDC and EFF models, respectively, for the Little Manatee River. It is expected the output values will be provided by the District near the beginning of August and I should be able to produce a technical memorandum with related key graphics about a week later. Using graphical techniques previously employed for three other estuarine rivers, these graphics may provide very useful information concerning suitable flow blocks for the lower section of the Little Manatee. I hope the panel can consider these results in their evaluation of suitable flow blocks for the lower river.

I also loaded to the web board a slide of a regression plot of the location of maximum chlorophyll *a* concentrations vs. flow in the Little Manatee to supplement comments made by myself and Dr. Ernst Peebles of USF regarding chlorophyll *a* in the river at the peer review meeting on July 12th.

Thanks for your consideration of this matter,
Sid Flannery

Contents of external hard drive provided by the SWFWMD to Sid Flannery 8/24/23 (2 pages)

Folders and contents on external hard drive

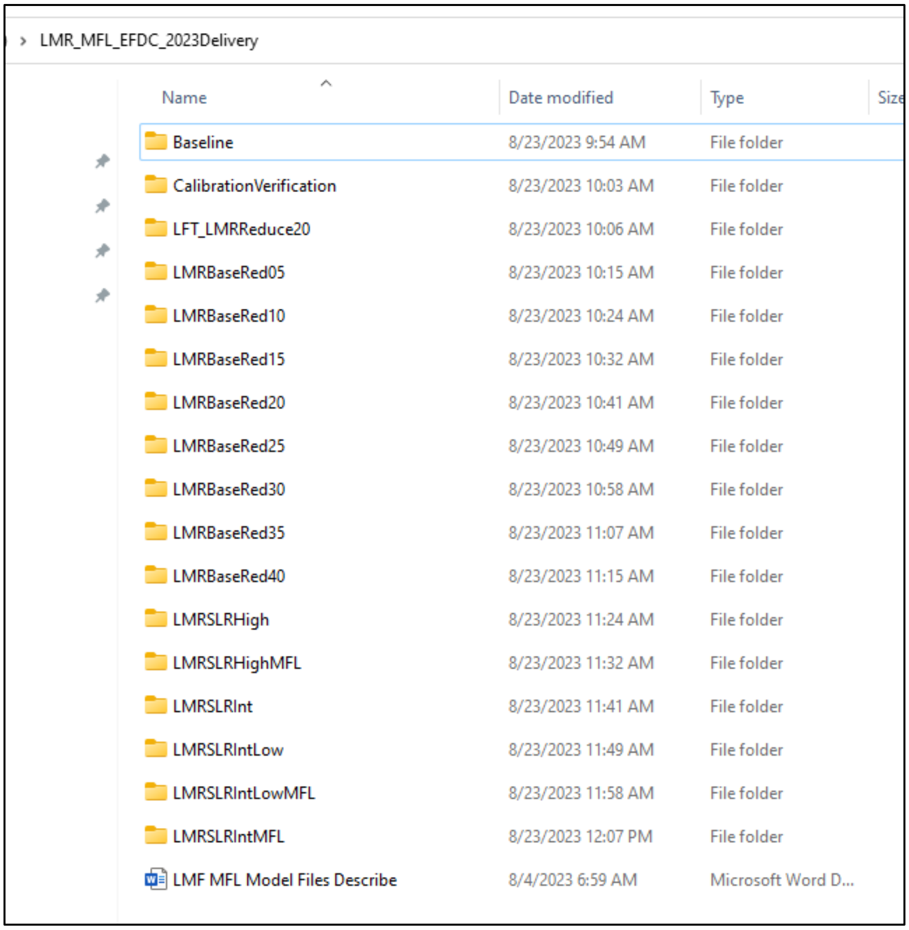
Name	Date modified	Type	Size
LMR_EFF_04AUG2023	8/23/2023 9:44 AM	File folder	
LMR_MFL_EFDC_2023Delivery	8/23/2023 12:06 PM	File folder	
Draft Appendix LMR EFDC Model Documentation TM	7/18/2023 9:20 AM	Adobe Acrobat D...	10,690 KB
Install Western Digital Software for Mac.dmg	4/21/2022 3:39 PM	DMG File	537 KB
Install Western Digital Software for Windows	7/8/2021 9:35 PM	Application	657 KB

SAS data sets in Folder LMR_EFF_04AUG2023

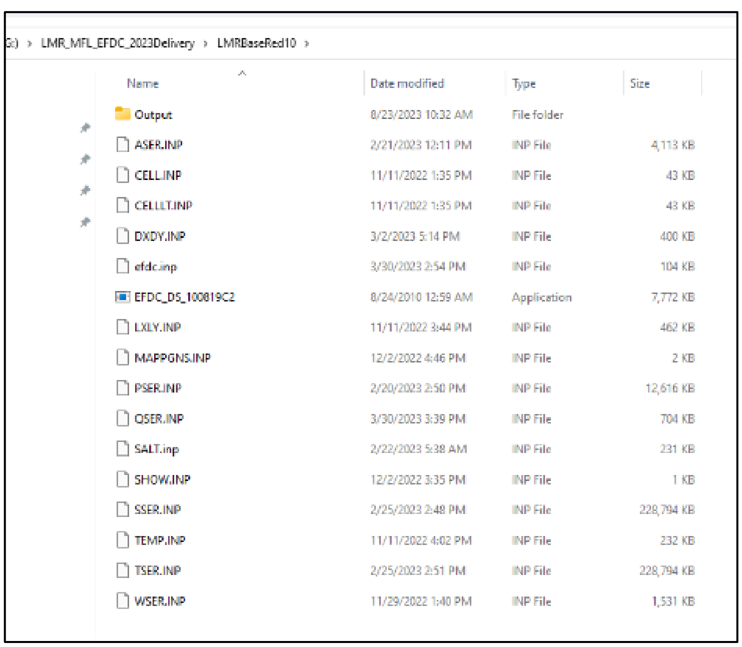
LMR_EFF_04AUG2023

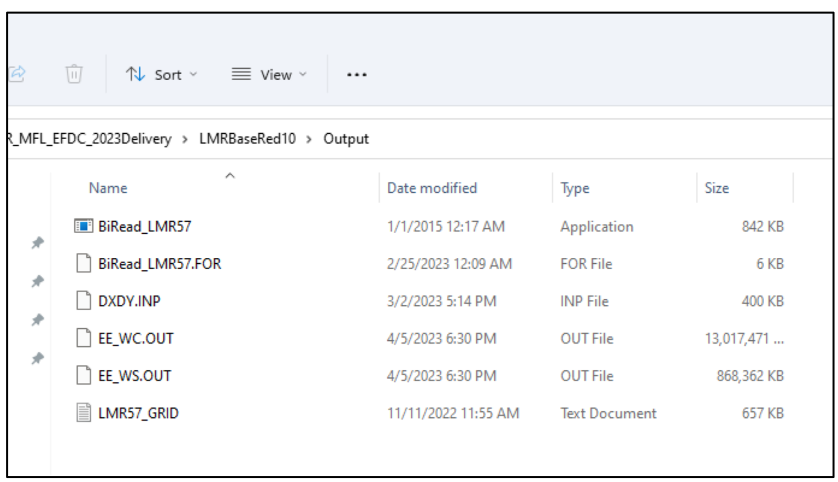
Name	Date modified	Type	Size
score_1.sas7bdat	8/4/2023 2:32 PM	SAS7BDAT File	12,394,304 KB
score_2.sas7bdat	8/4/2023 2:37 PM	SAS7BDAT File	12,394,304 KB
score_3.sas7bdat	8/4/2023 2:43 PM	SAS7BDAT File	12,394,304 KB
score_4.sas7bdat	8/4/2023 2:48 PM	SAS7BDAT File	12,394,304 KB
score_5.sas7bdat	8/4/2023 2:54 PM	SAS7BDAT File	12,394,304 KB
score_6.sas7bdat	8/4/2023 3:00 PM	SAS7BDAT File	12,394,304 KB
score_7.sas7bdat	8/4/2023 3:05 PM	SAS7BDAT File	12,394,304 KB
score_8.sas7bdat	8/4/2023 3:11 PM	SAS7BDAT File	12,394,304 KB
score_9.sas7bdat	8/4/2023 3:16 PM	SAS7BDAT File	12,394,304 KB
score_10.sas7bdat	8/4/2023 3:22 PM	SAS7BDAT File	12,394,304 KB
score_11.sas7bdat	8/4/2023 3:28 PM	SAS7BDAT File	12,394,304 KB

Folders for scenario runs with the EFDC model in Folder LMR_MFL_EFDC_2023Delivery



Contents of sub-folders for EFDC runs for each flow scenario (e.g., LMRBaseRed10)





Description of LMR MFL EFDC model files set provided to District, August 2023

Contact: Ray Pribble, rpribble@janickienvironmental.com or 727-543-3224

File copy time: full set of files with USG 3.0 from/to external drive approximately 2 hours

Calibration and Verification run files in folder "CalibrationVerification", run is for period 12/01/04-06/30/05:

- Model run files (*.inp) and executable
- Output files in subfolder \Output
  - *.OUT files contain site-specific 15-minute output for comparison to observed data at USGS continuous recorders for salinity (SALTS**.OUT), temperature (TEMTS**.OUT), and water surface elevation (SELTS**.OUT)
  - EE_WC.OUT and EE_WS.OUT contain 15-min output for water column conditions at each layer (salinity and temperature) and water column depth, respectively
  - Fortran text (BiRead_LMR57.FOR) and executable (BiRead_LMR57.exe) for reading binary *.OUT files, along with associated files needed (LMR57_GRID.TXT and DXDY.INP)

Baseline run files in folder "Baseline", run for 12/01/99-06/30/05:

- Model run files (*.inp) and executable
  - EE_WC.OUT and EE_WS.OUT contain hourly output for water column conditions at each vertical level at each grid cell (salinity and temperature) and water column depth at each grid cell, respectively
  - Fortran text (BiRead_LMR57.FOR) and executable (BiRead_LMR57.exe) for reading binary *.OUT files, along with associated files needed (LMR57_GRID.TXT and DXDY.INP)

All remaining runs (Sea Level Rise and Flow Reduction Scenarios) have same set of output files as for the Baseline run.

Sea Level Rise Intermediate Low w/Baseline Flows in folder "LMRSLRIntLow"
Sea Level Rise Intermediate w/Baseline Flows in folder "LMRSLRInt"
Sea Level Rise High w/Baseline Flows in folder "LMRSLRHigh"
Sea Level Rise Intermediate Low w/MFL Flows in folder "LMRSLRIntLowMFL"
Sea Level Rise Intermediate w/MFL flows in folder "LMRSLRIntMFL"
Sea Level Rise High w/MFL flows in folder "LMRSLRHighMFL"
5% Baseline Flow Reduction in folder "LMRBaseRed05"
10% Baseline Flow Reduction in folder "LMRBaseRed10"
15% Baseline Flow Reduction in folder "LMRBaseRed15"
20% Baseline Flow Reduction in folder "LMRBaseRed20"
25% Baseline Flow Reduction in folder "LMRBaseRed25"
30% Baseline Flow Reduction in folder "LMRBaseRed30"
35% Baseline Flow Reduction in folder "LMRBaseRed35"
40% Baseline Flow Reduction in folder "LMRBaseREd40"
20% Baseline Flow Reduction with Low Flow Threshold in effect in folder "LFT_LMRReduce20"

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Randy Smith; Chris Zajac; Doug Leeper; Yonas Ghile; Xinjian Chen; Gabe I. Herrick; Kristina Deak; Jordan D. Miller
Subject:	Limitations for my use of the files on the external hard drive I received from the District
Date:	Friday, August 25, 2023 3:02:36 PM
Attachments:	Contents of external hard drive.pdf LMF MFL Model Files Describe.docx

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and staff,

Thanks to Kym and records management staff for fulfilling my public records request for files for the Lower Little Manatee River. However, it looks like I will not be able to use or analyze these files for the reasons I describe below. First, though, I will describe the intent of my request and then the situation with the present files.

The email that I sent to the District on July 14th with my initial request for files is reprinted below this current email. The intent of that email was to get some simple output values from the EFDC and EFF model runs for the Lower Little Manatee River. As I have described in previous correspondence and presentations to the peer review panel, there are some very straightforward graphical analyses that can be performed that are very informative for evaluating flow blocks for the estuarine sections of rivers. In fact, one of these techniques was directly used to establish flow blocks in minimum flows reports for the Lower Peace, Pithlachascotee and Lower Myakka Rivers, and though not presented in the report, provided very useful information for the Lower Alafia.

As described in my email from July 14th below, what I was hoping to receive for the EFF model runs were files containing predicted values of volume, area, and shoreline length less than different salinity values (e.g., < 2 psu) for a series of flow reduction scenarios. Similarly, for the EFF model, these would be predicted output values of favorable fish habitat for selected species for a series of flow reduction scenarios. I specified the flow scenarios and salinity zones and fish taxa I was interested in. I could use whatever time interval these values were in (hours, days). Also, I could pull these values out of larger data sets if these variables are clearly identified, which I assumed they would be.

In addition to very large files of raw model values, I figured the consultant must have created some smaller reduced files for statistical and graphical analysis, as the minimum flows report has bar graphs of percent reductions in various salinity zones and fish habitats. Similarly, on page 123, there is a graph of the volume of water less that 2 psu salinity vs. flow and the report says that a number of other graphs were examined. Seeing that, I thought the District must have ready access to the exact type of information I am looking for, and suggested that I could deal with either EXCEL files or SAS data sets.

For the EFDC model output, it looks like what I received is something very different than what I requested. Attached is a pdf that shows the folders and contents of the external hard drive I picked up yesterday (Aug 24th). Also attached is a WORD document prepared by the consultant that describes the files related to the EFDC model. As that WORD document describes, the contents and format of the baseline model run file are similar to the files for the flow reduction scenario runs. It also specifies that these files contain "hourly output for water column conditions at each vertical level at each grid cell (salinity and temperature) and water column depth at each grid cell, respectively." Given that, it is no wonder the files are so huge. The hard drive also includes the FORTRAN text and executable code to read the output (OUT) files.

So, with regard to my public records request, am I supposed to execute these codes and then calculate how much volume etc. was less than a specified salinity value? Obviously, that is not possible. It looks like these EFDC files are one of the deliverables that the consultant is to provide for the contract with the District. Again, I was thinking there are some existing smaller data sets in which the volumes, etc. were already calculated and used for the statistical and graphical results that are presented in the minimum flows report.

The situation is different for the EFF model results. As shown in the pdf of contents of the hard drive, these are SAS data sets, which I normally can deal with. However, they are very large, over 12 gigabytes each, and the SAS program I use will not let me import files that large. Also, the large size of these files makes me wonder if they are the extensive raw model output by river length or whatever, in which I would have to calculate the percent habitat reduction for each taxon and flow scenario. The fellow that generated these files is a sharp guy and possibly he could generate the statistical and graphical results from these large files, but I have to wonder if there are smaller data sets that were developed from these large model output files.

So - (1) how did we get here, and (2) what to do now. #1 - Five days after placing my request on July 14th, I was informed it was a formal public records request and it would take about two weeks to produce the files, which I agreed to. Given that response, on July 24th I posted my plan of study for analysis of the files to the minimum flow weboard and said the expected date for file delivery is August 2nd.

On August 9th, I emailed the District to inquire how it was going. That same day, the District replied and said the files could be ready sometime next week and I would be given a cost for the retrieval. On August 16th, the District emailed and said the total cost of the records retrieval would be $402, which I happily paid, and I was informed the files should be ready by August 24th. Given that information, on August 22nd I made a post to the webboard about the new expected delivery date for the files and that I would work on it as promptly as possible to generate graphics and interpretive text which should take about a week or two to complete.

So, what to do now? I want to again emphasize that the types of analyses I am proposing are very straightforward, but also very informative and have been used in other minimum flows studies. As the percent of flow method has evolved for over 30 years, certain tools have proven to be very useful and the analyses I am proposing are at the top of the list.

At this time, I suggest the District and consultant look and see if there already exists any of the smaller output files similar to what I described on July 14th. If there are not, it should not take the consultant long to generate such files.

I appreciate that the District is trying to wrap up the Little Manatee report, but what I am suggesting should not take much time. Given that the high flow threshold of 96 cfs allows for the start of a shift in the percent allowable withdrawal from 13 to 32 percent, additional analyses are needed to ensure that the best available information was examined to support the flow blocks for the lower river or modify them if necessary.

Given what I discovered about the files I received yesterday, I need to again make a post to the minimum flows webboard informing the review panel that I will not be able to analyze these files. However, I will propose a couple of options by which these analyses can be performed. I will also strongly recommend that the review process continue until such analyses can be completed.

I would like to make such a post soon, possibly in the afternoon on Monday, August 28th or the next day. If you have any thoughts or comments in that regard, please let me know.

Have a fine weekend,
Sid

---------------email from July 14th below on which several District staff were cc'ed--

Hello Kym,

As we have previously discussed, I would like to receive some selected output from the EFDC salinity and EFF fish habitat model runs for a few flow scenarios. I first made this request over a year ago, but in email communication with the District agreed to wait until the revised models were finished.

I think the District's consultant should be able to pull these files from previous model runs together pretty quickly. If results for these specific scenarios could be separated out that would be great, but I could work with larger data sets if the variables and scenarios I have identified are within them. To make sure I am identifying the variables correctly, I might want to briefly communicate with the consultant or could forward any clarification requests through you.

Requests for EFDC and EFF output are described below. In both cases, daily values would be desirable, but I can work with shorter time intervals if that is what is available. If the low flow cutoff of 29 cfs was applied in scenarios other than baseline that is preferable, but if the cutoff was not applied that is okay too. Either EXCEL or SAS files would be fine, with SAS preferable if that is what the data are in now.

The results I am requesting for the EFDC model are baseline flows and predicted area, volume and shoreline length for the <1, <2, <5 < 10 and < 15 ppt salinity values for the baseline, 15, 20, 25, and 30 percent withdrawal scenarios. I would like values for the entire period of record that was used for the minimum flows determination using the EFDC model.

For the EFF favorable habitat models I would like to receive baseline flows and favorable habitat values for the eastern mosquitofish, clown goby, striped mojarra, naked goby, hogchoker, common snook, red drum, and small gobies less than 20 mm. I would like to receive output for the baseline, 15, 20, 25, 30 and 35 percent withdrawal scenarios. I would like values for the entire period of record that was used for the minimum flows determination using the EFF model.

I would like to get my assessment of the results as soon as possible, so if the District could facilitate this I would appreciate it very much. Please let me know if any clarification is needed or if any of this should be identified to be pulled out and prioritized first.

Thanks as always,
Sid

September 4, 2023

To: Kym Holzwart, Yonas Ghile, XinJian Chen, Gabe Herrick, Kristina Deak, Jordan Miller, Doug Leeper, Chris Zajac, Randy Smith, Jenette Seachrist

CC: Peer review panel for the minimum flows for the Litte Manatee River via the webboard

From: Sid Flannery, retired, formerly Chief Environmental Scientist with SWFWMD MFL program

Subject: Critical graphical analyses for the evaluation of flow blocks and allowable percent withdrawal rates as part of minimum flows determination for the Little Manatee River

This memorandum ties together some technical points I have made as part of the review of draft minimum flows report for the Little Manatee River. This memo discusses some graphs that were shown at meetings of the peer review panel for the minimum flows report, plus two important related graphs for the Lower Peace River were discussed but now shown at those meetings.

As application of the percent flow method had progressed over the years, important relationships have been described and documented in the estuarine reaches of rivers in the District. Based on those findings, certain analytical tools have proven to be very effective for determining flow blocks and allowable percent withdrawal rates that hopefully protect such rivers from significant harm from water supply withdrawals.

As I have previously discussed and will be put into further context below, minimum flows for the lower section of the Little Manatee River should not be recommended or adopted until some important, additional graphical analyses are performed and reviewed, as these types of analyses have been used effectively for the determination of minimum flows for other tidal rivers in the District and represent the application of some of the best available information which could help protect the Little Manatee River from significant harm that could result from water supply withdrawals.

The need to account for the high flow effect in the nonlinear response of salinity to freshwater inflow in the evaluation of flow blocks and allowable percentage withdrawal rates

As discussed in District papers and reports, the response of salinity in tidal rivers is often nonlinear with changes in salinity most sensitive at low flows. That is one justification for the percent of flow method, as it reduces the quantity of withdrawals from rivers during sensitive low flow periods. However, it is interesting that this nonlinearity applies even when the effects of simulated water withdrawals are limited to a percentage of flow, which is acknowledged on page 122 of the most recent draft minimum flows report for Little Manatee.

A clear demonstration of this is in Figure 1 for the Lower Alafia River on the following page, which was reviewed but not presented in the minimum flows report for that river. It is clear that a 30 percent withdrawal rate results in a greater percentage reduction in the volume of water less than 2 psu salinity at low flows and less percentage reductions for that salinity zone at high flows.

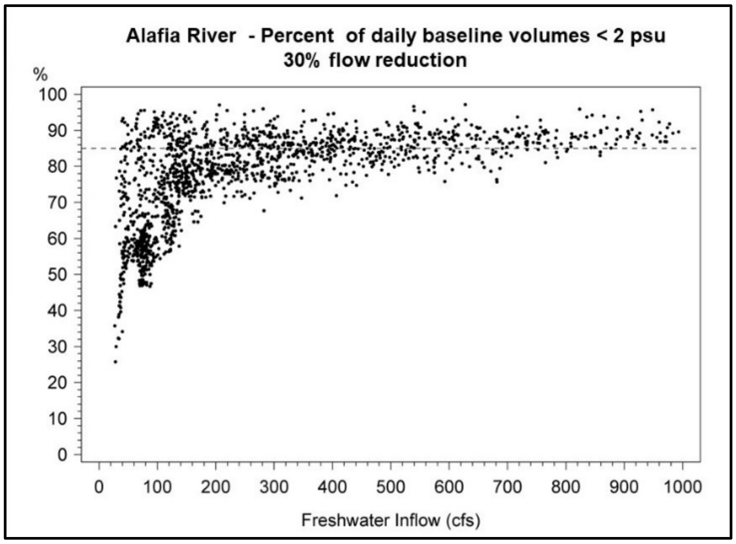


Figure 1. Percent of daily water volumes less than 2 psu salinity for a 30 percent withdrawal rate relative to the daily volumes for baseline conditions vs. the corresponding rate of baseline flow

These types of plots are very useful for evaluating flow blocks for tidal rivers and were used for that purpose and shown in minimum flows reports for the Lower Peace, Lower Myakka, and the Pithlachascotee Rivers. As shown by Figure 1, they were also examined for the Lower Alafia River, but not included in that report.

To support the flow blocks for the Lower Little Manatee River, the District presented only one graph in the minimum flows report, that being a plot of water volumes less than < 2 psu salinity vs. baseline flows. The report says that other graphics were examined, but did not describe the general content of those graphics. I strongly recommend that graphics of percent reductions in salinity zones for various flow reduction scenarios such as Figure 1 above be performed for the Little Manatee River and made available for review and possibly included in an Appendix to the report.

The nonlinear relationship of reduction in salinity zones to flow also has important implications for the determination of allowable percent withdrawal rates within flow blocks. Although not shown in Figure 1, the volumes of water < 2 psu will generally increase with flow and reach high values at higher flows. As flows increase, the volumes of water < 2 psu for both the baseline and a flow reduction scenario will increase, but the percent difference in these values generally decrease.

For example, If the percent reduction in the volume of a salinity zone is calculated from the difference in the average volume values for the baseline and the flow reduction scenario, the large volumes during high flows that have relative small differences between scenarios can overwhelm and mask the results for many days at lower flows in which the volumes are lower, but the relative differences between scenarios are greater.

It is therefore very important to define the method that is used to calculate the net percent reduction in salinity zones used to determine the allowable percent flow reduction for each flow block. I may have missed it, but it appears the method to determine the net percent reductions in salinity zones listed and shown in figures and tables in the draft minimum flows report is not identified in the report. In other District minimum flows reports, the same consultant generated cumulative distribution curves for salinity zones for baseline flows and various flow reduction scenarios and computed net percent reductions in salinity zones using the normalized area under the curve (NAUC) method. A good summary of this method is presented in the minimum flows report for the Lower Myakka River.

I have not personally applied the statistical program for the NAUC method, but is seems like it would produce results for percentage reductions in salinity zones similar to what the difference in the average values for salinity zones between the scenarios would yield. If so, the effects of large volumes of salinity zones that have small relative differences between flow scenarios during high flows could overwhelm and mask the effects of many days at low flows when the volumes are small, but the relative percent differences are greater.

A very informative analysis in that regard was performed for the minimum flows report for the Lower Peace River published in 2010. At that time, the District applied the calendar based approach to minimum flows for the lower river, with blocks corresponding to what are typically periods during the year that have low (Block 1), medium (Block 2), or high flows (Block 3). Along with a low flow cutoff of 130 cfs, the allowable flow reductions were 16% of flow for calendar based Block 1, 29% for Block 2, and 38% for Block 3.

Concerns were raised that low flows can periodically occur in any these blocks, particularly during Block 2 which ran from late October to mid-April. To account for the occurrence of low flows, a flow threshold of 625 cfs was applied to ensure that flows reach a suitably high rate before the higher withdrawal percentages could be applied in the calendar based medium and high flow Blocks 2 and 3.

Two graphs from the 2010 minimum flows report for the Lower Peace are reprinted here, as they represent very informative types of graphics that are useful for evaluating flow blocks in tidal rivers. Figure 2 is application of a 29 percent flow reduction in the calendar Block 2, along with a 130 cfs low flow cutoff and a 400 cfs withdrawal limit that was applied in that minimum flow determination and subsequent rule. Figure 2 does not include the 625 cfs flow threshold, and shows that within Block 2 the percent of water volume < 2 psu salinity relative to baseline varies considerably as a function of flow for the 29% withdrawal rate.

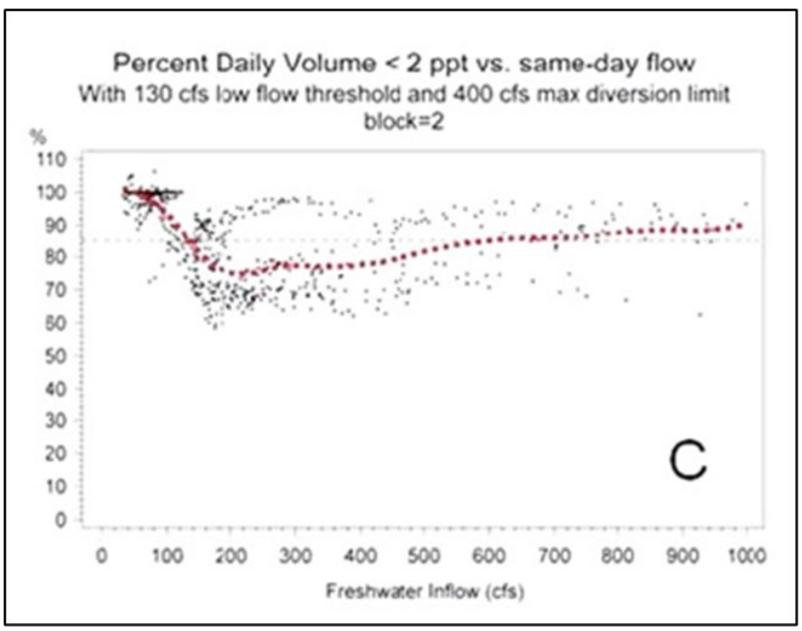


Figure 2. Percent of daily volumes of water < 2 psu salinity relative to baseline conditions for a 29% percent flow reduction vs. the rate of baseline flow within calendar based Block 2, with a reference line at 85% of volume and a LOWESS smoothed line fitted to the data. Reprinted from 2010 minimum flows report for Lower Peace River.

The allowable 29% flow reduction for the calendar Block 2 was determined using the NAUC method for all the days in that block. It is apparent in Figure 2 that daily reductions considerably greater than the District's 15% target (85% of baseline condition) for water volumes < 2 psu were frequent at flow rates between 150 and 600 cfs, with a greater frequency of smaller percentage reductions at higher flows.

The median flow for Block 2 during the 20 years prior to this 2010 report was 327 cfs, so reductions in the volume of water < 2 psu considerably greater than 15% would have occurred much of the time. This indicates the high flow effect described on pages 2 and 3 can mask large percent reductions in salinity zones at lower flows depending on how the allowable percent flow reductions are determined, in this case using the NAUC method, which may have been used for the Little Manatee, but again it appears the method to calculate net percent reductions in salinity zones is not identified in the draft report.

Based on information in Figure 2, the District applied a flow threshold of 625 cfs below which the allowable withdrawal percentages for Blocks 2 and 3 could not be applied, as the withdrawals must remain at the 16% rate for Block 1 until baseline flows exceed at rate of 625 cfs. The daily values of percent of water volume < 2 psu salinity relative to baseline conditions that employed the 625 cfs flow threshold is shown in Figure 3. It is apparent that this flow threshold did much to reduce the daily percentage reductions of that salinity zone at flows between 150 and 600 cfs, so the 625 cfs threshold was incorporated in minimum flow rule adopted for the Lower Peace River at that time.

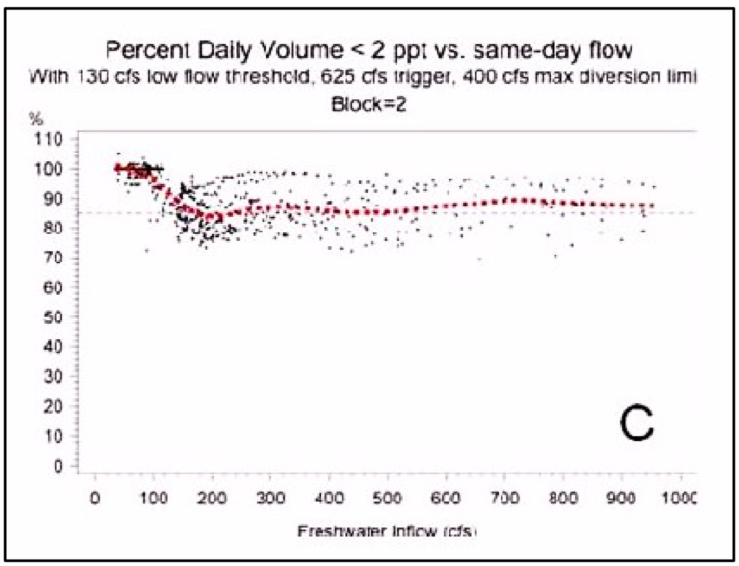


Figure 3. Percentages of the daily volumes of water < 2 psu salinity relative to baseline conditions for a 16% percent flow reduction below a flow rate of 625 cfs and a 29% flow reduction above a flow rate of 625 cfs vs. the rate of baseline flow within Block 2, with a reference line at 85% of volume and a LOWESS smoothed line fitted to the data. Reprinted from 2010 minimum flows report for Lower Peace River.

These graphs of percent reductions in salinity zones vs. flow for a various flow reductions scenarios can be very useful for determining flow blocks that change the allowable percentage withdrawal rates and the percentage withdrawal rates within those blocks. As previously described, such graphics were previously used to evaluate flow blocks for minimum flows for three rivers in the District. However, if such graphics were generated for the Little Manatee River, they were not shown in the recent draft report for the river. Accordingly, In addition to plots of salinity zones vs. baseline flows (one of which was shown in the report), graphics of the percentage reductions in salinity zones for various flow reduction scenarios should be

prepared and reviewed for the Little Manatee River, including the recommended minimum flows with the corresponding flow blocks of 29 and 96 cfs.

As part of my comments to the peer review panel during the first set of meetings in the fall of 2021, I recommended such graphic analyses be performed and described the approach taken for the Lower Peace River, though graphics were not shown for that river. Also, in subsequent communications with the District, I inquired about receiving files derived from output from the EFDC and EFF models for the river so I could do such analyses. However, when I learned that both models were being revised, I said I would wait until the new models were finalized. I then concluded that I would wait and see that the District recommended for flow blocks in the revised minimum flows report, which was made available in late June of 2023.

Based on the very limited results presented in that report, two days after the review panel meeting on July 12, 2023, I placed a request to the District for files of values of the area, volume and shoreline lengths less than certain salinity values (e.g., < 2 psu) for a series of flow reduction scenarios generated by the EFDC model. As described in the next section, values were also requested for the amounts favorable fish habitat produced by the EFF model. This was handled as a public records request, which I happily paid $402 to have processed.

As my request was being processed, I apprised the peer review panel of the expected timelines for delivery of the files from the District, which changed over time, and posted to the minimum flows Webboard my plan of study. However, possibly due to misunderstanding of what I was asking for, on August 24th I received an external hard drive that contained files I cannot use due to either their format or size. These are very large files, which appear to be the basic output from both the EFDC and EFF models with values for many cells, layers, or segments.

I will continue to pursue getting the type of files I was interested in from the District and want to perform the graphical analyses I was intending, which I initially expected to have completed well before now. These files should not be complex in structure and I have to believe the consultant has such files, as they have generated graphical and statistical results that indicate that smaller files that resulted from post-processing the model output data exist. Frankly, I would think the staff for the consultant could generate the simple types of graphics I am describing in a day or two.

Regardless of who generates these graphics, I think they are critical to evaluating flow blocks and allowable percentage flow reductions that protect the Little Manatee River from significant harm, a topic I will summarize in the final section of this memorandum.

Related analyses of favorable fish habitat from the EFF models for the lower river

The management of freshwater inflows is important because of major ways that inflows affect the physical, chemical, and ecological characteristics of estuaries, including the production of many fish and invertebrate species that comprise economically important sport and commercial fisheries in Florida. Accordingly, the District has sponsored outstanding studies of fish and invertebrate use of tidal rivers and also funded detailed analyses of data for fishes and selected invertebrates in tidal river estuaries in the District collected by the Florida Fish and Wildlife Conservation Commission (FFWCC).

As described in the draft minimum flows report, the data for the Little Manatee River are particularly extensive, with data available for analysis extending from 1996 to 2020 when the draft report was prepared. The consultant has done a very good job developing Environmental Favorability Function (EFF) models for a number of fish species in the Lower Little Manatee River based on the data collected by the FFWCC. What is interesting about the EFF models is that they include a salinity component and a shoreline component, based on the preferences for different shoreline types exhibited by various fish species in the tidal section of the Little Manatee River.

It is important to note the EFF modeling results for reductions in the favorable habitat for a number of fish species gave more conservative (lower) results for allowable percentage flow reductions than did analyses of reductions in salinity zones. So, as described in the draft minimum flows report, the final recommended minimum flows were based on reductions in fish habitat for a number of indicator species.

In that regard, it seems logical that the evaluation of flow blocks to best protect fish populations in the lower river should consider relationships of fish habitat to flows and examine flow ranges in which favorable fish habitats change from being more sensitive to less sensitive to the effects of flow reductions. However, from the minimum flows report, it appears the District only examined changes in salinity zones to determine flow blocks for the lower river, with one graphic shown in the report.

It is my conclusion that analyses of the relationships of favorable fish habitat to flow should be examined to determine flow blocks that will prevent significant harm to fish populations in the Little Manatee River. These analyses would be similar in approach to the graphical analyses I recommended for salinity zones, that for various species, examine the amount of favorable habitat as a function of baseline flows and also the how reductions in favorable habitat varies as a function of flow for various flow reduction scenarios.

Because it includes a shoreline component, relationships of fish habitats to flow may show inflexions and breakpoints that are different than those for relationships of salinity zones to flow. A brief summary of findings from FFWCC studies presented in the minimum flows report indicate that tributaries and backwaters with marshes along the river provide optimal habitat for snook and other species. In that regard, it is important to recognize that these physical features and various shoreline types are not evenly distributed along the river channel.

In that regard, I sent to District staff graphs for physical features, vegetation communities, and shoreline types along the river as a function of river kilometer that are available in files I left at the District. I also showed an graph of shoreline lengths per kilometer to the review panel that shows the effect of the braided zone in the river that is referred to in the minimum flows report. I am disappointed the District has chosen not to include such graphics in the report, the types of which are shown in minimum flows reports for other rivers, but I can live with that.

What is critical, though, is that along with salinity, the effects of shoreline features on the favorable fish habitats that are incorporated in the EFF models be accounted for in the determination of flow blocks for the lower river. Basically, if a minimum flows are ultimately based on favorable fish habitat, those relationships should be used to evaluate appropriate flow blocks for the lower river, as they may show different results than analyses that are based solely on salinity.

Similar to the situation for output from the EFDC model, on July 14, 2023, I requested files derived from the EFF models for the Little Manatee, but when I received those files on August 24th I realized I could not use them due to their size, as they might be the basic model output.

Again, I hope to interact with the District to receive files I can use, but as stated for the EFDC model output, I think the consultants for the District could generate the graphics for the EFF modeling results described in my plan of study in very short order. Regardless, they need to be completed by someone in order to provide information that would be critical for determining minimum flows that protect the Little Manatee River from significant harm.

Summary

As previously described, I believe it is very important that additional graphical analyses are needed to evaluate flow blocks for the Little Manatee River. This would include very informative graphical analyses of the relationships of salinity zones to flow that have been used to determine flow blocks for the other tidal rivers in the District. Also, since the minimum flows were ultimately based on favorable fish habitat, similar analyses should be performed on the response of favorable fish habitats to flow to evaluate flow blocks for the lower river. If the flow blocks are revised, it could affect the allowable percent flow reductions within the blocks, but that should be easy to evaluate.

I realize the District wants to adopt minimum flows for the Little Manatee River in 2023, but the analyses I am recommending should not take long to perform and that schedule can likely still be met if revisions are made to the report. However, getting these minimum flows right is the key consideration, even if it delays the adoption of minimum flows for the Little Manatee River into the very early part of 2014, which I don't think will be necessary.

Accordingly, I suggest peer review process for the minimum flows report for the Little Manatee River be extended so that these important additional analyses can be performed. The Litte Manatee River is truly one of the most ecologically important and valued tidal river estuaries in the District. It is also a river that has benefited from very extensive data collection and analyses over the years and was one of the foundational rivers on which the percent of flow method was initially based. In that regard it is important, as stated in Florida Statues, that the best information available be used to determine minimum flows for this outstanding river to protect it from significant harm.

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Chris Zajac; Yonas Ghile; Kristina Deak; Gabe I. Herrick; Xinjian Chen; Jordan D. Miller; Randy Smith
Subject:	Summary of technical basis for additonal graphical analyses needed to evaluate minimum flows for the Lower Little Manatee River
Date:	Tuesday, September 5, 2023 2:26:06 PM
Attachments:	Summary of technical basis for addtional graphical analyses.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello District staff,

I just made a post on the minimum flows webboard for the Little Manatee River that included the pdf file that is attached to this email. This document provides a summary and technical justification for the graphical analyses I think are needed to evaluate minimum flows that protect the Lower Little Manatee River from significant harm.

I hope staff can read this document and consider two key areas: The first is pretty straightforward but very important, and the second which is very interesting and needs to be addressed, not only for the Little Manatee, but for the evaluation of minimum flows for other upcoming tidal rivers. These two topics are summarized below.

1. Since the minimum flows for the Little Manatee River were ultimately based on reductions in favorable fish habitats, the evaluation of flow blocks for the lower river should evaluate changes in favorable fish habitats as a function of flow. It appears from the minimum flows report that only changes in salinity zones were considered.

2. Depending on how the allowable percent flow reductions for a block are calculated, the presence of high flows in a block can mask percent reductions in salinity zones well above the District's 15 percent threshold for many days in that block. The graphs and discussion of the Lower Peace River in the attached document is an example of this, which was remedied at that time by applying a flow based threshold that was based on a type of graphical analysis I am suggesting for the Little Manatee.

Also, as I have previously posted on the webboard, I could be wrong, but it appears the method to calculate net percent flow reductions for the flow blocks for the lower river is not described in the draft minimum flows report. I suspect the normalized area under the curve method (NAUC) was used. If so, the Peace River example, which used that method, strongly indicates that the type of graphical analyses I am suggesting are badly needed for the Little Manatee to check in what flow ranges reductions in salinity zones and favorable fish habitats greater than 15% would frequently occur.

As I have previously expressed, the analyses I am suggesting would not take long to perform, and had my public records request gone well, I had hoped to have them finished by early to mid-August. Also, I think the consultant could perform these analyses in very short order.

Regardless of who does these analyses, I strongly recommend a bit more time be allotted for review of the minimum flows report of the Little Manatee so that minimum flows can be determined that protect this valuable river from significant harm.   I expect the analyses I have suggested could be done promptly in time for the minimum flows for the Little Manatee to be adopted in 2023, but getting this minimum flow right is the key consideration, even if it delays the adoption of the minimum flows into the very early part of 2024, which I don't think will be necessary.

Best regards,
Sid

From:	Sid Flannery
To:	Randy Smith
Cc:	Kym Holzwart; Chris Zajac; Doug Leeper; Yonas Ghile; Xinjian Chen; Gabe I. Herrick; Kristina Deak; Jordan D. Miller
Subject:	Re: Limitations for my use of the files on the external hard drive I received from the District
Date:	Friday, September 8, 2023 8:27:10 AM

Hello Randy and District staff,

On Tuesday I said I would get back on Thursday, but I was busy yesterday so I am replying today. I hope the District and consultant can continue to consider my request for files that was handled as a public records request. My request was submitted in the spirit of good resource management and I hope it can be suitably fulfilled. I provide a bit of perspective below on the content of the request, much of which was expressed in the previous emails in the stream below.

There are many graphics and statistical results presented in the minimum flows report for the Little Manatee River that indicate the consultant has files useful for those purposes, which I assumed resulted from post-processing output from the EFDC and EFF models. I expected those would be smaller files that would contain the values I need, which are values for salinity zones (e.g., water volume < 2 psu salinity) or favorable fish habitats for the entire lower river for whatever time period the consultant had available such as hours or day. I know the consultant frequently uses SAS software, so I said in my initial request that either SAS or EXCEL files would be suitable for my purposes.

In the case of the EFDC model, the description of the files in the WORD document that was on the external hard drive I received indicates it contains basic output from the model which has "hourly output for water column conditions at each layer (salinity and temperature) and water column depth at each grid cell, respectively." Again, I was hoping to receive smaller files that had the net values for zones less than various salinity concentrations in the lower river for each time interval. I was not expecting to have to post-process the output to calculate such values. Also, the .OUT files on the hard drive I received appear to need an executable FORTRAN code to be read.

In the case of the EFF modeling, I received SAS data sets, but the SAS program I use will not let me upload files that large, and these are large, over 12 gigabytes each in size. I am thinking those files must also be basic output for the EFF models for each segment or whatever spatial unit was used. If so, I would have to post-process this output to obtain the net values for favorable habitat for each species in the river for each time interval. I could be wrong, but it appears the files I received were deliverables the consultant was to provide to the District to fulfill part of their contract for the EFDC and EFF modeling.

When I submitted my request via email on July 14th, I said to make sure I was identifying the variables correctly, I might want to briefly communicate with the consultant or could forward any clarification requests through the District project manager. Also, I said to please let me know if any clarification is needed or if any of this should be identified to be pulled out and prioritized first. However, I did not hear anything from the District regarding the technical content of my request prior to receiving the external hard drive on August 24th.

At this time, I think some communications would be in order to fulfill what I think is a very reasonable public records request, that I paid $402 dollars for. Again, I think the consultant likely has files that have the type of information I am looking for. In that regard, I have suggested a very short zoom meeting or three way call with the District and the consultant, whom I worked with extensively in the past, could be in order. I know that Kym is on very well deserved leave until September 18th, but someone else from staff could facilitate such a meeting. Or, the District could forward this email to the consultant and again consider if the types of files I am requesting can be provided. And again, I am asking the District to please contact me if any clarification is needed.

I think the District should strive to fulfill this request in the spirit of the most effective management of our water and natural resources. As you know, I have provided to the District data files relevant to its work, including data for a point source discharge from the Mosaic company in the Little Manatee River basin that was not addressed in the draft minimum flows report that was published in September 2021. In the case of the Lower Hillsborough River, I have provided to the District data and useful analyses from recorders in the river and Sulphur Springs operated by the USGS and valuable invertebrate data collected in the river by myself and two retired FDEP biologists.

In the spirit of professional interaction, I hope my request for files can be revisited to receive the types of files I requested. Again, please contact me if any clarification on the technical contents of this request is needed.

Thanks as always,
Sid

On Tue, Sep 5, 2023 at 1:28 PM Sid Flannery <sidflannery22@gmail.com> wrote:

> Randy,
>
> I am pretty busy the next two days, but will get back with you on Thursday.

In general, based on graphics and statistics presented in the minimum flows report, it appears the consultant has smaller files that resulted from post-processing of the model output that would contain the values I need.   It appears what I received were very large files that are basic model output, and in the case of the EFDC model in a code I cannot read, although I stated in my request EXCEL or SAS files would work.

Possibly something is getting lost in the translation. I think that a short three way conference call with the consultants (Ray and Mike) would be helpful.
Will get back with you on Thursday.

Thanks,
Sid

On Tue, Sep 5, 2023 at 1:12 PM Randy Smith <Randy.Smith@swfwmd.state.fl.us> wrote:

> Sid,
>
> Hope you made out well with the storm. Kym is on a long-planned vacation till the 18th. The draft final Peer Review report was posted to the web board on Friday. Staff are reviewing the report and we will meet when Kym returns on the 18th. Staff and our consultant have not found any additional information that we have not already provided to you that is responsive to your public records request. Staff will continue to look. Also, we will continue to review any information you provide and your request for additional analysis.
>
> Best regards,
>
> ~~~~~~
>
> Randy Smith, PMP
>
> Bureau Chief
>
> Natural Systems & Restoration Bureau
>
> Southwest Florida Water Management District
>
> Direct line: (352) 269-5836
>
> Brooksville District Office: (352) 796-7211

Email: randy.smith@watermatters.org

District website: www.watermatters.org

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Tuesday, September 5, 2023 9:56 AM
To: Randy Smith <Randy.Smith@swfwmd.state.fl.us>
Cc: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Yonas Ghile <Yonas.Ghile@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>
Subject: Re: Limitations for my use of the files on the external hard drive I received from the District

[EXTERNAL SENDER] Use caution before opening.

Hello Randy,

Thanks for your reply below regarding my public records request for files from the Little Manatee River.   I will be happy to work with staff to provide any feedback or clarification regarding the files I requested. As my previous communications have said, I expect the consultant has files very similar to what I am requesting, which hopefully they can provide if the District does not already have them.

This afternoon I will send an email to the District and post to the webboard a summary and brief justification of the graphical analyses that I think are needed to check the minimum flows for the Little Manatee River. As I have also stated, I don't think these graphics would take long to generate and they are critical to adopting minimum flows that will protect the Little Manatee River from significant harm.

In that regard, I will be asking the District and the peer review panel to allow a bit more time for review of the minimum flows report before it is finalized.

Thanks again,

Sid

On Fri, Aug 25, 2023 at 5:01 PM Randy Smith <Randy.Smith@swfwmd.state.fl.us> wrote:

> Sid,
>
> We will review this more detailed public records request and see if we have produced this specific information in any other format than what we have already provided. We will get back with you early next week. Hope you have a great weekend.
>
> Best regards,
>
> ~~~~~~
>
> Randy Smith, PMP
>
> Bureau Chief
>
> Natural Systems & Restoration Bureau
>
> Southwest Florida Water Management District
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> ---
>
> **From:** Sid Flannery <sidflannery22@gmail.com>
> **Sent:** Friday, August 25, 2023 3:02 PM

To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Cc: Randy Smith <Randy.Smith@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Yonas Ghile <Yonas.Ghile@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>
Subject: Limitations for my use of the files on the external hard drive I received from the District

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and staff,

Thanks to Kym and records management staff for fulfilling my public records request for files for the Lower Little Manatee River. However, it looks like I will not be able to use or analyze these files for the reasons I describe below. First, though, I will describe the intent of my request and then the situation with the present files.

The email that I sent to the District on July 14th with my initial request for files is reprinted below this current email. The intent of that email was to get some simple output values from the EFDC and EFF model runs for the Lower Little Manatee River. As I have described in previous correspondence and presentations to the peer review panel, there are some very straightforward graphical analyses that can be performed that are very informative for evaluating flow blocks for the estuarine sections of rivers. In fact, one of these techniques was directly used to establish flow blocks in minimum flows reports for the Lower Peace, Pithlachascotee and Lower Myakka Rivers, and though not presented in the report, provided very useful information for the Lower Alafia.

As described in my email from July 14th below, what I was hoping to receive for the EFF model runs were files containing predicted values of volume, area, and shoreline length less than different salinity values (e.g., < 2 psu) for a series of flow reduction scenarios. Similarly, for the EFF model, these would be predicted output values of favorable fish habitat for selected species for a series of flow reduction scenarios. I specified the flow scenarios and salinity zones and fish taxa I was interested in. I could use whatever time interval these values were in (hours, days). Also, I could pull these values out of larger data sets if these variables are clearly identified, which I assumed they would be.

In addition to very large files of raw model values, I figured the consultant must have created some smaller reduced files for statistical and graphical analysis, as the minimum flows report has bar graphs of percent reductions in various salinity zones and fish habitats. Similarly, on page 123, there is a graph of the volume of water less that 2 psu salinity vs. flow and the report says that a number of other graphs were examined.   Seeing that, I thought the District must have ready access to the exact type of information I am looking for, and suggested that I could deal with either EXCEL files or SAS data sets.

For the EFDC model output, it looks like what I received is something very different than what I requested. Attached is a pdf that shows the folders and contents of the external hard drive I picked up yesterday (Aug 24th). Also attached is a WORD document prepared by the consultant that describes the files related to the EFDC model. As that WORD document describes, the contents and format of the baseline model run file are similar to the files for the flow reduction scenario runs. It also specifies that these files contain "hourly output for water column conditions at each vertical level at each grid cell (salinity and temperature) and water column depth at each grid cell, respectively."   Given that, it is no wonder the files are so huge. The hard drive also includes the FORTRAN text and executable code to read the output (OUT) files.

So, with regard to my public records request, am I supposed to execute these codes and then calculate how much volume etc. was less than a specified salinity value?   Obviously, that is not possible. It looks like these EFDC files are one of the deliverables that the consultant is to provide for the contract with the District. Again, I was thinking there are some existing smaller data sets in which the volumes, etc. were already calculated and used for the statistical and graphical results that are presented in the minimum flows report.

The situation is different for the EFF model results. As shown in the pdf of contents of the hard drive, these are SAS data sets, which I normally can deal with.   However, they are very large, over 12 gigabytes each, and the SAS program I use will not let me import files that large. Also, the large size of these files makes me wonder if they are the extensive raw model output by river length or whatever, in which I would have to calculate the percent habitat reduction for each taxon and flow scenario.   The fellow that generated these files is a sharp guy and possibly he could generate the statistical and graphical results from these large files, but I have to wonder if there are smaller data sets that were developed from these large model output files.

So - (1) how did we get here, and (2) what to do now. #1 - Five days after placing my request on July 14th, I was informed it was a formal public records request and it would take about two weeks to produce the files, which I agreed to. Given that response, on July 24th I posted my plan of study for analysis of the files to the minimum flow weboard and said the expected date for file delivery is August 2nd.

On August 9th, I emailed the District to inquire how it was going. That same day, the District replied and said the files could be ready sometime next week and I would be given a cost for the retrieval. On August 16th, the District emailed and said the total cost of the records retrieval would be $402, which I happily paid, and I was informed the files should be ready by August 24th. Given that information, on August 22nd I made a post to the webboard about the new expected delivery date for the files and that I would work on it as promptly as possible to generate graphics and interpretive text which should take about a week or two to complete.

So, what to do now? I want to again emphasize that the types of analyses I am proposing are very straightforward, but also very informative and have been used in other minimum flows studies.   As the percent of flow method has evolved for over 30 years, certain tools have proven to be very useful and the analyses I am proposing are at the top of the list.

At this time, I suggest the District and consultant look and see if there already exists any of the smaller output files similar to what I described on July 14th. If there are not, it should not take the consultant long to generate such files.

I appreciate that the District is trying to wrap up the Little Manatee report, but what I am suggesting should not take much time. Given that the high flow threshold of 96 cfs allows for the start of a shift in the percent allowable withdrawal from 13 to 32 percent, additional analyses are needed to ensure that the best available information was examined to support the flow blocks for the lower river or modify them if necessary.

Given what I discovered about the files I received yesterday, I need to again make a post to the minimum flows webboard informing the review panel that I will not be able to analyze these files. However, I will propose a couple of options by which these analyses can be performed. I will also strongly recommend that the review process continue until such analyses can be completed.

I would like to make such a post soon, possibly in the afternoon on Monday, August 28th or the next day. If you have any thoughts or comments in that regard, please let me know.

Have a fine weekend,

Sid

---------------email from July 14th below on which several District staff were cc'ed---

Hello Kym,

As we have previously discussed, I would like to receive some selected output from the EFDC salinity and EFF fish habitat model runs for a few flow scenarios. I first made this request over a year ago, but in email communication with the District agreed to wait until the revised models were finished.

I think the District's consultant should be able to pull these files from previous model runs together pretty quickly. If results for these specific scenarios could be separated out that would be great, but I could work with larger data sets if the variables and scenarios I have identified are within them.   To make sure I am identifying the variables correctly, I might want to briefly communicate with the consultant or could forward any clarification requests through you.

Requests for EFDC and EFF output are described below. In both cases, daily values would be desirable, but I can work with shorter time intervals if that is what is available. If the low flow cutoff of 29 cfs was applied in scenarios other than baseline that is preferable, but if the cutoff was not applied that is okay too. Either EXCEL or SAS files would be fine, with SAS preferable if that is what the data are in now.

The results I am requesting for the EFDC model are baseline flows and predicted area, volume and shoreline length for the <1, <2, <5 < 10 and < 15 ppt salinity values for the baseline, 15, 20, 25, and 30 percent withdrawal scenarios.   I would like values for the entire period of record that was used for the minimum flows determination using the EFDC model.

For the EFF favorable habitat models I would like to receive baseline flows and favorable habitat values for the eastern mosquitofish, clown goby, striped mojarra, naked goby, hogchoker, common snook, red drum, and small gobies less than 20 mm. I would like to receive output for the baseline, 15, 20, 25, 30 and 35 percent withdrawal scenarios.   I would like values for the entire period of record that was used for the minimum flows determination using the EFF model.

I would like to get my assessment of the results as soon as possible, so if the District could facilitate this I would appreciate it very much. Please let me know if any clarification is needed or if any of this should be identified to be pulled out and prioritized first.

Thanks as always,

Sid

July 24, 2023 (with additions in red, September 18, 2023)

Plan of Study – Graphical analyses to evaluate flow blocks for minimum flows for the Lower Little Manatee River

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

As part of a public records request, the Southwest Florida Water Management District (the District) will provide to me files of predicted output values from the EFDC hydrodynamic model and EFF favorable fish habitat models for the Lower Little Manatee River. These files will be used to generate graphics to help evaluate suitable flow rates to serve as blocks to allow changes in allowable percent withdrawal rates for the lower river.

The District has estimated these files can be provided near the beginning of August, but the exact date of delivery may vary. I will begin to generate the graphics as soon as I receive the files and hope to produce a series of plots and a corresponding technical memorandum within a week or so. This memorandum may support the flow blocks of 29 and 96 cfs recommended in the revised draft minimum flows report, or instead could possibly suggest revised flow blocks for the lower river.

The graphics that will be generated are fairly simple, but are very informative and have been used to evaluate flow blocks for tidal estuarine rivers in three previous minimum flow studies conducted by the District. Examples of these types of graphics and their utility were discussed in a supplemental analyses, data presentations, and clarifications report I submitted to the District in January 2002 and also shown in two slides I presented to the minimum flows peer review panel at their meeting on July 5, 2023.

In the case of the Little Manatee River, it is critical that relationships of favorable fish habitats to freshwater inflow be evaluated, as the minimum flows for the lower river were ultimately based on reductions in fish habitats as they generally provided more conservative results that reductions in salinity zones. Also, the EFF fish habitat models include both a salinity and shoreline type component, so the predicted values may show relationships with freshwater flow that are different than simple salinity zones because shoreline types change along the length of the lower river.

Plots of baseline values - The first type of graphics will be plots of daily values for the quantities of salinity zones and favorable fish habitats vs. baseline flows. The salinity zones that will be graphically evaluated will include bottom area, volume, and shoreline lengths below salinity values of <1, <2, <5, <10 and <15 psu. Similar plots of the amount of favorable fish habitats vs. baseline flows will be generated for eight taxa of fish analyzed in the minimum flows reports.

Plots of reductions in salinity zones and fish habitat v. baseline flows for various flow reduction scenarios - The second type of plots will show percent reductions in daily values for salinity zones and favorable fish habitats for a series percent flow reduction scenarios. Based on findings from previous minimum flow studies of other tidal estuarine rivers (lower reaches of the Peace, Myakka, and Pithlachascotee Rivers), these types of graphics are very useful for evaluating flow blocks that allow increases in allowable percentage withdrawal rates.

***** ***one of several with that job title at the District including another staff member in the minimum flows program at the time of my retirement***

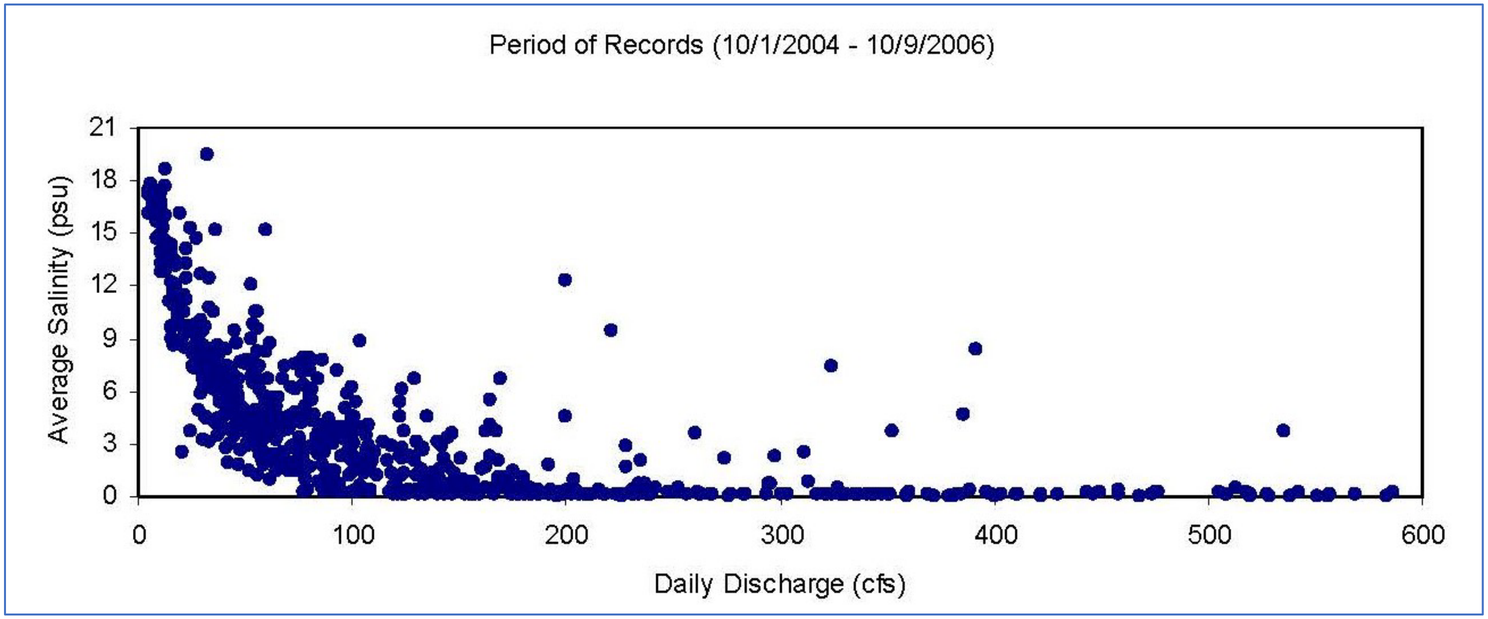
Using output from the EFDC model, plots of daily values for percent reductions in the volume, bottom area, and shoreline lengths less than the aforementioned five salinity values vs. the corresponding rate of baseline flow will be produced for the flow reduction scenarios of 10, 15, 20, 25, 30 and 35 percent. Using output from the EFF models, plots of daily values for percent reductions in favorable fish habitats vs. the corresponding rate of baseline flow will be shown for eight fish taxa that were assessed in the minimum flows report for flow reductions of 10, 15, 20, 25, 30 and 35 percent.

Plots of chlorophyll *a* and ichthyoplankton and nekton abundance and distribution vs. flow

As a separate effort, graphics and analyses of the response of the chlorophyll *a* in the lower river to freshwater inflow may also be submitted to the District and the peer review panel if they provide useful related findings that support the evaluation of flow blocks that are based on salinity zones and favorable fish habitats. In addition, regressions of freshwater inflow with the number and center of abundance for various fish species in the ichthyoplankton and nekton catch published in previous studies of the lower river by the University of South Florida and the Florida Fish and Wildlife Conservation Commission may also be examined as they pertain to the establishment of flow blocks for the lower river.

Data presentation and analyses - It is expected that a series of graphics will be provided for some, but not all, of the plots in a technical memorandum I will prepare with emphasis on those graphics that seem most critical to the evaluation of flow blocks for the lower river. Appendices containing of the total set of graphics can be provided upon request.

As previously mentioned, the findings of this assessment may either support the 29 and 96 cfs thresholds for flow blocks for the lower river recommended in the draft minimum flows report, or instead may recommend revisions to the flow blocks. If revisions to the flow blocks are recommended, the memo will statistically analyze the percent reductions of salinity zones and favorable fish habitats within each of those flow blocks.



Average daily salinity (top and bottom recorders combined) at the USGS gage Little Manatee River at I-75 near Ruskin (# 02300542) vs. same day flow at the Little Manatee River near Wimauma gage. This gage with the salinity recorders (computed from specific conductance) was located near river kilometer 12.0.

Interpretation - This graph indicates that a high flow block could be established between 150 and 200 cfs in order to allow oligohaline wetlands along the Little Mantee River near Interstate 75 to continue to be inundated with fresh or near fresh water at high flows after withdrawals. These wetlands include some freshwater species (e.g., sawgrass, cattail) that have some salt tolerance but benefit from periodic inundation of fresh water which reduces soil salinity, especially during high flows when river water penetrates farther into the marshes. Periodic inundation of these wetlands with fresh water during high flows would help maintain the species composition and productivity of these plant communities, whereas inundation with more brackish water due to the effects of water withdrawals at lower flows could lead to an alteration and loss of productivity of these systems. A high flow block based on relationships with baseline flows as shown above should allow for a buffer set at a slightly higher flow to adjust for the actual flows that would occur after withdrawals, including in the flow block below it.

September 4, 2023

To: Kym Holzwart, Yonas Ghile, XinJian Chen, Gabe Herrick, Kristina Deak, Jordan Miller, Doug Leeper, Chris Zajac, Randy Smith, Jenette Seachrist

CC: Peer review panel for the minimum flows for the Litte Manatee River via the webboard

From: Sid Flannery, retired, formerly Chief Environmental Scientist with SWFWMD MFL program

Subject: Critical graphical analyses for the evaluation of flow blocks and allowable percent withdrawal rates as part of minimum flows determination for the Little Manatee River

This memorandum ties together some technical points I have made as part of the review of draft minimum flows report for the Little Manatee River. This memo discusses some graphs that were shown at meetings of the peer review panel for the minimum flows report, plus two important related graphs for the Lower Peace River were discussed but now shown at those meetings.

As application of the percent flow method had progressed over the years, important relationships have been described and documented in the estuarine reaches of rivers in the District. Based on those findings, certain analytical tools have proven to be very effective for determining flow blocks and allowable percent withdrawal rates that hopefully protect such rivers from significant harm from water supply withdrawals.

As I have previously discussed and will be put into further context below, minimum flows for the lower section of the Little Manatee River should not be recommended or adopted until some important, additional graphical analyses are performed and reviewed, as these types of analyses have been used effectively for the determination of minimum flows for other tidal rivers in the District and represent the application of some of the best available information which could help protect the Little Manatee River from significant harm that could result from water supply withdrawals.

The need to account for the high flow effect in the nonlinear response of salinity to freshwater inflow in the evaluation of flow blocks and allowable percentage withdrawal rates

As discussed in District papers and reports, the response of salinity in tidal rivers is often nonlinear with changes in salinity most sensitive at low flows. That is one justification for the percent of flow method, as it reduces the quantity of withdrawals from rivers during sensitive low flow periods. However, it is interesting that this nonlinearity applies even when the effects of simulated water withdrawals are limited to a percentage of flow, which is acknowledged on page 122 of the most recent draft minimum flows report for Little Manatee.

A clear demonstration of this is in Figure 1 for the Lower Alafia River on the following page, which was reviewed but not presented in the minimum flows report for that river. It is clear that a 30 percent withdrawal rate results in a greater percentage reduction in the volume of water less than 2 psu salinity at low flows and less percentage reductions for that salinity zone at high flows.

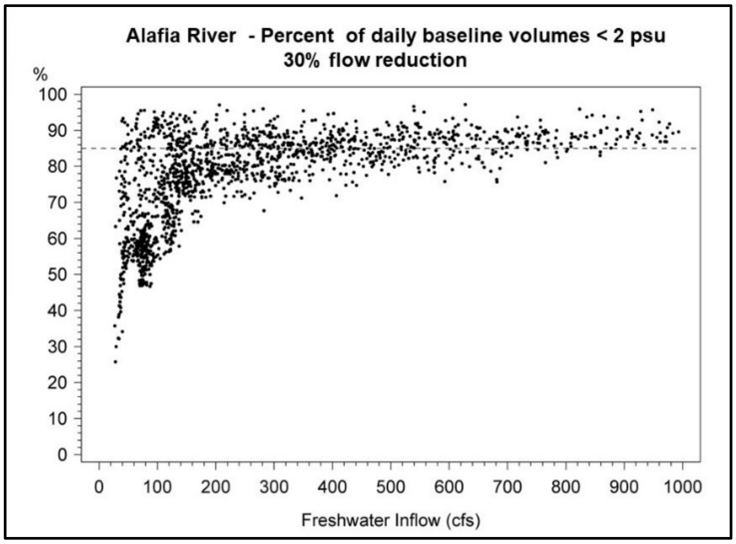


Figure 1. Percent of daily water volumes less than 2 psu salinity for a 30 percent withdrawal rate relative to the daily volumes for baseline conditions vs. the corresponding rate of baseline flow

These types of plots are very useful for evaluating flow blocks for tidal rivers and were used for that purpose and shown in minimum flows reports for the Lower Peace, Lower Myakka, and the Pithlachascotee Rivers. As shown by Figure 1, they were also examined for the Lower Alafia River, but not included in that report.

To support the flow blocks for the Lower Little Manatee River, the District presented only one graph in the minimum flows report, that being a plot of water volumes less than < 2 psu salinity vs. baseline flows. The report says that other graphics were examined, but did not describe the general content of those graphics. I strongly recommend that graphics of percent reductions in salinity zones for various flow reduction scenarios such as Figure 1 above be performed for the Little Manatee River and made available for review and possibly included in an Appendix to the report.

The nonlinear relationship of reduction in salinity zones to flow also has important implications for the determination of allowable percent withdrawal rates within flow blocks. Although not shown in Figure 1, the volumes of water < 2 psu will generally increase with flow and reach high values at higher flows. As flows increase, the volumes of water < 2 psu for both the baseline and a flow reduction scenario will increase, but the percent difference in these values generally decrease.

For example, If the percent reduction in the volume of a salinity zone is calculated from the difference in the average volume values for the baseline and the flow reduction scenario, the large volumes during high flows that have relative small differences between scenarios can overwhelm and mask the results for many days at lower flows in which the volumes are lower, but the relative differences between scenarios are greater.

It is therefore very important to define the method that is used to calculate the net percent reduction in salinity zones used to determine the allowable percent flow reduction for each flow block. I may have missed it, but it appears the method to determine the net percent reductions in salinity zones listed and shown in figures and tables in the draft minimum flows report is not identified in the report. In other District minimum flows reports, the same consultant generated cumulative distribution curves for salinity zones for baseline flows and various flow reduction scenarios and computed net percent reductions in salinity zones using the normalized area under the curve (NAUC) method. A good summary of this method is presented in the minimum flows report for the Lower Myakka River.

I have not personally applied the statistical program for the NAUC method, but is seems like it would produce results for percentage reductions in salinity zones similar to what the difference in the average values for salinity zones between the scenarios would yield. If so, the effects of large volumes of salinity zones that have small relative differences between flow scenarios during high flows could overwhelm and mask the effects of many days at low flows when the volumes are small, but the relative percent differences are greater.

A very informative analysis in that regard was performed for the minimum flows report for the Lower Peace River published in 2010. At that time, the District applied the calendar based approach to minimum flows for the lower river, with blocks corresponding to what are typically periods during the year that have low (Block 1), medium (Block 2), or high flows (Block 3). Along with a low flow cutoff of 130 cfs, the allowable flow reductions were 16% of flow for calendar based Block 1, 29% for Block 2, and 38% for Block 3.

Concerns were raised that low flows can periodically occur in any these blocks, particularly during Block 2 which ran from late October to mid-April. To account for the occurrence of low flows, a flow threshold of 625 cfs was applied to ensure that flows reach a suitably high rate before the higher withdrawal percentages could be applied in the calendar based medium and high flow Blocks 2 and 3.

Two graphs from the 2010 minimum flows report for the Lower Peace are reprinted here, as they represent very informative types of graphics that are useful for evaluating flow blocks in tidal rivers. Figure 2 is application of a 29 percent flow reduction in the calendar Block 2, along with a 130 cfs low flow cutoff and a 400 cfs withdrawal limit that was applied in that minimum flow determination and subsequent rule. Figure 2 does not include the 625 cfs flow threshold, and shows that within Block 2 the percent of water volume < 2 psu salinity relative to baseline varies considerably as a function of flow for the 29% withdrawal rate.

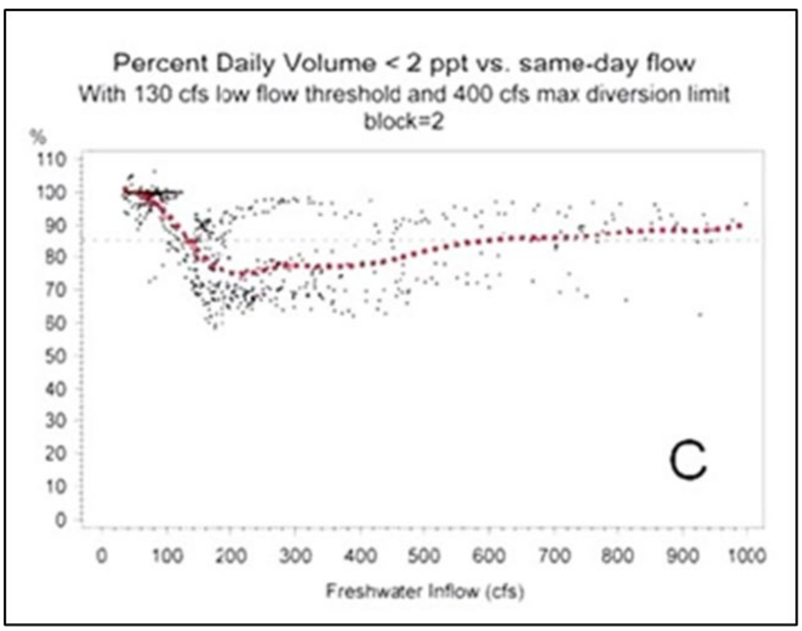


Figure 2. Percent of daily volumes of water < 2 psu salinity relative to baseline conditions for a 29% percent flow reduction vs. the rate of baseline flow within calendar based Block 2, with a reference line at 85% of volume and a LOWESS smoothed line fitted to the data. Reprinted from 2010 minimum flows report for Lower Peace River.

The allowable 29% flow reduction for the calendar Block 2 was determined using the NAUC method for all the days in that block. It is apparent in Figure 2 that daily reductions considerably greater than the District's 15% target (85% of baseline condition) for water volumes < 2 psu were frequent at flow rates between 150 and 600 cfs, with a greater frequency of smaller percentage reductions at higher flows.

The median flow for Block 2 during the 20 years prior to this 2010 report was 327 cfs, so reductions in the volume of water < 2 psu considerably greater than 15% would have occurred much of the time. This indicates the high flow effect described on pages 2 and 3 can mask large percent reductions in salinity zones at lower flows depending on how the allowable percent flow reductions are determined, in this case using the NAUC method, which may have been used for the Little Manatee, but again it appears the method to calculate net percent reductions in salinity zones is not identified in the draft report.

Based on information in Figure 2, the District applied a flow threshold of 625 cfs below which the allowable withdrawal percentages for Blocks 2 and 3 could not be applied, as the withdrawals must remain at the 16% rate for Block 1 until baseline flows exceed at rate of 625 cfs. The daily values of percent of water volume < 2 psu salinity relative to baseline conditions that employed the 625 cfs flow threshold is shown in Figure 3. It is apparent that this flow threshold did much to reduce the daily percentage reductions of that salinity zone at flows between 150 and 600 cfs, so the 625 cfs threshold was incorporated in minimum flow rule adopted for the Lower Peace River at that time.

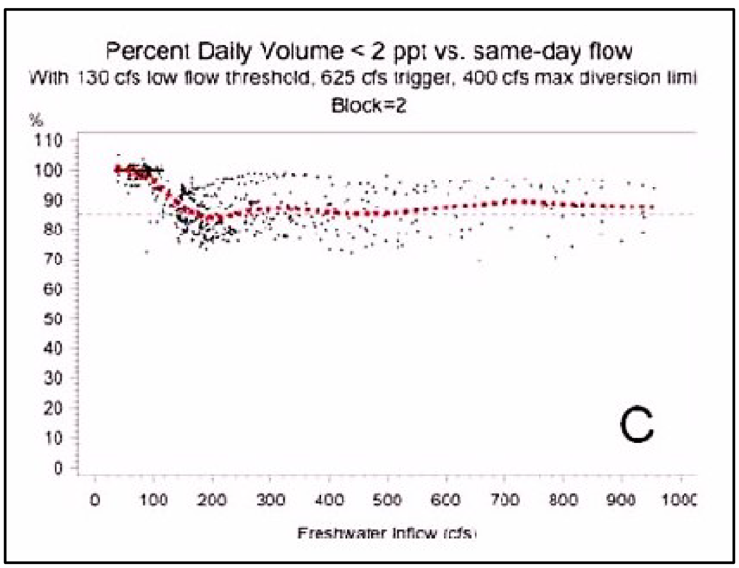


Figure 3. Percentages of the daily volumes of water < 2 psu salinity relative to baseline conditions for a 16% percent flow reduction below a flow rate of 625 cfs and a 29% flow reduction above a flow rate of 625 cfs vs. the rate of baseline flow within Block 2, with a reference line at 85% of volume and a LOWESS smoothed line fitted to the data. Reprinted from 2010 minimum flows report for Lower Peace River.

These graphs of percent reductions in salinity zones vs. flow for a various flow reductions scenarios can be very useful for determining flow blocks that change the allowable percentage withdrawal rates and the percentage withdrawal rates within those blocks. As previously described, such graphics were previously used to evaluate flow blocks for minimum flows for three rivers in the District. However, if such graphics were generated for the Little Manatee River, they were not shown in the recent draft report for the river. Accordingly, In addition to plots of salinity zones vs. baseline flows (one of which was shown in the report), graphics of the percentage reductions in salinity zones for various flow reduction scenarios should be

prepared and reviewed for the Little Manatee River, including the recommended minimum flows with the corresponding flow blocks of 29 and 96 cfs.

As part of my comments to the peer review panel during the first set of meetings in the fall of 2021, I recommended such graphic analyses be performed and described the approach taken for the Lower Peace River, though graphics were not shown for that river. Also, in subsequent communications with the District, I inquired about receiving files derived from output from the EFDC and EFF models for the river so I could do such analyses. However, when I learned that both models were being revised, I said I would wait until the new models were finalized. I then concluded that I would wait and see that the District recommended for flow blocks in the revised minimum flows report, which was made available in late June of 2023.

Based on the very limited results presented in that report, two days after the review panel meeting on July 12, 2023, I placed a request to the District for files of values of the area, volume and shoreline lengths less than certain salinity values (e.g., < 2 psu) for a series of flow reduction scenarios generated by the EFDC model. As described in the next section, values were also requested for the amounts favorable fish habitat produced by the EFF model. This was handled as a public records request, which I happily paid $402 to have processed.

As my request was being processed, I apprised the peer review panel of the expected timelines for delivery of the files from the District, which changed over time, and posted to the minimum flows Webboard my plan of study. However, possibly due to misunderstanding of what I was asking for, on August 24th I received an external hard drive that contained files I cannot use due to either their format or size. These are very large files, which appear to be the basic output from both the EFDC and EFF models with values for many cells, layers, or segments.

I will continue to pursue getting the type of files I was interested in from the District and want to perform the graphical analyses I was intending, which I initially expected to have completed well before now. These files should not be complex in structure and I have to believe the consultant has such files, as they have generated graphical and statistical results that indicate that smaller files that resulted from post-processing the model output data exist. Frankly, I would think the staff for the consultant could generate the simple types of graphics I am describing in a day or two.

Regardless of who generates these graphics, I think they are critical to evaluating flow blocks and allowable percentage flow reductions that protect the Little Manatee River from significant harm, a topic I will summarize in the final section of this memorandum.

Related analyses of favorable fish habitat from the EFF models for the lower river

The management of freshwater inflows is important because of major ways that inflows affect the physical, chemical, and ecological characteristics of estuaries, including the production of many fish and invertebrate species that comprise economically important sport and commercial fisheries in Florida. Accordingly, the District has sponsored outstanding studies of fish and invertebrate use of tidal rivers and also funded detailed analyses of data for fishes and selected invertebrates in tidal river estuaries in the District collected by the Florida Fish and Wildlife Conservation Commission (FFWCC).

As described in the draft minimum flows report, the data for the Little Manatee River are particularly extensive, with data available for analysis extending from 1996 to 2020 when the draft report was prepared. The consultant has done a very good job developing Environmental Favorability Function (EFF) models for a number of fish species in the Lower Little Manatee River based on the data collected by the FFWCC. What is interesting about the EFF models is that they include a salinity component and a shoreline component, based on the preferences for different shoreline types exhibited by various fish species in the tidal section of the Little Manatee River.

It is important to note the EFF modeling results for reductions in the favorable habitat for a number of fish species gave more conservative (lower) results for allowable percentage flow reductions than did analyses of reductions in salinity zones. So, as described in the draft minimum flows report, the final recommended minimum flows were based on reductions in fish habitat for a number of indicator species.

In that regard, it seems logical that the evaluation of flow blocks to best protect fish populations in the lower river should consider relationships of fish habitat to flows and examine flow ranges in which favorable fish habitats change from being more sensitive to less sensitive to the effects of flow reductions. However, from the minimum flows report, it appears the District only examined changes in salinity zones to determine flow blocks for the lower river, with one graphic shown in the report.

It is my conclusion that analyses of the relationships of favorable fish habitat to flow should be examined to determine flow blocks that will prevent significant harm to fish populations in the Little Manatee River. These analyses would be similar in approach to the graphical analyses I recommended for salinity zones, that for various species, examine the amount of favorable habitat as a function of baseline flows and also the how reductions in favorable habitat varies as a function of flow for various flow reduction scenarios.

Because it includes a shoreline component, relationships of fish habitats to flow may show inflexions and breakpoints that are different than those for relationships of salinity zones to flow. A brief summary of findings from FFWCC studies presented in the minimum flows report indicate that tributaries and backwaters with marshes along the river provide optimal habitat for snook and other species. In that regard, it is important to recognize that these physical features and various shoreline types are not evenly distributed along the river channel.

In that regard, I sent to District staff graphs for physical features, vegetation communities, and shoreline types along the river as a function of river kilometer that are available in files I left at the District. I also showed an graph of shoreline lengths per kilometer to the review panel that shows the effect of the braided zone in the river that is referred to in the minimum flows report. I am disappointed the District has chosen not to include such graphics in the report, the types of which are shown in minimum flows reports for other rivers, but I can live with that.

What is critical, though, is that along with salinity, the effects of shoreline features on the favorable fish habitats that are incorporated in the EFF models be accounted for in the determination of flow blocks for the lower river. Basically, if a minimum flows are ultimately based on favorable fish habitat, those relationships should be used to evaluate appropriate flow blocks for the lower river, as they may show different results than analyses that are based solely on salinity.

Similar to the situation for output from the EFDC model, on July 14, 2023, I requested files derived from the EFF models for the Little Manatee, but when I received those files on August 24th I realized I could not use them due to their size, as they might be the basic model output.

Again, I hope to interact with the District to receive files I can use, but as stated for the EFDC model output, I think the consultants for the District could generate the graphics for the EFF modeling results described in my plan of study in very short order. Regardless, they need to be completed by someone in order to provide information that would be critical for determining minimum flows that protect the Little Manatee River from significant harm.

Summary

As previously described, I believe it is very important that additional graphical analyses are needed to evaluate flow blocks for the Little Manatee River. This would include very informative graphical analyses of the relationships of salinity zones to flow that have been used to determine flow blocks for the other tidal rivers in the District. Also, since the minimum flows were ultimately based on favorable fish habitat, similar analyses should be performed on the response of favorable fish habitats to flow to evaluate flow blocks for the lower river. If the flow blocks are revised, it could affect the allowable percent flow reductions within the blocks, but that should be easy to evaluate.

I realize the District wants to adopt minimum flows for the Little Manatee River in 2023, but the analyses I am recommending should not take long to perform and that schedule can likely still be met if revisions are made to the report. However, getting these minimum flows right is the key consideration, even if it delays the adoption of minimum flows for the Little Manatee River into the very early part of 2014, which I don't think will be necessary.

Accordingly, I suggest peer review process for the minimum flows report for the Little Manatee River be extended so that these important additional analyses can be performed. The Litte Manatee River is truly one of the most ecologically important and valued tidal river estuaries in the District. It is also a river that has benefited from very extensive data collection and analyses over the years and was one of the foundational rivers on which the percent of flow method was initially based. In that regard it is important, as stated in Florida Statues, that the best information available be used to determine minimum flows for this outstanding river to protect it from significant harm.

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Yonas Ghile; Kristina Deak; Gabe I. Herrick; Jordan D. Miller; Xinjian Chen; Chris Zajac; Randy Smith
Subject:	Addtional graphical analyses neeed to determine minimum flows for the Lower Little Manatee River
Date:	Monday, September 18, 2023 9:04:10 AM
Attachments:	Summary of technical basis for addtional graphical analyses.pdf Plan of study for graphical assessment of flow blocks for the Lower Little Manatee River, updated Sept. 18, 2023.pdf Salinity vs. flow at USGS recorder at I-75.pdf

Hello Kym and District staff,

First, congrats to Kym for some well deserved time off. Below are my recommendations for some quick graphical analyses that still need to be completed in order to evaluate and determine minimum flows for the lower section of the Little Manatee River that will protect this ecosystem from significant harm that could result from water supply withdrawals.

Statements by the peer review panel - On page 2-41 in their draft final report dated August 2023, the Little Manatee River minimum flows peer review panel restates a recommendation that "Some additional analyses of the sensitivity of the allowable reductions under differing flow blocks should be provided to assess how the MFL may change depending upon the flow block choices for the Lower River", which was first presented in the panel's initial report dated November 2021. The fifth paragraph on page 2-41 in the most recent peer review report states that this recommendation has not yet been specifically addressed by the District.

These statements by the panel are very similar in intent to my recommendation that additional analyses are needed to further examine the flow blocks for the lower river and the percent flow reductions that would be allowed within them.   As described in the attached technical summary that I sent to the District on September 5th, these additional analyses could employ some very simple graphical techniques that were used to evaluate flow blocks for minimum flows on three other rivers in the District and generated for a fourth. The technical summary also suggests the consultant for the District could generate these graphics pretty quickly.   However, I am continuing my request that the District provide to me the types of files I described in my public records request that dates from July 14th.

In the first paragraph on this same page (2-41), the panel reprints another sentence from their initial report that states "It is not clear at present what changing the flow block extents would do to the EFF analyses which presently drive the MFL." Accordingly, I have maintained that since the proposed minimum flows were ultimately based on reductions in favorable fish habitats predicted by the EFF models, the determination of flow blocks for the lower river should examine the response of favorable fish habitats to flow in addition to the response of salinity zones to flow. The same types of simple graphical techniques I recommend to examine the response of salinity zones to flow could also be used to evaluate relationships of favorable fish habitats to flow for a number of key species.

Proposed plan of study - A summary of the graphics and flow scenarios I suggest be assessed are in the attached plan of study I submitted to the District and posted to minimum flows weboard in July, with some minor updates shown in red. This document is based on graphical analyses I will perform if my public request from July 14th is suitably fulfilled, but these analyses could be also performed by the District or its consultant, again pretty quickly.

As described in my technical summary and information I posted to the minimum flows webboard, it appears the method to calculate the net allowable percent withdrawals within each flow block is not described in the District's draft minimum flows report, which if so, needs to be resolved and clarified in the report. As also described in the technical summary, if the same method was used as in some other minimum flows reports, I suspect that a high flow effect may be causing relatively small percent reductions in salinity zones at high flows to overwhelm and mask higher percent reductions in salinity zones that occur at lower flows.

If so, it is especially important that the graphical techniques I am recommending be conducted for various flow reduction scenarios, as they have proven to be very informative for evaluating allowable percent withdrawal rates within different flow blocks for three other rivers in the District. Along with plots of salinity zones and habitats vs. flow for baseline conditions, these graphics for various percent flow reduction scenarios should be standard practice for minimum flows determinations. As done in previous minimum flows reports, with an example from the Lower Peace River shown in the technical summary, a smoothed line should be fitted to the data with a reference line on the Y axis for either a 15% reduction in salinity zones or fish habitats, or instead the equivalent 85% of baseline values. I tend to like the latter graphical format as it shows the improvement in conditions with increasing flows.

This graphical method can be used for the final determination of the flow blocks and the allowable percent flow reductions within them. The switch to a higher flow block is the rate of flow at which a specific percent flow reduction (e.g., 20%) no longer typically results in more than a 15% reduction in daily values for salinity zones or habitats based on the smoothed line fitted to the data. Similarly, the percent allowable flow reduction within a block is the flow range in which the highest possible percent flow reduction does not typically result in more than a 15%

reduction in daily values of salinity zones or fish habitats. As described in the technical summary with an example for the Lower Peace River, this avoids the high flow effect that can occur with some other methods in which small percent reductions in salinity zones or habitats at high flows can mask larger percent reductions at lower flows. I suspect this high flow effect is occurring in the results presented in the draft District report for the Little Manatee, and it needs to be checked or replaced with another method.

More complete presentation of results - The draft District report only shows one graphic to support the flow blocks of 29 and 96 cfs that are proposed for the lower river. In a revision to the report, the District should expand the information that is presented to support the flow blocks for the lower river and allowable percent flow reductions that are determined within them. The main body of the report should show a series of key graphics in that regard, and other related graphics could be included in an appendix to the report.

Other relevant information - My plan of study also contains suggestions for analyses that could be conducted on relationships of freshwater inflow with chlorophyll *a* concentrations and the distribution and abundance of ichthyoplankton and nekton species in the lower river documented in studies conducted by the University of South Florida and the Florida Fish and Wildlife Conservation Commission. I am not suggesting the District perform these analyses, as the District's determination of the flow blocks and percent withdrawal rates will likely be based on evaluations of changes in salinity zones and favorable fish habitats.

However, such information could provide important supportive information for the flow blocks for the lower river. On September 7, 2022, I submitted to the District a document that presented analyses of how relationships of chlorophyll *a* concentrations to flow could be used to support the determination of flow blocks for the lower river. Also, attached to this email is a graphic and brief discussion of salinity at the previous USGS recorder at I-75 vs. flow. Both these results and the chlorophyll *a* assessment indicate that a high flow block in the range of 150 to 200 cfs could benefit the river. Both documents also point out that such a high flow block based on an analysis of baseline flows should include a buffer, so that flow block is set at a slightly higher flow rate compared to baseline flows to allow for the lower actual flows that would occur after withdrawals, including in the flow block below it.

Need to simulate the final minimum flow scenario - Finally, as described in Chapter 1 in the draft District report, the percent-of-flow method is a "top down" approach that has been viewed as a progressive method for water management in the technical literature and has been applied to manage water supply withdrawals from three rivers in the

District (Alafia, Peace, and Little Manatee). As the percent-of-flow method has been employed over the years, some findings and analytical tools have proved very effective for evaluating flow blocks and the percent allowable flow reductions within them, with the EFF fish habitat analyses on the Little Manatee being an example of that.

In that regard, for future minimum flows reports and possibly the Little Manatee, I suggest the District run simulations of the final minimum flows that are recommended for adoption. In the flow records for the entire period that is used in each type of model, apply all the flow blocks, transitions between the blocks, and the allowable percent flow reductions within them. Using hydrodynamic models, the effects of such minimum flow scenarios on key salinity zones were simulated in the 2008 report for the Lower Alafia River, the 2010 report for the Lower Peace, and a scenario very similar to the final minimum flows in the 2011 report for the Lower Myakka River.

To date, I have only suggested that additional graphics be generated for existing model runs of baseline flows and fixed percent withdrawal rates (e.g. 20% withdrawals) for the Lower Little Manatee River. I think that would be sufficient to further evaluate the flow blocks and allowable percent flow reductions for the lower river. However, it would also be very beneficial to also run a simulation of the complete minimum flow scenario that is recommended in the current draft minimum flows report. Diagnostic plots such as I have suggested for existing model runs could also be run on the complete minimum flow scenario.

If some of the flow blocks and percent flow reductions are changed, which I think may prove to be warranted, the new minimum flow scenario should also be run to compare the results. I realize the District may not think that simulating these complete minimum flows scenarios is feasible for the Lower Little Manatee at this time, but it should be considered if at all possible, and certainly considered for future minimum flow evaluations for estuarine rivers in the District.

Thanks as always,
Sid

From:	Kym Holzwart
To:	Sid Flannery
Cc:	Randy Smith; Kelly Keck
Subject:	RE: Limitations for my use of the files on the external hard drive I received from the District
Date:	Friday, September 29, 2023 12:01:00 PM

Sid,
We have provided all the EFF results that are available (e.g., the SAS files that are on the hard drive). What you describe below was not produced by the consultant and is not available.
Have a great weekend,
Kym

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Wednesday, September 27, 2023 7:26 AM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Cc: Randy Smith <Randy.Smith@swfwmd.state.fl.us>; Kelly Keck <Kelly.Keck@swfwmd.state.fl.us>
Subject: Re: Limitations for my use of the files on the external hard drive I received from the District

[EXTERNAL SENDER] Use caution before opening.
Good morning Kym,

Thanks very much for sending the file of daily values of model results for the salinity zones in the Little Manatee River and the new appendix to the report.

The salinity zone results are just what I needed and fulfills that part of the public records request. I have done a few plots of the data and they look supportive of the District's recommended flow blocks and the percent allowable withdrawals within them.

I am thinking the consultant must have similar files of daily values for favorable fish habitats for the baseline and the same flow reduction scenarios for the key species identified in my July 14th request, though they would be for a longer period of simulation. Can you check on that and send them if they are available? Again, the salinity zone results you sent yesterday were just what I needed and I greatly appreciate it.

Thanks again,
Sid

On Tue, Sep 26, 2023 at 10:47 AM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

> Good Morning Sid,
> Attached is the following additional information in support of your public records request:
>
> 1. A csv file of EFDC model results that contains daily values for the 5-yr period 2000-2004 for baseline flow and bottom area, volume, and shoreline length for the isohalines ≤1 psu, ≤2 psu, ≤5 psu, ≤10 psu, and ≤15 psu for Baseline, 15% flow reduction, 20% flow reduction, 25% flow reduction, and 30% flow reduction scenarios.

2. An appendix (Appendix L) that has been added to the final draft of the Little Manatee Minimum Flows report that includes the plots of information we evaluated as part of developing flow blocks for the lower river.

Best regards,
Kym

Kym Rouse Holzwart, M.S.
Certified Senior Ecologist
Lead Ecologist
Environmental Flows and Levels Section
Natural Systems & Restoration Bureau
Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604
352-269-5946
kym.holzwart@swfwmd.state.fl.us

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Friday, September 8, 2023 8:27 AM
To: Randy Smith <Randy.Smith@swfwmd.state.fl.us>
Cc: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Yonas Ghile <Yonas.Ghile@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>
Subject: Re: Limitations for my use of the files on the external hard drive I received from the District

[EXTERNAL SENDER] Use caution before opening.
Hello Randy and District staff,

On Tuesday I said I would get back on Thursday, but I was busy yesterday so I am replying today.   I hope the District and consultant can continue to consider my request for files that was handled as a public records request. My request was submitted in the spirit of good resource management and I hope it can be suitably fulfilled. I provide a bit of perspective below on the content of the request, much of which was expressed in the previous emails in the stream below.

There are many graphics and statistical results presented in the minimum flows report for the Little Manatee River that indicate the consultant has files useful for those purposes, which I assumed resulted from post-processing output from the EFDC and EFF models. I expected those would be smaller files that would contain the values I need, which are values for salinity zones (e.g., water volume < 2 psu salinity) or favorable fish habitats for the entire lower river for whatever time period the consultant had available such as hours or day.   I know the consultant frequently uses SAS software, so I said in my initial request that either SAS or EXCEL files would be suitable for my purposes.

In the case of the EFDC model, the description of the files in the WORD document that was on the external hard drive I received indicates it contains basic output from the model which has "hourly output for water column conditions at each layer (salinity and temperature) and water column depth at each grid cell, respectively." Again, I was hoping to receive smaller files that had the net values for zones less than various salinity concentrations in the lower river for each time interval. I was not expecting to have to post-process the output to calculate such values. Also, the .OUT files on the hard drive I received appear to need an executable FORTRAN code to be read.

In the case of the EFF modeling, I received SAS data sets, but the SAS program I use will not let me upload files that large, and these are large, over 12 gigabytes each in size. I am thinking those files must also be basic output for the EFF models for each segment or whatever spatial unit was used. If so, I would have to post-process this output to obtain the net values for favorable habitat for each species in the river for each time interval.   I could be wrong, but it appears the files I received were deliverables the consultant was to provide to the District to fulfill part of their contract for the EFDC and EFF modeling.

When I submitted my request via email on July 14th, I said to make sure I was identifying the variables correctly, I might want to briefly communicate with the consultant or could forward any clarification requests through the District project manager. Also, I said to please let me know if any clarification is needed or if any of this should be identified to be pulled out and prioritized first. However, I did not hear anything from the District regarding the technical content of my request prior to receiving the external hard drive on August 24th.

At this time, I think some communications would be in order to fulfill what I think is a very reasonable public records request, that I paid $402 dollars for. Again, I think the consultant likely has files that have the type of information I am looking for. In that regard, I have suggested a very short zoom meeting or three way call with the District and the consultant, whom I worked with extensively in the past, could be in order.   I know that Kym is on very well deserved leave until September 18th, but someone else from staff could facilitate such a meeting. Or, the District could forward this email to the consultant and again consider if the types of files I am requesting can be provided. And again, I am asking the District to please contact me if any clarification is needed.

I think the District should strive to fulfill this request in the spirit of the most effective management of our water and natural resources. As you know, I have provided to the District data files relevant to its work, including data for a point source discharge from the Mosaic company in the Little Manatee River basin that was not addressed in the draft minimum flows report that was published in September 2021. In the case of the Lower Hillsborough River, I have provided to the District data and useful analyses from recorders in the river and Sulphur Springs operated by the USGS and valuable invertebrate data collected in the river by myself and two retired FDEP biologists.

In the spirit of professional interaction, I hope my request for files can be revisited to receive the types of files I requested. Again, please contact me if any clarification on the technical contents of this request is needed.

Thanks as always,
Sid

On Tue, Sep 5, 2023 at 1:28 PM Sid Flannery <sidflannery22@gmail.com> wrote:

> Randy,
>
> I am pretty busy the next two days, but will get back with you on Thursday.
>
> In general, based on graphics and statistics presented in the minimum flows report, it appears the consultant has smaller files that resulted from post-processing of the model output that would contain the values I need. It appears what I received were very large files that are basic model output, and in the case of the EFDC model in a code I cannot read, although I stated in my request EXCEL or SAS files would work.
>
> Possibly something is getting lost in the translation. I think that a short three way conference call with the consultants (Ray and Mike) would be helpful.
> Will get back with you on Thursday.
>
> Thanks,
> Sid
>
> On Tue, Sep 5, 2023 at 1:12 PM Randy Smith <Randy.Smith@swfwmd.state.fl.us> wrote:
>
>> Sid,
>>
>> Hope you made out well with the storm. Kym is on a long-planned vacation till the 18th. The draft final Peer Review report was posted to the web board on Friday. Staff are reviewing the report and we will meet when Kym returns on the 18th. Staff and our consultant have not found any additional information that we have not already provided to you that is responsive to your public records request. Staff will continue to look. Also, we will continue to review any information you provide and your request for additional analysis.
>>
>> Best regards,
>>
>> ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
>>
>> Randy Smith, PMP

Bureau Chief
Natural Systems & Restoration Bureau
Southwest Florida Water Management District
Direct line: (352) 269-5836
Brooksville District Office: (352) 796-7211

Email: randy.smith@watermatters.org
District website: www.watermatters.org

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Tuesday, September 5, 2023 9:56 AM
To: Randy Smith <Randy.Smith@swfwmd.state.fl.us>
Cc: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Yonas Ghile <Yonas.Ghile@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>
Subject: Re: Limitations for my use of the files on the external hard drive I received from the District

[EXTERNAL SENDER] Use caution before opening.
Hello Randy,

Thanks for your reply below regarding my public records request for files from the Little Manatee River.   I will be happy to work with staff to provide any feedback or clarification regarding the files I requested. As my previous communications have said, I expect the consultant has files very similar to what I am requesting, which hopefully they can provide if the District does not already have them.

This afternoon I will send an email to the District and post to the webboard a summary and brief justification of the graphical analyses that I think are needed to check the minimum flows for the Little Manatee River. As I have also stated, I don't think these graphics would take long to generate and they are critical to adopting minimum flows that will protect the Little Manatee River from significant harm.

In that regard, I will be asking the District and the peer review panel to allow a bit more time for review of the minimum flows report before it is finalized.

Thanks again,
Sid

On Fri, Aug 25, 2023 at 5:01 PM Randy Smith <Randy.Smith@swfwmd.state.fl.us> wrote:

> Sid,

We will review this more detailed public records request and see if we have produced this specific information in any other format than what we have already provided. We will get back with you early next week. Hope you have a great weekend.

Best regards,

~~~~~~

Randy Smith, PMP
Bureau Chief
Natural Systems & Restoration Bureau
Southwest Florida Water Management District
Direct line: (352) 269-5836
Brooksville District Office: (352) 796-7211

Email: randy.smith@watermatters.org
District website: www.watermatters.org

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Friday, August 25, 2023 3:02 PM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Cc: Randy Smith <Randy.Smith@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Yonas Ghile <Yonas.Ghile@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>
Subject: Limitations for my use of the files on the external hard drive I received from the District

[EXTERNAL SENDER] Use caution before opening.
Hello Kym and staff,

Thanks to Kym and records management staff for fulfilling my public records request for files for the Lower Little Manatee River. However, it looks like I will not be able to use or analyze these files for the reasons I describe below. First, though, I will describe the intent of my request and then the situation with the present files.

The email that I sent to the District on July 14th with my initial request for files is reprinted below this current email. The intent of that email was to get some simple output values from the EFDC and EFF model runs for the Lower Little Manatee River. As I have described in previous correspondence and presentations to the peer review panel, there are some very straightforward graphical analyses that can be performed that are very informative for evaluating flow blocks for the estuarine sections of rivers. In fact, one of these techniques was
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directly used to establish flow blocks in minimum flows reports for the Lower Peace, Pithlachascotee and Lower Myakka Rivers, and though not presented in the report, provided very useful information for the Lower Alafia.

As described in my email from July 14th below, what I was hoping to receive for the EFF model runs were files containing predicted values of volume, area, and shoreline length less than different salinity values (e.g., < 2 psu) for a series of flow reduction scenarios. Similarly, for the EFF model, these would be predicted output values of favorable fish habitat for selected species for a series of flow reduction scenarios. I specified the flow scenarios and salinity zones and fish taxa I was interested in. I could use whatever time interval these values were in (hours, days). Also, I could pull these values out of larger data sets if these variables are clearly identified, which I assumed they would be.

In addition to very large files of raw model values, I figured the consultant must have created some smaller reduced files for statistical and graphical analysis, as the minimum flows report has bar graphs of percent reductions in various salinity zones and fish habitats. Similarly, on page 123, there is a graph of the volume of water less that 2 psu salinity vs. flow and the report says that a number of other graphs were examined. Seeing that, I thought the District must have ready access to the exact type of information I am looking for, and suggested that I could deal with either EXCEL files or SAS data sets.

For the EFDC model output, it looks like what I received is something very different than what I requested. Attached is a pdf that shows the folders and contents of the external hard drive I picked up yesterday (Aug 24th). Also attached is a WORD document prepared by the consultant that describes the files related to the EFDC model. As that WORD document describes, the contents and format of the baseline model run file are similar to the files for the flow reduction scenario runs. It also specifies that these files contain "hourly output for water column conditions at each vertical level at each grid cell (salinity and temperature) and water column depth at each grid cell, respectively." Given that, it is no wonder the files are so huge. The hard drive also includes the FORTRAN text and executable code to read the output (OUT) files.

So, with regard to my public records request, am I supposed to execute these codes and then calculate how much volume etc. was less than a specified salinity value? Obviously, that is not possible. It looks like these EFDC files are one of the deliverables that the consultant is to provide for the contract with the District. Again, I was thinking there are some existing smaller data sets in which the volumes, etc. were already calculated and used for the statistical and graphical results that are presented in the minimum flows report.

The situation is different for the EFF model results. As shown in the pdf of contents of the hard drive, these are SAS data sets, which I normally can deal with. However, they are very large, over 12 gigabytes each, and the SAS program I use will not let me import files that large. Also, the large size of these files makes me wonder if they are the extensive raw model output by river length or whatever, in which I would have to calculate the percent habitat reduction for each taxon and flow scenario. The fellow that generated these files is a sharp guy and possibly he could generate the statistical and graphical results from these large files, but I have to wonder if there are smaller data sets that were developed from these large model output files.

So - (1) how did we get here, and (2) what to do now. #1 - Five days after placing my request on July 14th, I was informed it was a formal public records request and it would take about two weeks to produce the files, which I agreed to. Given that response, on July 24th I posted my plan of study for analysis of the files to the minimum flow weboard and said the expected date for file delivery is August 2nd.

On August 9th, I emailed the District to inquire how it was going. That same day, the District replied and said the files could be ready sometime next week and I would be given a cost for the retrieval. On August 16th, the District emailed and said the total cost of the records retrieval would be $402, which I happily paid, and I was informed the files should be ready by August 24th. Given that information, on August 22nd I made a post to the webboard about the new expected delivery date for the files and that I would work on it as promptly as possible to generate graphics and interpretive text which should take about a week or two to complete.

So, what to do now? I want to again emphasize that the types of analyses I am proposing are very straightforward, but also very informative and have been used in other minimum flows studies. As the percent of flow method has evolved for over 30 years, certain tools have proven to be very useful and the analyses I am proposing are at the top of the list.

At this time, I suggest the District and consultant look and see if there already exists any of the smaller output files similar to what I described on July 14th. If there are not, it should not take the consultant long to generate such files.

I appreciate that the District is trying to wrap up the Little Manatee report, but what I am suggesting should not take much time. Given that the high flow threshold of 96 cfs allows for the start of a shift in the percent allowable withdrawal from 13 to 32 percent, additional analyses are needed to ensure that the best available information was examined to support the flow blocks for the lower river or modify them if necessary.

Given what I discovered about the files I received yesterday, I need to again make a post to the minimum flows webboard informing the review panel that I will not be able to analyze these files. However, I will propose a couple of options by which these analyses can be performed. I will also strongly recommend that the review process continue until such analyses can be completed.

I would like to make such a post soon, possibly in the afternoon on Monday, August 28th or the next day. If you have any thoughts or comments in that regard, please let me know.

Have a fine weekend,
Sid

---------------email from July 14th below on which several District staff were cc'ed--

Hello Kym,

As we have previously discussed, I would like to receive some selected output from the EFDC salinity and EFF fish habitat model runs for a few flow scenarios. I first made this request over a year ago, but in email communication with the District agreed to wait until the revised models were finished.

I think the District's consultant should be able to pull these files from previous model runs together pretty quickly. If results for these specific scenarios could be separated out that would be great, but I could work with larger data sets if the variables and scenarios I have identified are within them. To make sure I am identifying the variables correctly, I might want to briefly communicate with the consultant or could forward any clarification requests through you.

Requests for EFDC and EFF output are described below. In both cases, daily values would be desirable, but I can work with shorter time intervals if that is what is available. If the low flow cutoff of 29 cfs was applied in scenarios other than baseline that is preferable, but if the cutoff was not applied that is okay too. Either EXCEL or SAS files would be fine, with SAS preferable if that is what the data are in now.

The results I am requesting for the EFDC model are baseline flows and predicted area, volume and shoreline length for the <1, <2, <5 < 10 and < 15 ppt salinity values for the baseline, 15, 20, 25, and 30 percent withdrawal scenarios. I would like values for the entire period of record that was used for the minimum flows determination using the EFDC model.

For the EFF favorable habitat models I would like to receive baseline flows and favorable habitat values for the eastern mosquitofish, clown goby, striped mojarra, naked goby, hogchoker, common snook, red drum, and small gobies less than 20 mm. I would like to receive output for the baseline, 15, 20, 25, 30 and 35 percent withdrawal scenarios. I would like values for the entire period of record that was used for the minimum flows determination using the EFF model.

I would like to get my assessment of the results as soon as possible, so if the District could facilitate this I would appreciate it very much.

Please let me know if any clarification is needed or if any of this should be identified to be pulled out and prioritized first.

Thanks as always,
Sid

Plots of daily values for reductions in salinity zone volumes for different percent flow reduction rates vs. the corresponding rates of baseline flows predicted by the EFDC hydrodynamic model of the Lower Little Manatee River

Prepared by Sid Flannery, October 2, 2023

Three sets of graphics are presented on the following pages that show reductions in salinity zone volumes vs. corresponding rates of baseline flows for different percent flow reductions that were predicted by the EFDC hydrodynamic model for the Lower Little Manatee River. Graphics are shown for the volumes of water less than 2 psu salinity, as it was the zone most sensitive to flow reductions and was emphasized in the District's minimum flows report for the Little Manatee.

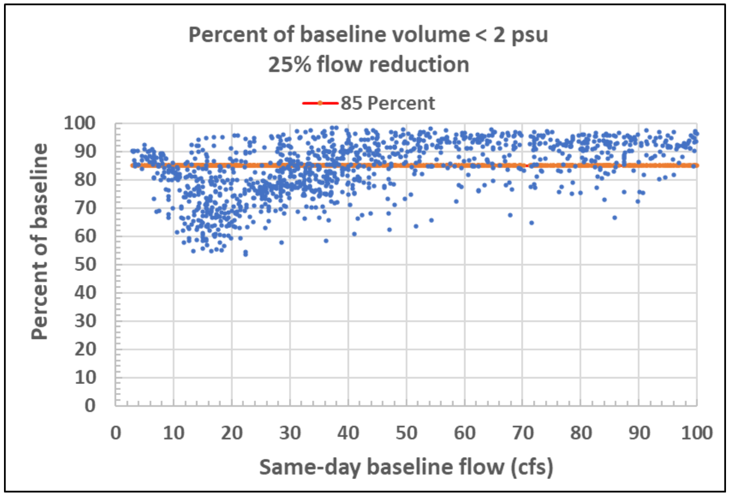
These graphics are presented to illustrate how such plots can be used to evaluate allowable percent flow reductions and flow blocks for estuarine rivers. Some interpretive comments are associated with each set of graphics, but none of the graphics presented herein are intended to represent recommended percent withdrawal rates or flow blocks for the Lower Little Manatee River.

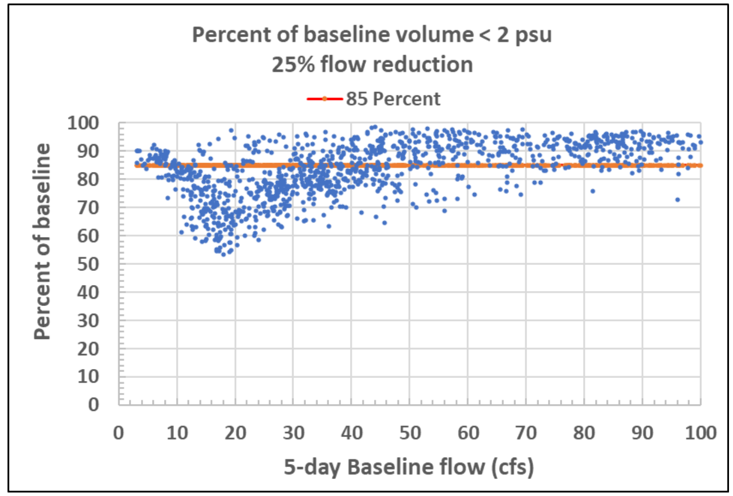
These types of graphics were used to evaluate flow blocks in other District minimum flows reports, including the lower sections of the Peace, Myakka and Pithlachascotee Rivers and were also generated for the Lower Alafia. Examples from Lower Alafia and Lower Peace Rivers are presented on the last two pages of this document as examples of the utility of this type of graphical approach.

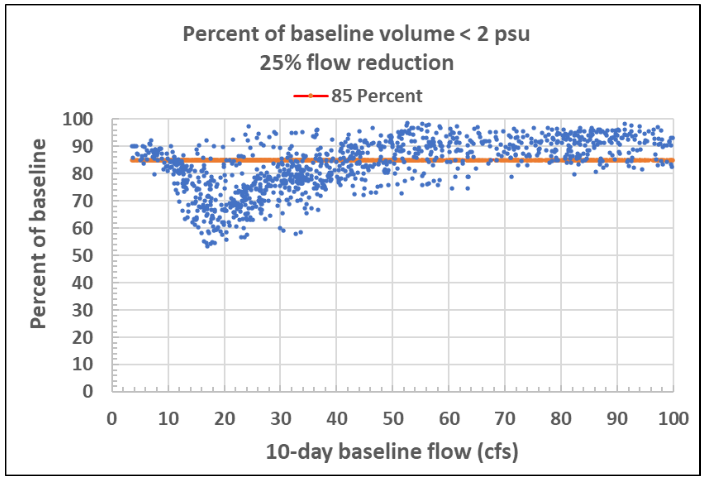
As discussed in separate correspondence, I have some questions on why the EFDC model for the Little Manatee predicts some seemingly unusual values for percent reductions in salinity zones at very low flow rates. As with any model simulations, these are predicted values which inherently will include some degree of error and therefore should be accompanied by analyses of measured data to determine minimum flows for the lower river. Having said that, such graphics of model predicted values for reductions in salinity zones or habitats for different flow reduction scenarios are very useful tools that should be routinely used in the application of the percent-of-flow method to determine percent allowable withdrawal rates and flow blocks for estuarine rivers.

Such graphical analyses have not yet been presented by the District for the Lower Little Manatee River and I recommend they be pursued, which should not take much time. A recommendation is also presented on the following pages for running a simulation of the complete set of recommended minimum flows for the lower river in order to get the most accurate assessment of its effects.

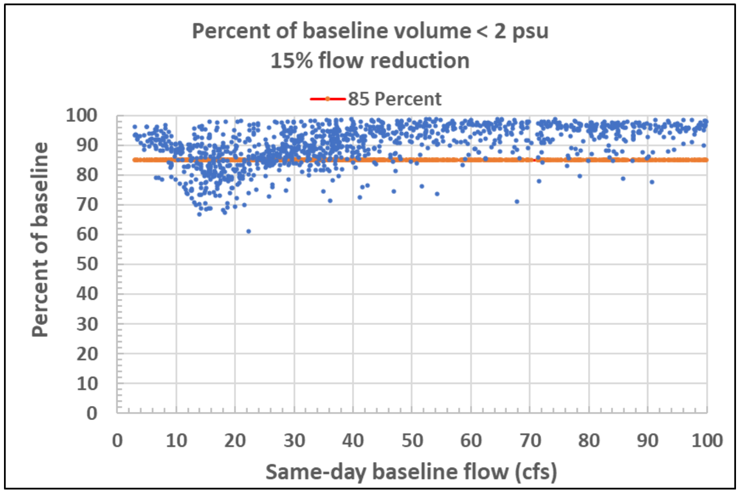
It is also important to recognize that the recommended minimum flows for the Lower Little Manatee River presented in the draft District report were ultimately based on simulations of favorable fish habitats predicted by Environmental Favorability Function (EFF) models for key species in the lower river, as they gave more conservative (protective) results than the simulation of salinity zones using the EFDC model. I therefore recommend that similar graphics of percent reductions of favorable fish habitats vs. baseline flows for different percent flow reduction scenarios be prepared for key species and evaluated to determine allowable flow reductions and flow blocks for the Lower Little Manatee River. Similar to the graphics from EFDC output, I think the consultant to the District could generate these graphics pretty quickly. Also, the effects of the complete minimum flows scenario on favorable fish habitats should be simulated using the EFF models for key species.

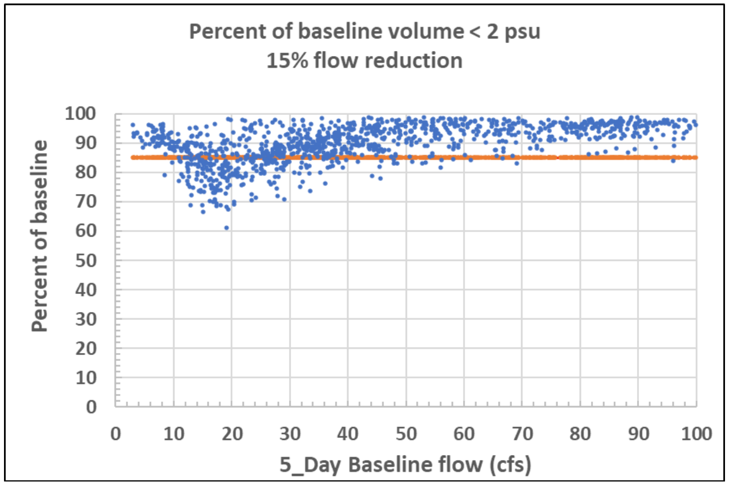


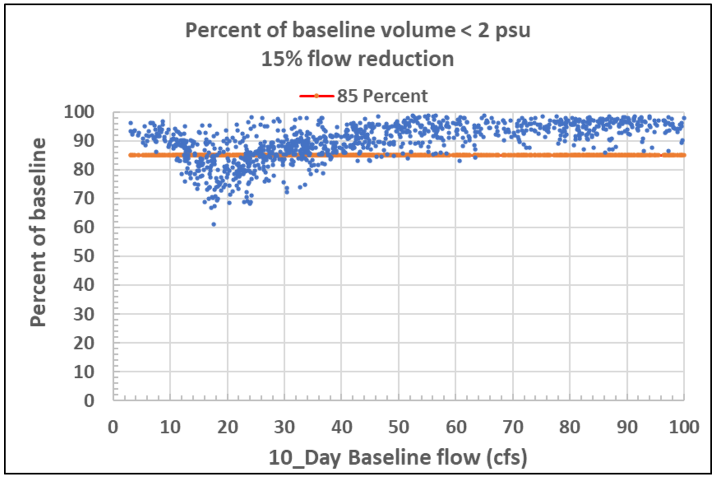




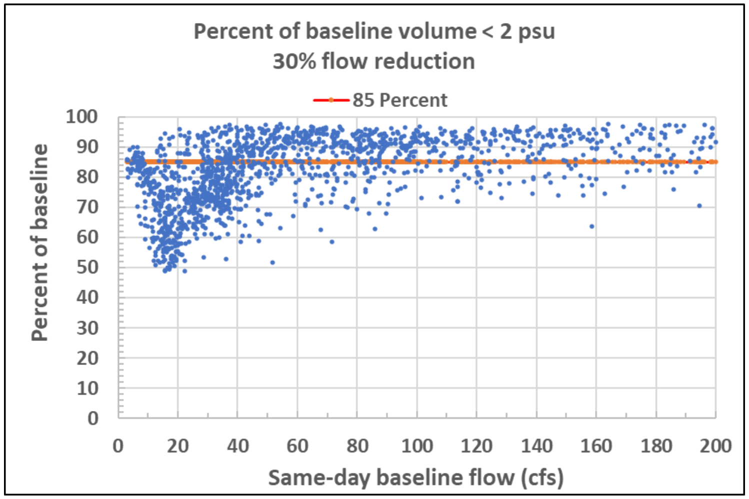
The graphics above show percent reductions (as percent of baseline remaining) for the volume of water < 2 psu salinity in the Little Manatee River vs. average baseline flows calculated for different preceding time periods, which reduces scatter as salinity responds to preceding flow conditions. A reference line is shown at 85 percent which corresponds to a 15 percent reduction in baseline conditions. Smoothed or trend lines can also be fitted to the data using LOWESS or some other function. These graphics are shown only as examples, as the current recommended minimum flows do not involve a 25 percent withdrawal rate from the river. If they did, the recommended 29 cfs low flow cutoff would not be appropriate and a higher flow value should be selected. These types of graphics are very useful for determining flow blocks for estuarine rivers. However, the low percent reductions in salinity zones at very low flows (< 10 cfs) shown above are unusual in tidal rivers, which may be due to the lowest daily flows the EFDC model was calibrated to (30 cfs) and verified against (26 cfs).

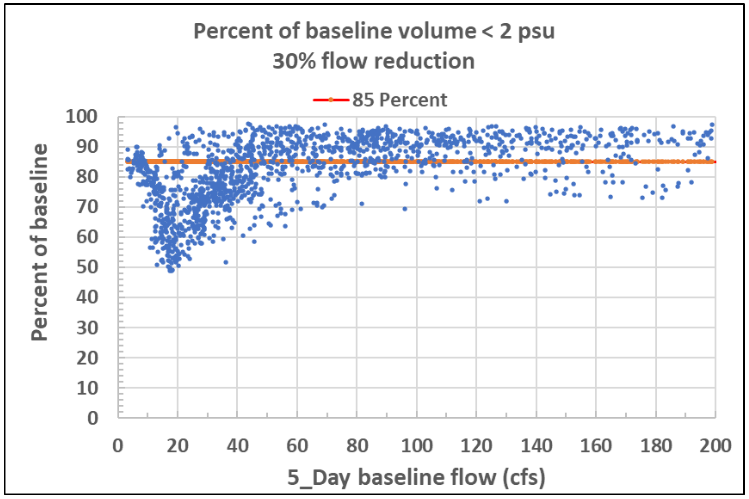


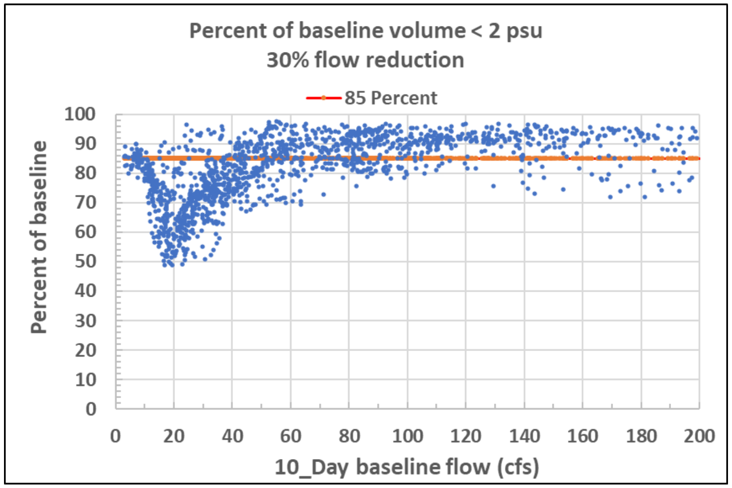




These graphics for a 15% flow reduction are more supportive of the 29 cfs low flow cutoff included in the recommended minimum flow rule for the Lower Little Manatee River. A percent flow reduction of 13% in block 2 (medium flows) that is included in the recommended minimum flows would result in slightly less reductions in salinity zones. However, a 13% withdrawal rate was not simulated, but was instead based on interpolation of net percent reductions in salinity zones between the 10% and 15% flow reduction scenarios in block 2. Accordingly, I recommend that the complete recommended minimum flows for the lower river be simulated using the EFDC model and diagnostic graphics be generated. On many days it would produce more conservative results as the flow reductions would change between flow blocks, for example no withdrawals below the low flow cutoff which would affect the salinity of the river during rising flows going into block 2. As indicated by examples for the Lower Alafia and Lower Peace Rivers on pages 5 and 6, the complete minimum flows scenario for the Lower Little Manatee would be very informative and should be simulated.

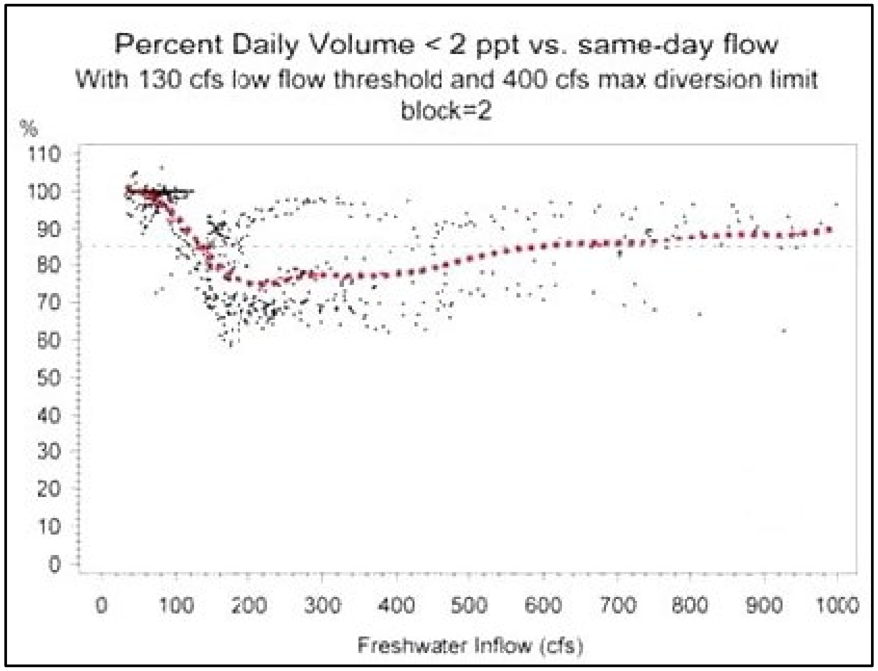


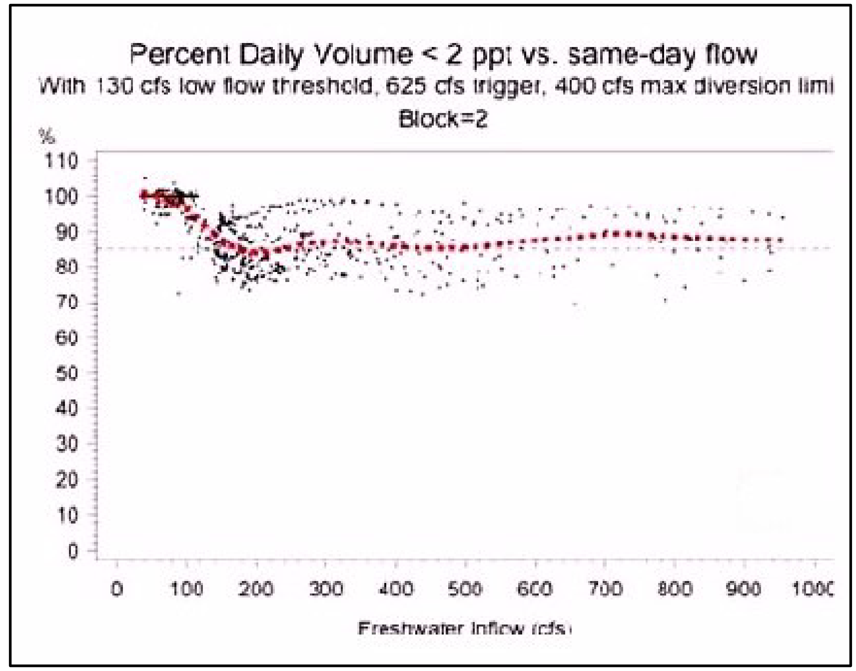




These graphics of percent reductions of the volume water less than 2 psu for a 30% withdrawal rate are supportive of the recommended flow block of 96 cfs, which allows for a transition from a 13% to a 32% withdrawal rate with a full 32% being available at a flow of 123 cfs. As discussed on the previous page, a simulation of the complete recommended minimum flow rule for the lower river should show more protective results as the percent withdrawal rates would change between flow blocks.

However, as will be reiterated again, similar graphics need to be generated for reductions in favorable fish habitats using the EFF models for key species in the lower river, as they produced more conservative (lower) results for percent allowable flow reductions, which the minimum flows were ultimately based on.

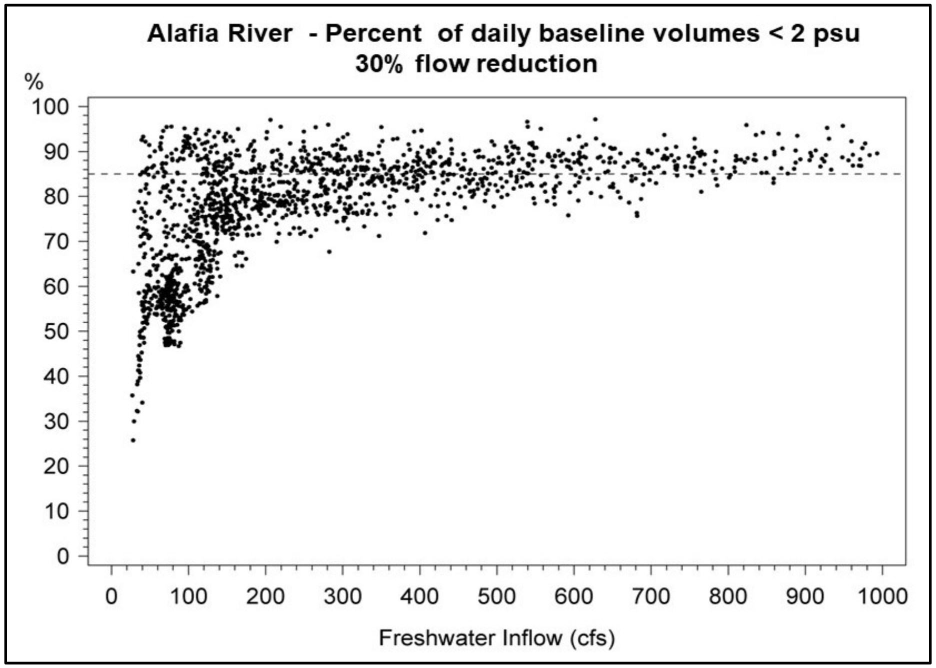


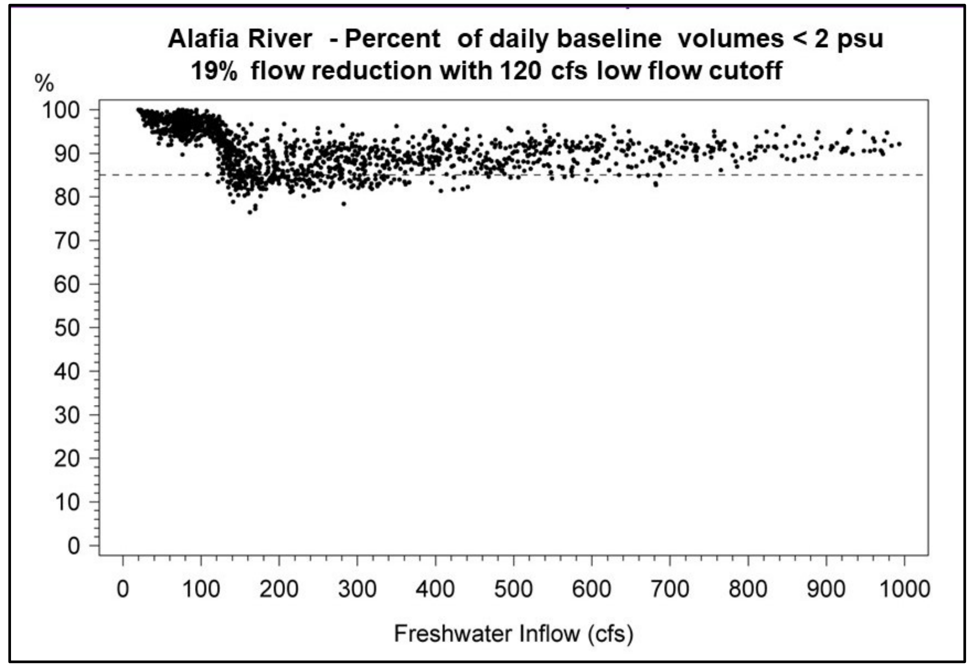


The two graphics above were taken from the minimum flows report for the Lower Peace River published in 2010, which also simulated changes in salinity zones using a hydrodynamic model for that river. However, the approach for that minimum flow analysis involved seasonal blocks (which fortunately have been discontinued) that included a block 2 that ran from October 27 to April 19. The graphs above were generated for all days in seasonal block 2 for the simulation period, which included a 130 low flow cutoff and a 400 cfs withdrawal limit that were included in the report and adopted in the rule at that time. The graph on the left shows the percent reductions in the volume of water < 2 psu salinity during block 2 if a high flow threshold is not applied. It is clear that the recommended percent flow rate for seasonal block 2 (29%) results in greater than a 15 percent reduction in that salinity zone at flows between 130 about 600 cfs.

The graph on the right show results for implementation of the final recommended minimum flow that was adopted at that time, which stipulated that a flow of rate of 625 cfs had to be reached before the full allowable withdrawal rates for blocks 2 and 3 could be achieved, with the withdrawal rate (16%) for the dry season block 1 (April 19 to June 20) remaining in effect between flows of 130 and 625 cfs regardless of the time or year.

These graphics further reflect the utility of this type of analyses for evaluating suitable flow blocks and the value of simulating the complete set of recommended minimum flows for a tidal river, as among other things, it shows the effect of a low flow cutoff on minimizing impacts to salinity zones during critical low flow periods.





The graphics above were developed for the Lower Alafia River but not presented in that minimum flows report. That analysis similarly predicted changes in salinity zones using a hydrodynamic model for that river, with the recommended minimum flows incorporating a single percent withdrawal rate of 19% combined with low flow cutoff of 120 cfs.

The graphic on the left for a 30% flow reduction shows the pronounced nonlinear response of the reduction in salinity zones as function of flow, even when the withdrawals are limited to a fixed percentage of flow. The graphic on the right for the adopted 19% flow reduction shows how effective the low flow cutoff of 120 cfs is for preventing large reductions in salinity zones at low flows and keeping reductions in salinity zones predominantly less than 15 percent at higher flows. These graphics show the value of value of simulating the complete set of minimum flows for a tidal river, which still needs to be done for the Little Manatee.

Also, as described on page 1, these types of graphics need to be generated for predicted reductions in favorable fish habitats using the EFF models for key species in the lower river, as that is what the minimum flows were based on and those graphics could result in different conclusions than derived from the predicted reductions in salinity zones. As I have described in other correspondence, such graphics could be generated by the consultant pretty quickly.

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Yonas Ghile; Kristina Deak; Jordan D. Miller; Xinjian Chen; Gabe I. Herrick; Chris Zajac; Randy Smith
Subject:	Little Manatee minimum flows graphs and thoughts for upcoming EAC meeting
Date:	Tuesday, October 3, 2023 7:25:02 AM
Attachments:	Little Manatee River - Plots of EFDC modeling results.pdf

Hello Kym and staff,

Attached is a document that includes some graphs I generated concerning minimum flows for the Little Manatee River. The latter part of this email also offers a subject related to minimum flows for the Little Manatee that could be covered at the upcoming meeting of the District's Environmental Advisory Committee, of which I am a member.

The graphs in the attached file show percent reductions in water volumes less than 2 psu salinity for three flow reduction scenarios predicted by the EFDC hydrodynamic model for the lower river. The files the graphs were generated from were requested on July 14th and provided on September 26th, thus their submittal now. As the document describes, these are shown as examples of the utility of this type of graphical analysis. As the document also describes, these types of graphics were used to determine flow blocks in District minimum flows reports for three other tidal rivers and also generated for a fourth. I consider them to be some of the most informative and essential tools that can be applied using the percent-of-flow method.

Although these are examples, they generally support the 29 and 96 cfs flow blocks in the currently recommended minimum flows for the Lower Little Manatee River. However, I don't think it is a huge problem, but the model seems to predict some unusual values for reductions in salinity zones at very low flows (< 10 cfs), which are fairly rare in the actual gauged record. I will send a brief email in that regard to the District on Thursday morning, as I am soon leaving town for a couple of days.

More importantly, I suggest these types of graphical analyses need to be conducted for favorable fish habitat values for key species predicted by the EFF models for the lower river. This is critical, as the minimum flows were ultimately based on reductions in fish habitats, as it provided more conservative results (lower withdrawal percentages) than the modeled changes in salinity zones. Also, minimum flows should be oriented to directly protecting fish and wildlife where such analytical tools are available, and not just salinity zones per se. My recommendation is in keeping with comments of the peer review panel, which were summarized in my email to staff on September 18th.

I had hoped to do these analyses myself based on the public records request I submitted on July 14th, two days after the last minimum flows peer review meeting. However, as I have communicated to the District, I cannot use the SAS files for the EFF output that were made available on August 23rd, as they are very large and will not upload using the SAS website I use. However, I have to believe the consultant must have generated daily (or hourly) values for the predicted habitat values I requested somewhere in their programs, which allowed them to generate the statistical results for the model output that are presented in the minimum flows report. If these values are not readily at hand, I expect the consultant could quickly generate them. I honestly believe the consultant could produce the graphics I suggested in my plan of study (which I sent to the District) within one day's time.

In that regard, I suggest it would be useful to present such graphics for favorable fish habitats for key species at the EAC meeting next Tuesday (Oct 10th), at least for the 15 and 35 percent withdrawal schedules. If those graphics look supportive of the recommended minimum flows, the District is in the clear. If they don't, similar graphics should be generated for other flow reduction percentages and reviewed as they would be critical to determining technically sound minimum flows that protect the Lower Little Manatee River from significant harm.

The analyses I have suggested involve flow reduction scenarios that have already been simulated with the EFDC and EFF models. However, the attached document describes the value and shows examples of graphics based on applying the entire minimum flow scenario for a river, as was done for the Lower Peace, Lower Alafia, and nearly so for the Lower Myakka River. As also described, this would provide the most accurate measure of the effects of the recommended minimum flows for the Little Manatee, as the percentage withdrawal rates would change with the flow blocks. Given the considerable time and costs that were incurred to revise both the EFDC and EFF models, I suggest it would be worthwhile to perform model runs for the recommended minimum flows scenario and any revised minimum flows if that is warranted.

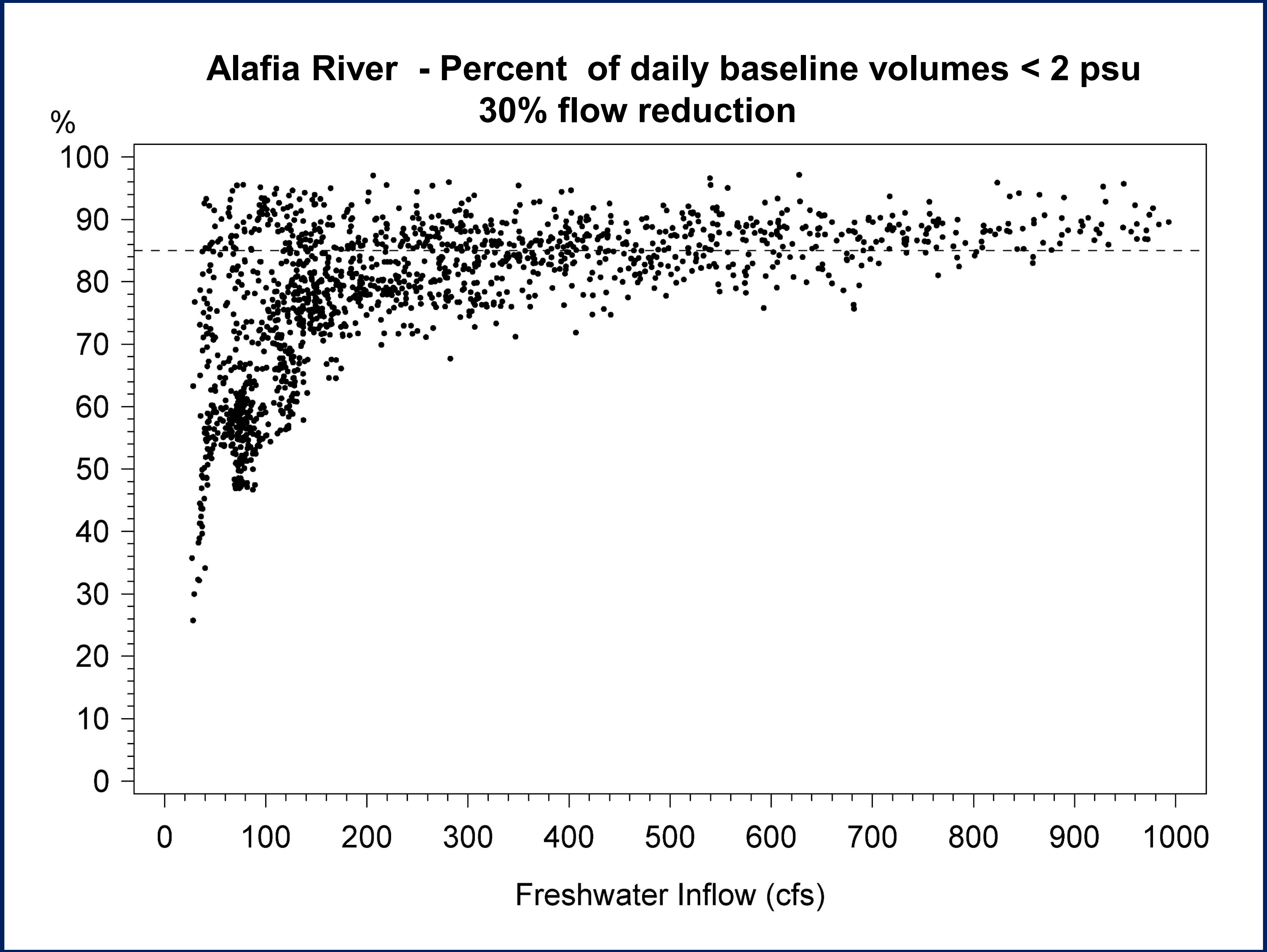
Regarding the upcoming EAC meeting, I suggest the District describe the statistical method that was used to determine the net percent reductions in salinity zones and fish habitats for each flow block that were reported in tables and figures in Chapter 6 of the minimum flows report. I have conjectured that the normalized area under the curve method was used by the consultant, but the District can check on that.

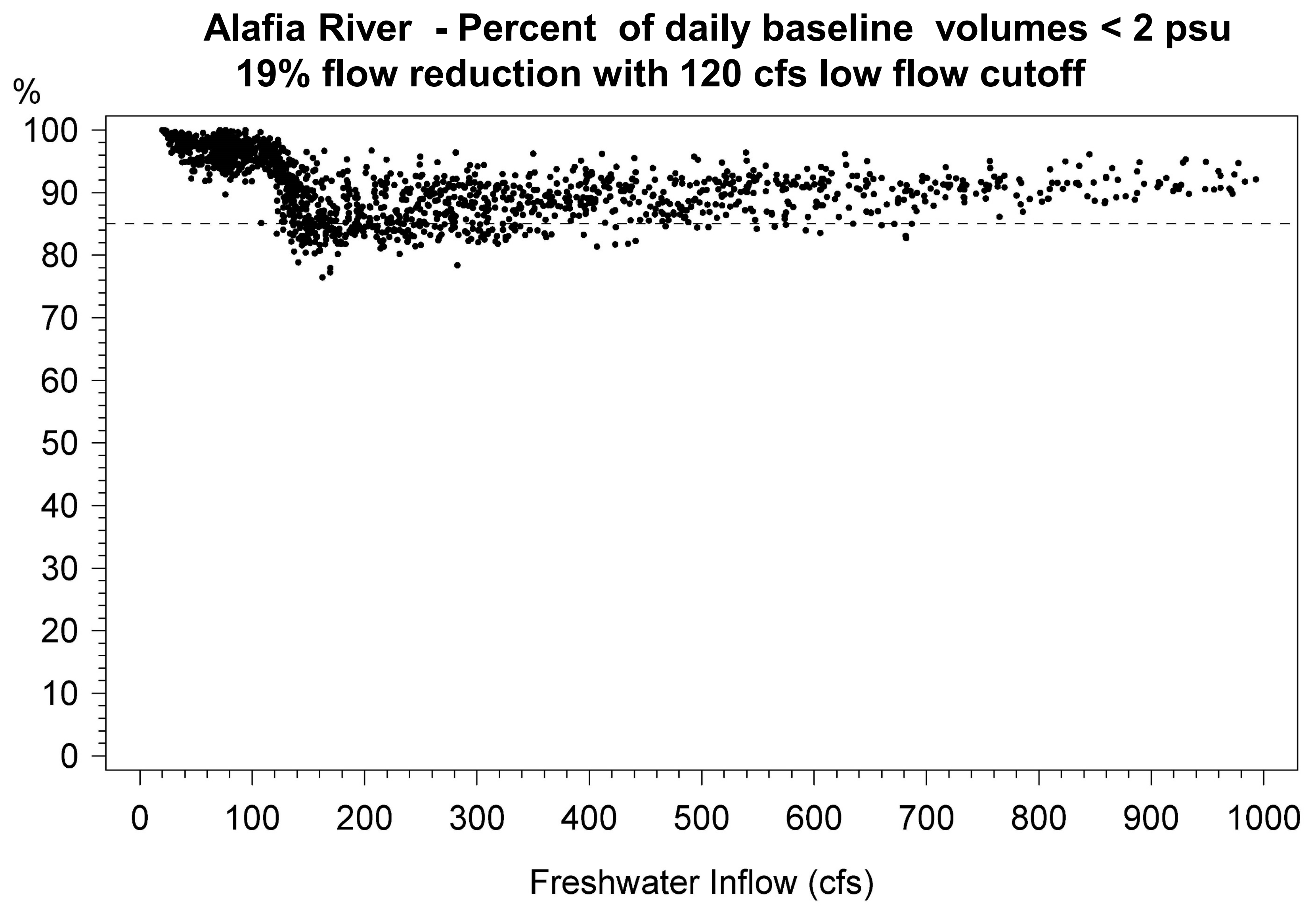
In general, I hope the District leaves ample time to discuss the status of the minimum flows report for the Little Manatee at the next EAC meeting. It is the last item on the agenda. The District has said I could show some slides after Kym's presentation. I previously estimated it might be 4 or 6 slides but it might be a bit more. Given the importance of the Little

Manatee River, whatever discussions that occur will be warranted and valuable.

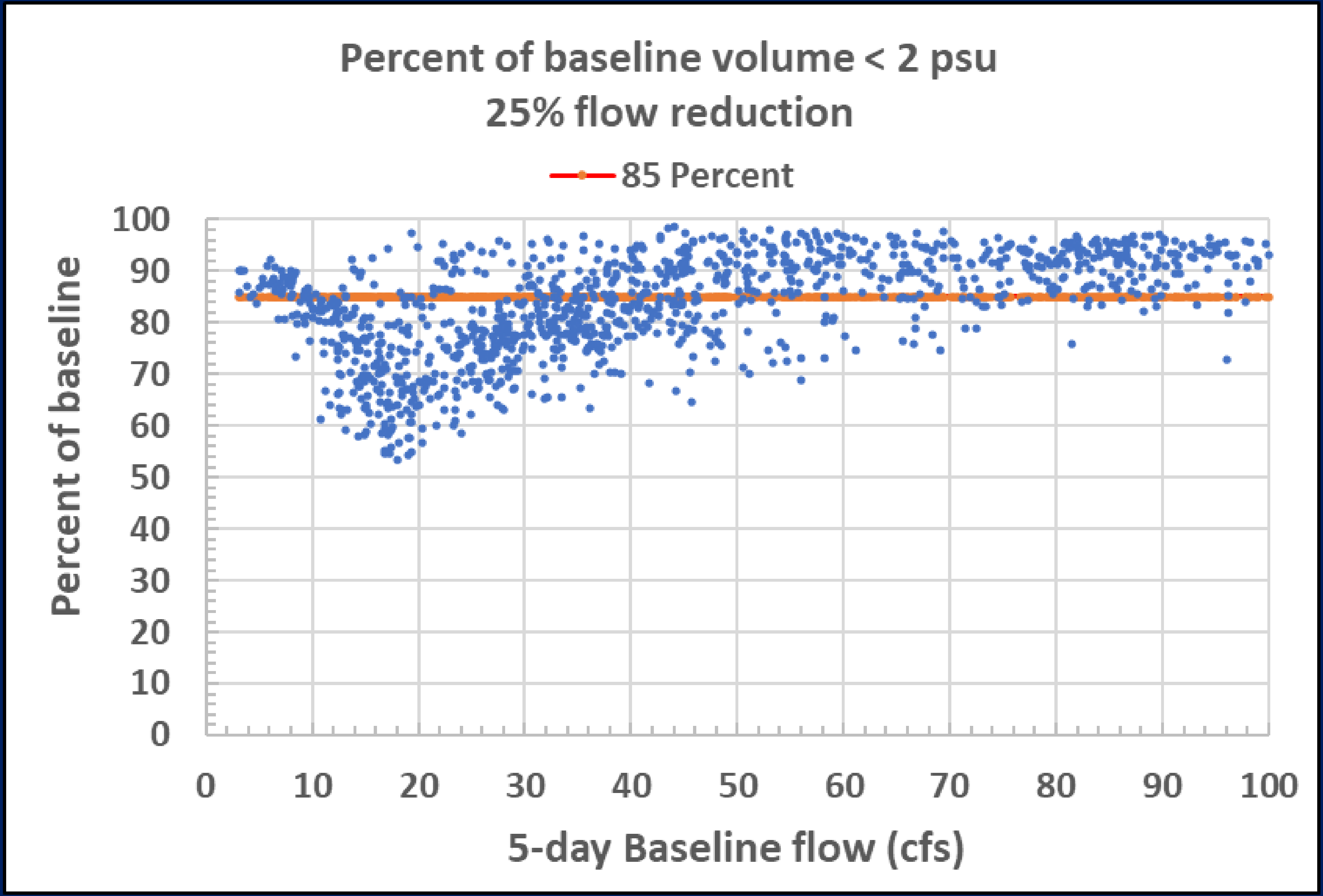
Thanks as always,

Sid

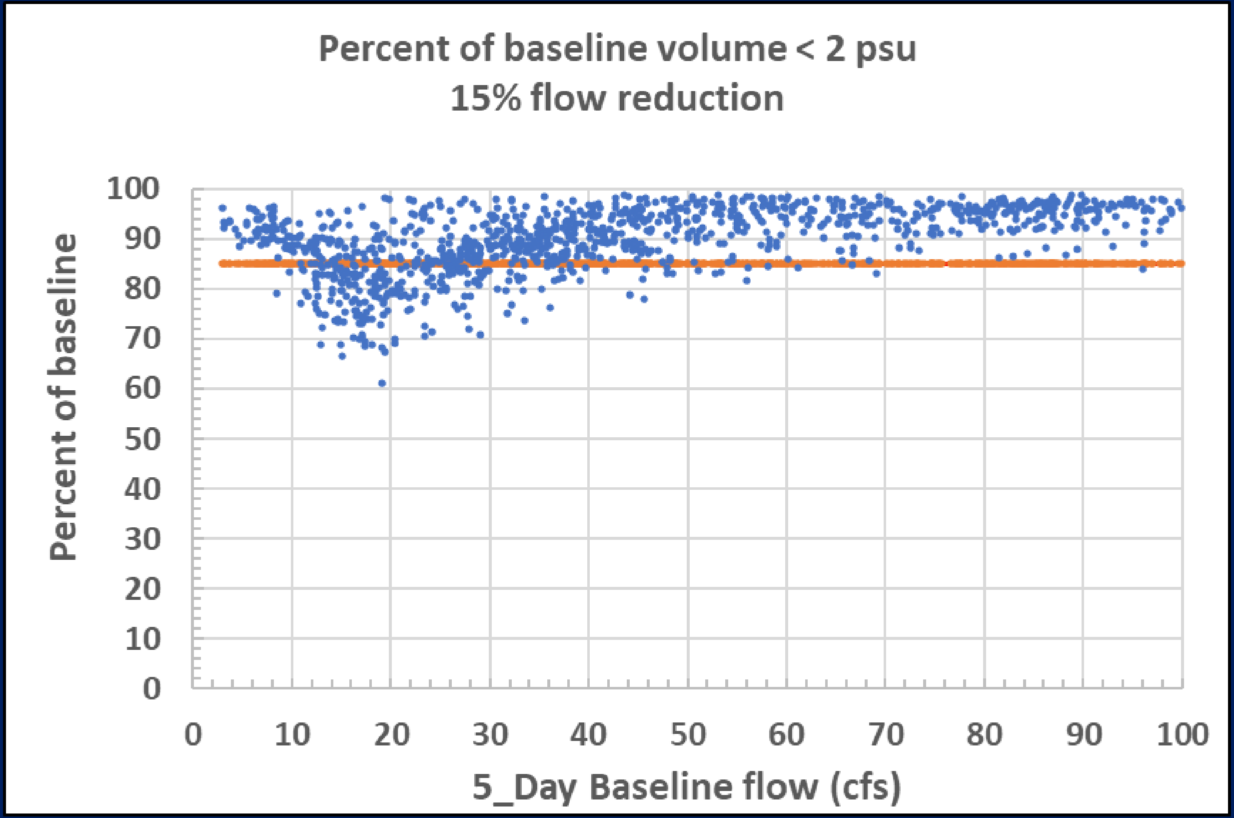

Alafia River - Percent of daily baseline volumes < 2 psu
30% flow reduction
%
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
1000
Freshwater Inflow (cfs)

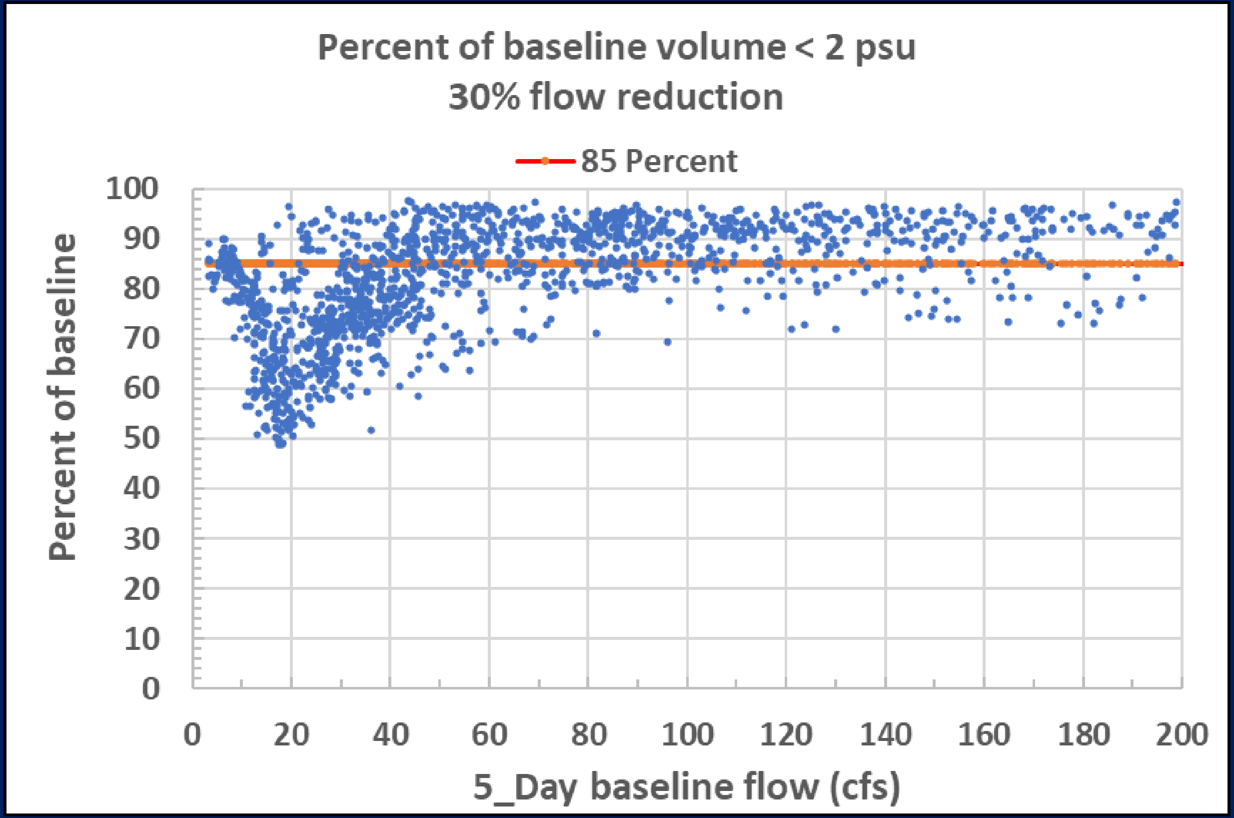

Alafia River - Percent of daily baseline volumes < 2 psu
19% flow reduction with 120 cfs low flow cutoff
%
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
1000
Freshwater Inflow (cfs)

Little Manatee River – Graphs of percent of baseline volume of water < 2 psu salinity remaining for different percent flow reductions



Graphs of volume of water < 2 psu salinity for 15% and 30% flow reductions





Peer review comment in section about flow blocks for the lower river

- “It is not clear at present what changing the flow block extents would do to the EFF analyses which presently drive the MFL.”

My recommendation - Similar graphics need to be prepared to examine the response of modeled favorable fish habitats to flow as a check of the suitability of the flow blocks for the lower river

1. The minimum flows were ultimately determined by the EFF modeling as it gave more conservative results. Therefore, fish habitat relationships with flow should also be used to examine flow blocks for the lower river

2. The EFF models included components for salinity, shoreline type, and season. Shorelines are not evenly distributed along the river channel and certain fish species have a strong seasonal component to their use of the lower river. Thus, relationships of fish habitats with flow might differ than simple salinity zones.

3. The ultimate goal of freshwater inflow management is to protect fish and wildlife, which respond to flow related factors other than just salinity. Analytical tools should be used when they are available.

4. This could be used in a weight of evidence approach to evaluate suitable flow blocks for the lower river

Recommendation (this all can be done quickly)

Relationships of favorable fish habitats with flow using existing runs of the EFF models should be graphed to examine the suitability of flow blocks for the lower river in a weight of evidence approach

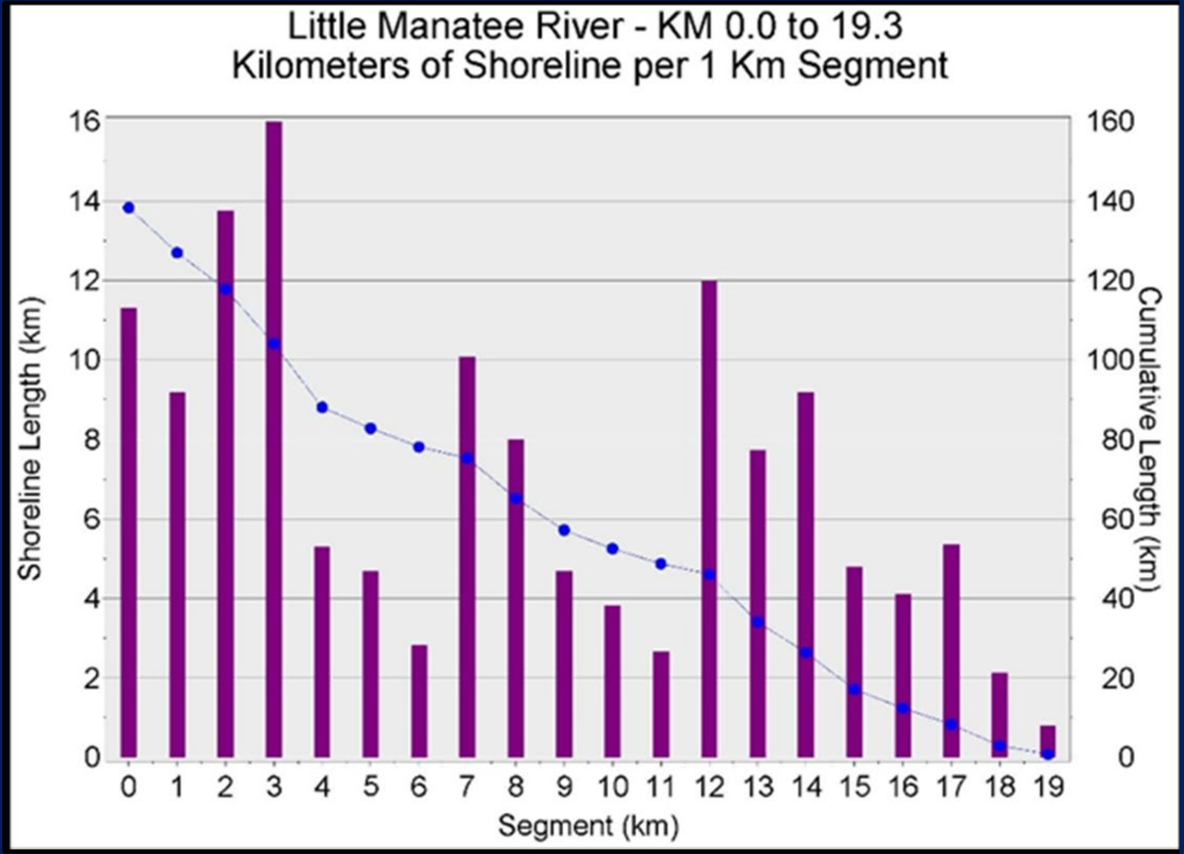
X

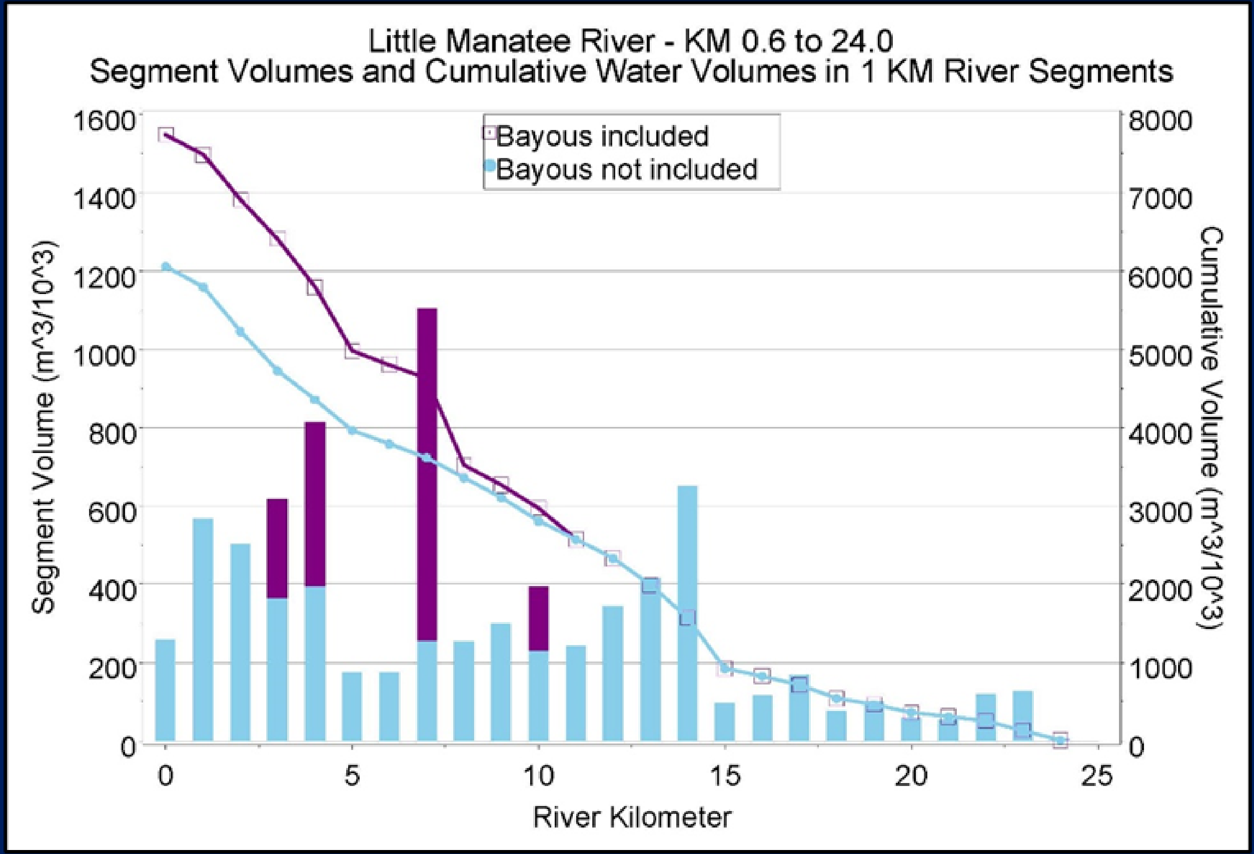
Also important

Two existing graphics of the physical characteristics of the lower river need to be added to support the ecological findings and the recommended minimum flows

Three previous important ecological studies of the river need to be cited an briefly described as they are relevant to the minimum flows with an interest expressed by the review panel

Two graphics are needed in the report to describe important physical and habitat characteristics of the Little Manatee River that are related to its biological organization and relationships with freshwater inflow.





Initial Peer River Report (2021), Little Manatee River minimum flows, page 2-26

"it would be useful to summarize to 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 of selection of the 15% EFF habitat reduction. Note that establishing the precise flow blocks for the estuary also needs additional analysis."

USF Zooplankton Report for the District

(not mentioned in the minimum flows report)

Rast. J. P., M. E. Flock, T. T. Sutton and T. Hopkins . 1992. The zooplankton of the Little Manatee River Estuary: Species composition, distributions, and relationships with salinity and freshwater discharge.   Report of the University of South Florida for the Southwest Florida Water Management District.

Panel comment - "Would occurrences of chlorophyll a >11 ug/L as an annual geometric mean be expected to increase at minimum flows implementation withdrawals in the Little Manatee River estuarine nutrient region."

District funded USF studies of phytoplankton composition, production and relationships to freshwater inflow in the Little Manatee River that are not currently mentioned in the minimum flows report

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

Mean chlorophyll *a* concentrations at four salinity locations in three rivers				
	18 or 20 psu	**12 psu**	**6 psu**	**0.5 psu**
Little Manatee	4	9	14	**21**
Peace	8	**32**	22	9
Alafia	44	**96**	63	15

From:	Sid Flannery
To:	Kym Holzwart; Randy Smith
Cc:	Chris Zajac; Doug Leeper; Barbara Matrone; Michael Molligan; Yonas Ghile; Xinjian Chen; Kristina Deak; Jordan D. Miller; Gabe I. Herrick; Virginia Singer
Subject:	Slides for today"s EAC meeting
Date:	Tuesday, October 10, 2023 6:45:22 AM
Attachments:	Slides for EAC meeting from Sid Flannery.pdf Slides for EAC meeting from Sid Flannery.pptx

Hello Kym and Randy,

In previous communications, the District said it would be okay for me to show some slides at today's EAC meeting regarding minimum flows for the Little Manatee River.   Attached are the slides I would like to show as both a powerpoint presentation and a pdf file.

There are nine slides involved, but I think they should go pretty quickly. I don't know how my screen share will go, so I may need the District to call the file up and advance the slides or pages depending on the file that is used.

Thanks and look forward to seeing you virtually today at 10 a.m.

Sid

Overview of selected technical reports about the Little Manatee River and suggested text, figures, or tables for the District's minimum flows report

Prepared by Sid Flannery, October 19, 2021

This document provides an overview of technical reports about the Lower Little Manatee River that were prepared for the District by staff from the State University System, the Florida Marine Research Institute, or Mote Marine Laboratory. I have also prepared paragraphs or single pages of text that include a figure or table that can be inserted into the minimum flows report to present findings from these reports that describe important relationships of the lower river to freshwater inflows.

These findings support the technical basis for the recommended minimum flows and provide valuable information on the physical, chemical and biological characteristics of the Little Manatee River. As described in the 2002 paper in the journal *Estuaries*, the Little Manatee was one of the three rivers on which the development of the percent-of-flow approach for minimum flows was initially based (Flannery et al. 2002). Furthermore, the tidal reach of the Little Manatee River is a State of Florida Aquatic Preserve and one of the most valued natural resources in the Tampa Bay region. As such, it would be beneficial for the report to briefly describe its biological characteristics, especially as they relate to freshwater inflows that will be affected by the proposed minimum flow rules.

1.1 Overview of Phytoplankton Reports

Dr. Gabriel Vargo of the USF College of Marine Science published two reports for the District about phytoplankton related parameters in the Little Manatee River based on just over two years of sampling from December 1987 to January 2000 (Vargo, 1989, 1991). In a separate report, he compared these data to phytoplankton related data collected from the Lower Peace and Alafia Rivers that used a similar salinity based sampling design (Vargo et al. 2004). None of these three reports are currently cited in the draft minimum flows report, but it does cite a paper that Dr. Vargo submitted to the proceedings of the BASIS 2 conference (Vargo et al. 1991).

Combined, these three reports are very informative about the relationships of different salinity zones to phytoplankton related parameters in tidal rivers, particularly the unusual characteristic of the Little Manatee in which the highest phytoplankton counts and chlorophyll *a* concentrations typically occur at the interface of fresh and brackish waters (0.5 psu), compared to other rivers where the highest phytoplankton counts and chlorophyll *a* concentrations typically occur in mesohaline waters.

In a week or so, I will present data that indicate that relationships of chlorophyll *a* to the rate of freshwater inflow and residence time in the lower river could be important to determining flow thresholds to switch between low, medium, and high minimum flow blocks for the estuarine section of the Little Manatee.

References for the three phytoplankton reports are below, including brief overviews of that work. This is followed text on page 4 that I suggest be inserted into the minimum flows report regarding the phytoplankton work on the Little Manatee River.

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

> Nutrients, chlorophyll *a*, and primary production were monitored on a bi-weekly basis for one year at four moving salinity based stations in the Little Manatee River and two fixed location stations; one near the mouth of the river in Tampa Bay and one in Ruskin Inlet, an urbanized inlet to the middle reaches of the Little Manatee River estuary. Among the salinity based stations, mean chlorophyll *a* and primary production rates were greatest at the 0.5 psu station and lowest at the 18 psu station. The Little Manatee has very low N:P rations due to high inorganic phosphorus concentrations in the river water.

Vargo, G.A. 1991. Phytoplankton studies in the Little Manatee River and Tampa Bay: Species Composition, Size Fractionated Chlorophyll, Primary Production, and Nitrogen Enrichment Studies. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> During the second year of a two-year study of phytoplankton populations in the Little Manatee River and adjacent waters of Tampa Bay, nutrients, size fractionated values for chlorophyll *a* and primary production rates were monitored monthly at a moving 12 psu salinity station in the river and a fixed location station in Tampa Bay. Phytoplankton populations were found to be nutrient sufficient or borderline nitrogen limited with respect to short-term photosynthesis, but long-term growth and biomass were clearly nitrogen limited based on bioassays of natural populations.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> Phytoplankton populations, nutrients and chlorophyll *a* concentrations were compared from similar, salinity based sampling designs in the Lower Alafia, Peace, and Little Manatee Rivers. Samples were collected on at least a monthly basis at the locations 0.5, 6, 12, and 18 psu surface salinity values in each river, with exception of the location of 20 psu being sampled in the Peace River. Mean phytoplankton counts were highest at the 12 psu station in the Alafia, the 6 psu station in the Peace, and the 0.5 psu station in the Little Manatee (see figure on next page). Phytoplankton counts were frequently an order of magnitude higher in the Alafia compared to the other rivers, presumably due to high nutrient loading from that watershed. In the figure on the next page, note separate axis for the Alafia River, which is an order of magnitude greater.

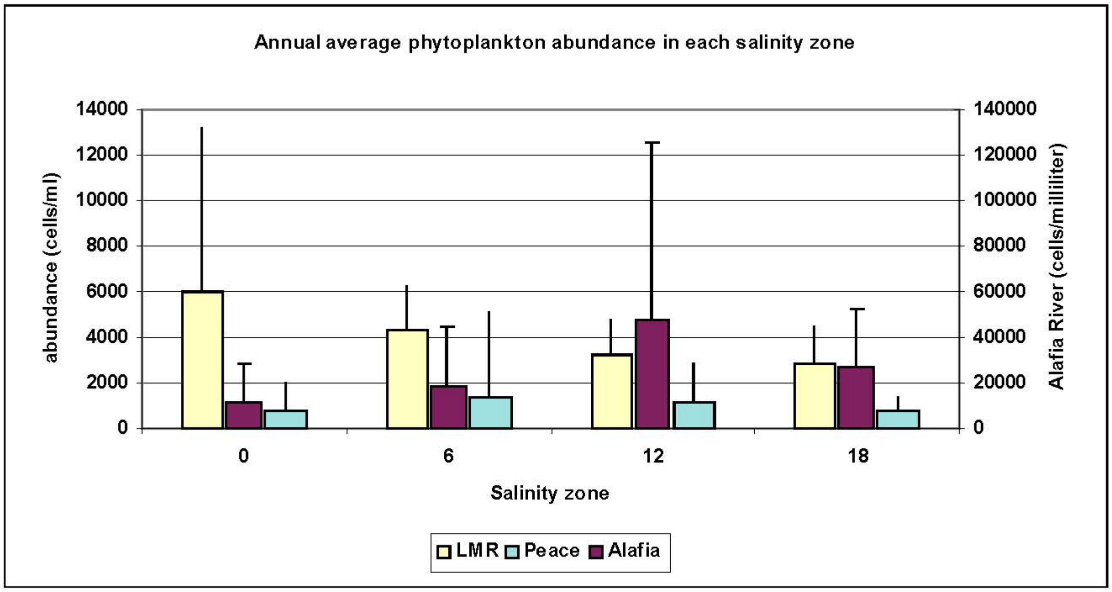


Figure X. Annual average phytoplankton abundance in the Little Manatee, Peace, and Alafia Rivers by salinity zone (20 psu for the Peace grouped with 18 psu). The Alafia is shown on a separate axis since the counts are an order of magnitude greater than the other rivers. From Vargo et al. (2004)

Mean values for chlorophyll *a* concentrations during the phytoplankton sampling periods for these rivers are listed on the following page. The much higher chlorophyll concentrations in the Alafia River are apparent, especially in mesohaline waters. Similar to the phytoplankton count data, the pattern for high chlorophyll *a* in the very low salinity zone (0.5 psu) in the Little Manatee River is again apparent, as are the high concentrations in the mesohaline zones for the Peace and Alafia. Although cell counts are higher in the mesohaline zone in the Little Manatee than in the Peace, chlorophyll *a* concentrations were higher in the Peace due to differences in the species composition of the phytoplankton between the rivers.

Comment - I think that differences in residence time for the Little Manatee contribute to it having its highest phytoplankton abundance and chlorophyll *a* concentrations at the 0.5 psu zone. The upper reaches of the Little Manatee are braided, and given the smaller rates of freshwater inflow, water moves more slowly through the tidal freshwater and oligohaline zones of the Little Manatee compared to the other rivers. All of these rivers (Peace, Alafia and Little Manatee) have residence time values that were generated from hydrodynamic model simulations.

Suggested page for phytoplankton. I think the Little Manatee minimum flows report could contain one page that ties the findings from these reports together. As an example, I have prepared three paragraphs and a table on the following page.

1.2 Phytoplankton (suggested text)

Based on just over two years of sampling spanning 1988 and 1989, the University of South Florida College of Marine Science produced two reports describing phytoplankton related parameters in the tidal reaches of the Little Manatee River and a nearby station in Tampa Bay (Vargo 1989, 1991). Data for nutrients, light penetration, chlorophyll *a*, phytoplankton species composition and primary production rates were measured at four moving salinity-based stations in the river and a fixed location station near the mouth of the river in Tampa Bay (Vargo 1989). Nutrient concentrations in the Little Manatee were characterized by very low nitrogen/phosphorus ratios (generally less than 2) due to high phosphorus concentrations in the inflowing river water. The second of these reports concluded that increased nitrogen loading could result in increased algal biomass and eutrophication in the tidal river (Vargo 1991).

In a subsequent report, (Vargo et al. 2004) compared data from the Little Manatee to phytoplankton related data collected in the Lower Peace and Alafia Rivers that were collected using a similar moving salinity-based design. The highest phytoplankton counts and chlorophyll *a* concentrations typically occurred at the interface of fresh and brackish waters (0.5 psu salinity) in the Little Manatee, whereas the highest cell counts and chlorophyll *a* concentrations typically occurred in mesohaline waters (6 and 12 psu salinity) in the Peace and Alafia (Table x). Using a separate data set for the Alafia, Vargo et al. (1991) compared chlorophyll *a* concentrations and primary production rates for the Little Manatee, the Alafia, and a nearby station in Tampa Bay.

Table X. 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

The high chlorophyll *a* concentrations at the freshwater/brackish water interface in the Little Manatee may be related to comparatively long residence times there, which were simulated as part of the development of the hydrodynamic EFDC model for the river (Huang and Liu 2007, Huang et al. 2010, 2011). These comparatively long residence times are related to the braided morphology of the river between kilometers 12 and 16, where the water slows compared to the upstream freshwater reach. These findings and data presented in this report indicate chlorophyll *a* concentrations in the upper reaches of the tidal river could be sensitive to the effects of freshwater flow reductions.

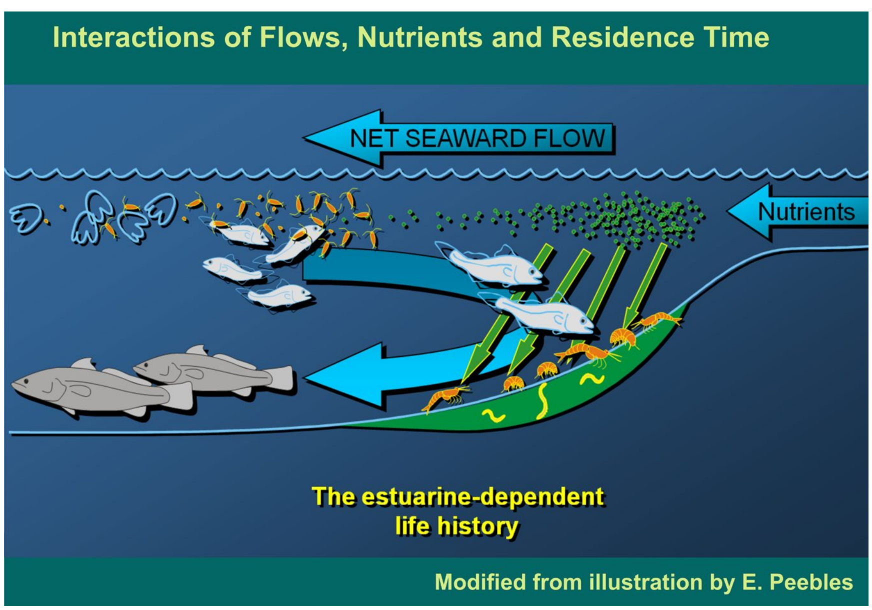
2.1 Overview – Zooplankton Report

Zooplankton were sampled in the estuarine section of the Little Manatee River during 1988 and 1989 concurrently at the same stations as the ichthyoplankton work performed by Dr. Ernst Peebles. Five stations were sampled ranging from the mouth of the river to kilometer 14.2, with another station located at a nearby site in Tampa Bay. The second of these two reports is the more comprehensive of the two and should be briefly described in the District report.

Rast, J.R. and T. L. Hopkins. 1989. The Zooplankton of the Little Manatee River Estuary, Florida. First yearly report. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Rast, J.P., M.E. Flock, T. T. Sutton and T. L. Hopkins. 1991. The Zooplankton of the Little Manatee River Estuary: Species Composition, Distribution, and Relationships with Salinity and Freshwater Discharge. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

In contrast to fish and benthic macroinvertebrate studies, which have been conducted in many rivers, this is the only true zooplankton study in the region's tidal rivers and it is very informative. The second report describes the abundance and distribution of zooplankton, which for many species are more abundant in the lower reaches of the tidal river. Following the tidal river engine concept developed by Peebles (illustration below), this is where the larval stages of many fishes are concentrated early in their life history when they feed on zooplankton. As they grow to juveniles, these fishes migrate to lower salinity waters and feed more on benthic oriented prey. See the illustration below, all evidence I've seen indicates this conceptual model is generally true.



The abundance of zooplankton in higher salinity waters in the lower river probably also results in increased grazing of phytoplankton and contributes to the tendency for chlorophyll *a* concentrations to be lower and more stable near the mouth of the river. Conversely, ungrazed phytoplankton blooms in lower salinity waters probably results in more deposition (see illustration).

The District minimum flows report could briefly summarize the zooplankton study. Along with one table, this would fit on one page and not substantially affect the pagination of the report. Suggested text for a brief discussion of the zooplankton is provided on the following page

Go to next page

2.2 Zooplankton (Suggested text)

Zooplankton in the Lower Little Manatee River were studied during 1988 and 1989 by the University of South Florida College of Marine Science (Rast et al. 1991). These data were collected concurrently with the ichthyoplankton work in the lower river (Peebles and Flannery, 1992), at the same five locations that ranged from kilometers 0 to 14.2, plus a nearby station in Tampa Bay. This project provides valuable information for the abundance and distribution of major zooplankton groups in the lower river, including; holoplankton (entire life cycle in the water column), meroplankton (in the water column for only a portion of their life cycle), tychoplankton (swept off of the river bottom) and hypoplankton (swim off the bottom for a limited amount of time).

Average values for the abundance and estimated biomass of these zooplankton groups are listed in Table X. Holoplankton and meroplankton had their highest values and biomass near the mouth of the river and Tampa Bay, whereas combined tycho-hypoplankton had highest values in the middle and upper parts of the lower river (year 1 only as two stations were discontinued in year 2).

Table X. Average density (numbers/m3) and biomass (in parentheses as mg dry weight/m3) for total holoplankton, meroplankton and tycho-hypoplankton for 25 trips from 1/29/88 – 1/31/89

	Bay or River Kilometer					
	Tampa Bay	**0.0**	**3.8**	**7.1**	**10.3**	**14.3**
Holoplankton	309,000 (147.7)	235,000 (87.6)	177,000 (44.5)	150,000 (34.4)	84,300 (15.1)	29,700 (5.7)
Meroplankton	40,900 (23.8)	12,000 (6.5)	4,350 (3.9)	3,540 (1.7)	4,220 (3.6)	1,490 (1.0)
Tycho-hypoplankton	1,520 (3.7)	1,290 (3.5)	1,390 (22.6)	5,820 (11.3)	4,590 (12.7)	1,530 (3.1)

Zooplankton are very important prey for the early life stages of many fishes, and their abundance in the river is important to the nursery function provided for many estuarine dependent fish species. Based on 48 total samples, the report by Rast et al. (1991) provided informative plots of zooplankton density versus salinity and the rate of freshwater inflow for eleven dominant species or taxonomic groups (e.g., *Acartia tonsa*, *Oithona colcarva,* copepod nauplii, polychaete larvae).

The numbers and biomass of the major zooplankton groups were were also plotted vs. salinity and freshwater inflow at the five stations in the river and Tampa Bay. The response of the different species or groups to inflow and salinity differed, with the abundance of several taxa or groups associated with the lower part of the river increasing upstream with decreased freshwater inflow. On the other hand, benthic harpacticoid copepods maintained relatively high abundance in the upper river stations except for very high flow events. In general, this project provides very useful information on how zooplankton species and communities respond to changes in salinity and freshwater inflow, which can affect fish nursery use of the lower river and is related to the establishment of minimum flows.

3.1 Overview – Mollusk Report

Dr. Ernest Estevez of Mote Marine Laboratory performed a field intensive survey of the distribution of mollusks in subtidal and intertidal habitats in the Little Manatee River during August 2006. The draft minimum flows report has one sentence on page 78 that cites Estevez (2006) and states this work was performed, but mentions no findings from the study.

The minimum flows report should provide one table and a brief description of the findings of the Mote study for three reasons. First, the mollusk communities show clear gradients with regard to salinity in the river, which supports the District's use of salinity as a parameter for determining the minimum flows. Secondly, the report describes the distribution of oyster bars in the river, which are important for shoreline stability, improving water quality, and creating habitat for reef associated fauna in the tidal river. Lastly, as previously discussed, the Lower Little Manatee River is an aquatic preserve and the District report should describe the biological communities of the lower river, especially as they relate to freshwater inflows and the determination of minimum flows.

Based on mollusk studies conducted within the District, noted invertebrate biologist Dr. Paul Montagna of Texas A&M University was the senior author of the journal article below that assessed the relationship of salinity to the distribution of mollusk species in tidal creeks and rivers in the region. This study can also be cited along with a discussion of the Mote Marine Study.

> Montagna, P. A., E. D. Estevez, T. A. Palmer and M. S. Flannery. 2008. Meta-analysis of the relationship between salinity and molluscs in tidal river estuaries of southwest Florida, U.S.A. *American Malacological Bulletin* 24:101-115.

Two short paragraphs about the Mote study and Montagna et al. findings are provided on the following page, including one figure. I suggest that this text or something similar, including the figure, be included in minimum flows report to enhance the biological information presented for the river and provide additional support of the recommended minimum flows

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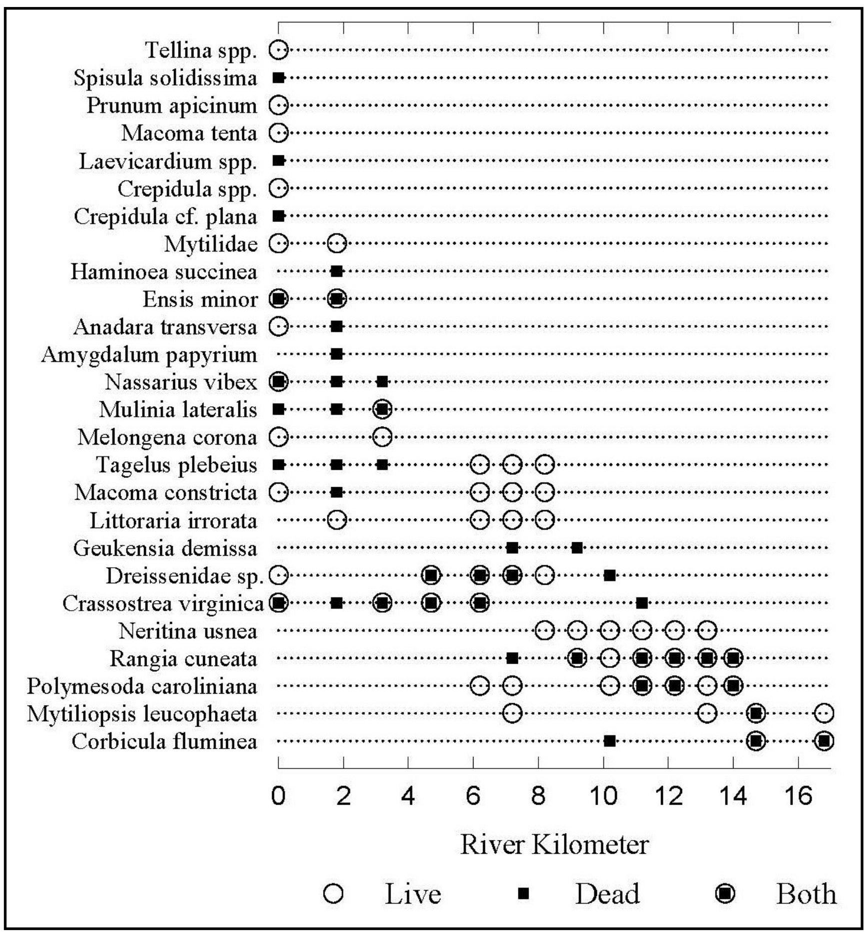
3.2 Mollusks (Suggested Text)

In August of 2006, Dr. Ernest Estevez of Mote Marine Laboratory performed a survey of the distribution of mollusk species in subtidal and intertidal habitats in the Lower Little Manatee River that identified both live mollusks and dead mollusk material (Estevez 2006). Sampling transects were established at 15 locations in the river ranging between river kilometers 0.4 and 16.8 In addition to their presence within the sampling transects, the distribution of oysters in the river was visually described, with large oyster reefs most conspicuous between kilometers 3 and 5 and in the back bays. Smaller oyster reefs with mostly dead material were near the river mouth, with small reefs widely distributed upstream to near kilometer 11, where only dead material was found.

A total of 26 mollusk species or taxa were found (Table x), which is similar to the species richness found using similar methods in other tidal rivers in the District. Mollusk species showed district distributional patterns in relation to salinity gradients in the lower river. In a study of mollusk communities from eleven tidal tributary systems within the District, Montagna et al. (2008) found that salinity was the primary factor affecting the distribution and species composition of mollusk communities.

Table X. Distribution of mollusk species vs. kilometer in the Little Manatee River, including subtidal and intertidal samples with live mollusks and dead mollusk material, from Estevez (2006).



4.1 Overview – Vegetation in the lower river floodplain.

Section 4.1.2 in the draft minimum flows report describes vegetation communities along the tidal reach of the Lower Little Manatee River. The first sentence in the section says that estuarine conditions extend 15 miles (24 kilometers) upstream from the river mouth, but that is incorrect. Based on extensive field work, Peebles and Flannery (1992) report that brackish waters (>1 psu) typically do not extend farther than 16 to 18 kilometers upstream. Also, as described on page 17 in the minimum flows report, minor tidal fluctuations in water levels can sometimes occur about 1 kilometer upstream of the US 301 bridge, but brackish water does not extend nearly that far.

The description of vegetation communities in the river on pages 69 and 70 in the draft report is pretty good and it references the previous minimum flows report from 2011 (Hood et al. Appendix A). Such a description may be in Hood et al., but I ran out of time and could not find such a discussion in that report which focuses on the freshwater section of the river. However, other reports that can be cited that describe vegetation along the lower river (Peebles and Flannery 1992, Clewell et al. 2002).

Most importantly, vegetation communities along the tidal reach of the Little Manatee River were mapped by the Florida Marine Research Institute (FMRI 1997), with reference the given below. This study focused on five tidal rivers including the Little Manatee. Ground truthing was conducted on the Little Manatee and the report contains a very detailed map of vegetation communities along the river and a discussion of the distribution of plant species and communities.

> Florida Marine Research Institute. 1997. Development of GIS-based vegetation maps for the tidal reaches of five gulf coast rivers. Report prepared by the Florida Department of Environmental Protection Florida Marine Research Institute for the Southwest Florida Water Management District.

I showed a slide of the vegetation map from this project at the kick-off meeting of the peer review panel on October 5th. I strongly recommend the minimum flows report include the FMRI map and the cite the report that produced it, at it is much more detailed than the FLUCCS vegetation map shown in the draft report. In that regard, it better supports the District's recommended minimum flows that are based on the maintenance of low salinity habitats. The aerial photography on which the FMRI map is based was taken in 1990, but from my frequent trips on the river it does not appear that vegetation in this part of the river had changed or been altered significantly since that time.

If the District prefers, it could still include the FLUUCS map shown on page 70, but also present the more detailed FMRI map. The report could qualify that map was based on photography from 1990, but it is unlikely that vegetation in this section of the river has changed significantly since that time. This map is impressive and I suggest it be displayed full page with landscape orientation as shown on the following page. This would follow nicely the discussion on pages 69 to 71 in the draft minimum flows report. That discussion could possibly be slightly improved in a second round of edits, but getting the FMRI map and citation in the minimum flows report is very important, in no small part because he District should highlight the excellent work it has funded.

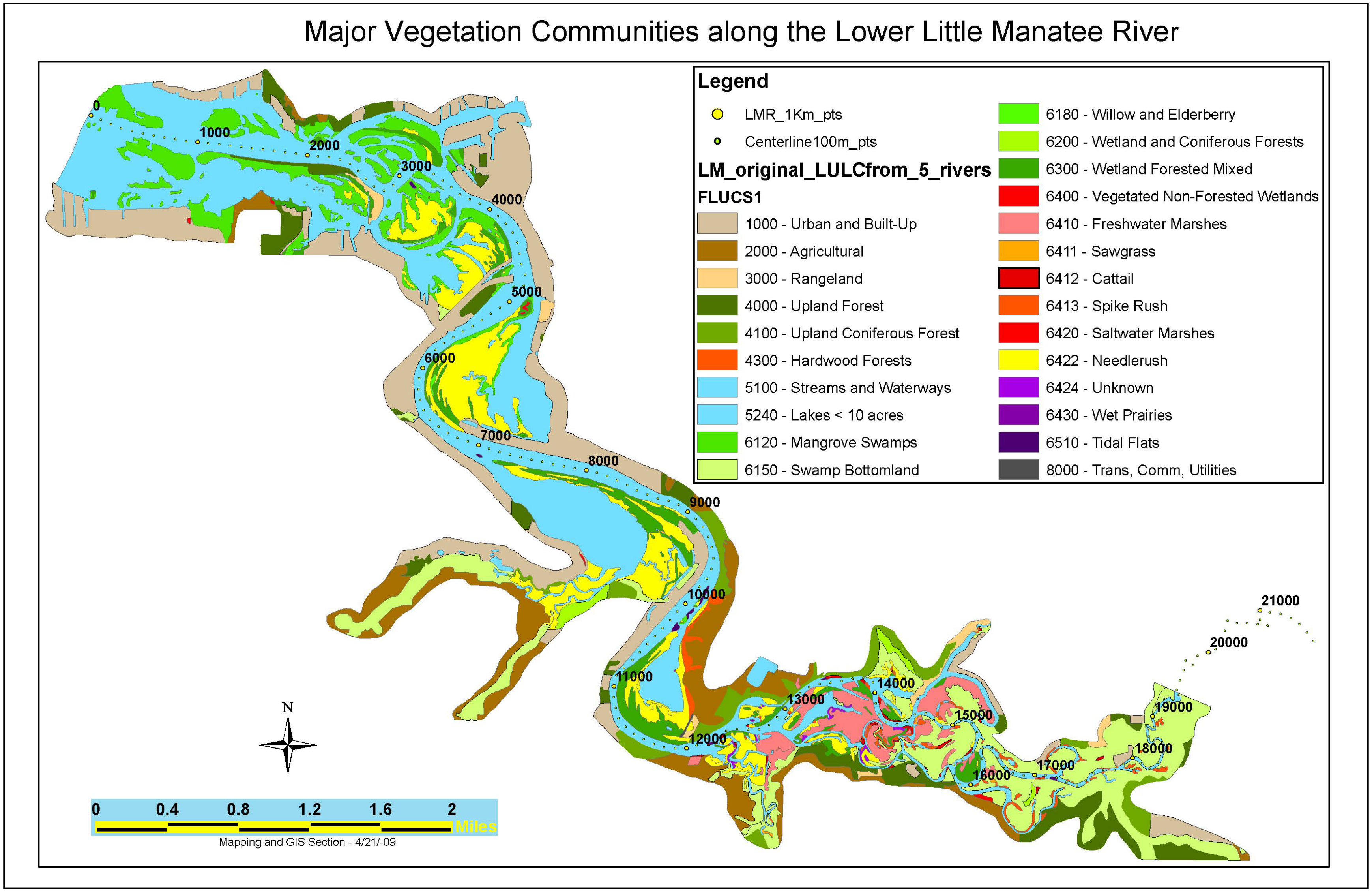


Figure X. Major vegetation communities along the Little Manatee Rive from FMRI (1997), with channel distances in meters.

5.1 Overview - Residence time analyses

In Section 5.4.5 the draft minimum flows report has a good description of EFDC hydrodynamic model for the Lower Little Manatee River that was developed by faculty and staff from FSU (Huang and Liu 2007). As in other tidal rivers (Alafia, Myakka, Lower Peace), model simulations of changes in salinity were a key analytical approach used to determine the minimum flows.

What the minimum flows report does not describe is that this project also included residence time simulations for the lower that were described in the project report (Huang and Liu 2007). This was pursued because the earlier minimum flows analyses for the Lower Alafia River found relationships between residence time (as water age) and very high chlorophyll *a* concentrations in sections of that tidal river. Since then, the District has made a point of having residence time simulations performed for tidal rivers, including the Lower Peace and the Little Manatee.

The project by Huang and Liu simulated residence time as Estuarine Residence Time (ERT) and Pulse Residence Time (PRT), with values of water age at ten locations in the tidal river used to calculate PRT at those locations. Two journal articles concerning residence time in the Little Manatee were also produced from this work (Huang et al. 2020, 2011), for which references are listed below.

Huang, W., X. Liu, X. Chen and M. S. Flannery. 2010. Estimating river flow effects on water ages by hydrodynamic modeling in the Little Manatee River estuary. *Journal of Environmental Fluid Mechanics* 10(1-2):197-211.

Huang, W., X. Liu, X. Chen and M. S. Flannery. 2011. Critical flow for water management in a shallow tidal river based on estuarine residence time. *Water Resources Management* 25(10): 2367-2385.

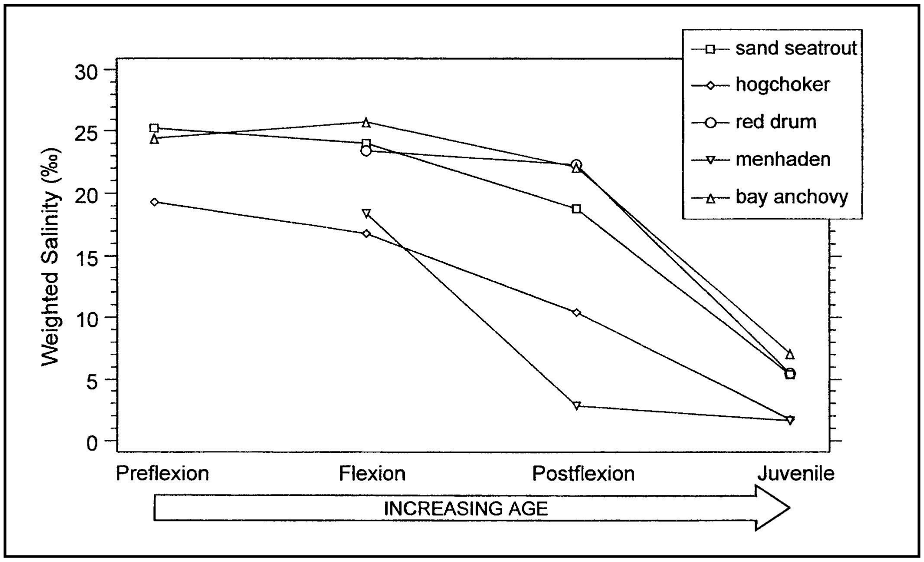
In comments I will submit in a week or so, I will recommend that further analyses be performed to evaluate flow thresholds for switching between low, medium, and high flow blocks specific to the lower river. At present, the thresholds for the flow blocks for the estuarine section of the river were based solely on freshwater analyses, which the District has never done before. This is probably not the best approach and needs to be addressed with additional analyses specific to the lower river.

In that regard, I think that examination of residence time as a function of freshwater inflow needs to be conducted, including evaluating the effects of various flow reductions on residence time. Next week, I will present some information concerning residence time (as water age) and the occurrence of high chlorophyll *a* concentrations in some segments of the tidal Little Manatee River.

But that is for another day. At this time, I recommend that the minimum flows report reference the residence time work performed by Huang and others, possibly showing the results of some residence time simulations in the minimum flows report.

6.1 Overview and suggested text for ichthyoplankton reports

On page 4.3.3 the report has one paragraph that summarizes the Ichthyoplankton work performed by Dr. Ernst Peebles of the University of South Florida College of Marine Science. This summary is good and well written, but I recommend two additions. First, the figure from Peebles and Flannery (1992) below be shown in the minimum flows report. As I mentioned at the peer review kick-off meeting, I think if there is one figure that best justifies the District's minimum flows program for tidal river estuaries, this is it.



Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages, from Peebles and Flannery (1992)

To reference this figure, the text could be added to say something like "Based on detailed microscopic work that identified early life stages as eggs, larvae, or juveniles, density weighted mean salinity values for different life stages were calculated. For a number of species, this showed a movement from higher salinity to lower salinity waters located further upstream as the species matured from larval to juvenile stages (Figure x). This occurs as these fish develop stronger swimming ability and have a change in food habits, switching from diets rich in zooplankton near the mouth of the river to more benthic food resources further upstream (Peebles 2005)." A reference for this second report is below.

Peebles, E. 2005. Review of feeding habits of juvenile estuarine dependent fishes and blue crabs: Identification of important prey. Report prepared by the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

The second addition I suggest pertains to the report by Peebles (2008). At present the draft minimum flows report has one sentence that says "These data were re-evaluated in 2008 using newly developed analytical methods (Peebles 2008)." Some of these findings in the 2008 report are very interesting and are relevant to freshwater inflow management. I suggest the District and JEI review

the summary section for this report and select two or three findings to briefly mention in the minimum flows report. I suggest "These data were re-evaluated in 2008 using new analytical methods that included analyses of organism dispersion as a function of freshwater inflow and organism associations with water masses of varying water age. The study also assessed community heterogeneity as a function of freshwater inflow and mean salinity at the sampling stations in the river."

6.2 Overview and suggested text for Nekton sampling conducted as part of the Fisheries Independent Monitoring Program of the Florida Fish and Wildlife Conservation Commission

The consultant has done a very good job of accessing and analyzing the extensive data for nekton (fishes and free swimming macroinvertebrates) in the estuarine section of the Little Manatee River collected by the Fisheries Independent Monitoring Program (FIM) of the Florida Fish and Wildlife Conservation Commission (FFWCC or FWC). On page 93 the draft minimum flows report provides a one sentence summary of a report produced by the FFWCC for the District based on these same data collected between 1996 and 2006 (MacDonald et al. 2007). That sentence mentions this study "demonstrated the importance of the Little Manatee River estuary for providing habitat throughout the year, as peaks in juvenile abundance of offshore spawners, juvenile nearshore spawners, estuarine spawners, and tidal-river residents occurred in different seasons (MacDdonald et al. 2007)."

Though this characterization is helpful, I suggest the minimum flows report could mention a couple other analyses or data presentations from the MacDonald et al. (2007) report. Also, it is not critical, but one page of figures from that report could be shown to highlight the types of information that are presented in it. I suggest something like below, including the figures for Red drum shown on the following page.

"This report also provides useful analyses and tabular and graphical presentations of the abundance and distribution response of various species in relation to freshwater inflow, plus the size classes, salinity at capture, and abundance of species in different sections and habitats in the lower river. As an example, a series of graphics for the seine catch of Red drum (*Sciaenops ocellatus*) from MacDonald et al. (2007) are shown on the following page." (see figure on the following page).

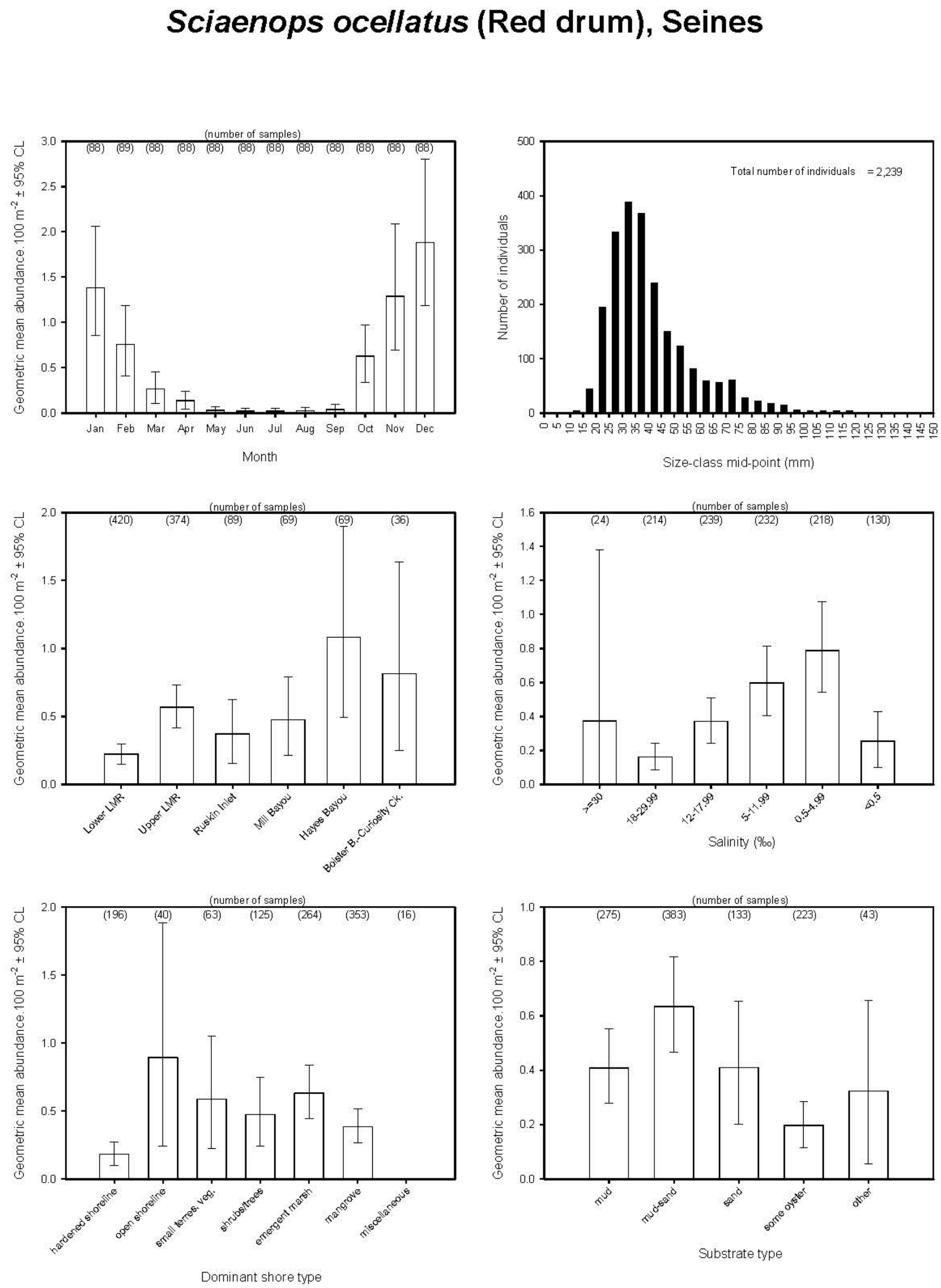


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

Figure X. Graphics for the seine catch of Red drum (*Sciaenops ocellatus*) in the Lower Little Manatee River reprinted from MacDonald et al. (2007).

6.3 Multi-River Fish Reports

Both FFWCC and USF prepared reports for the District that analyzed data pooled for the 18 or so rivers they studied for the District. The consultant might find some useful results in these reports that are relevant to the findings presented in the Little Manatee minimum flows report. References for these reports are below.

Hollander, D. and E.B. Peebles. 2004. Estuarine Nursery Function of Tidal Rivers in West-Central Florida: Ecosystem Analyses Using Multiple Stable Isotopes. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Peebles, E.B. 2005. Review of Feeding Habits of Juvenile Estuarine-Dependent Fishes and Blue Crabs: Identification of Important Prey. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Burghart, S.E. and E.B. Peebles. 2011. A Comparison of Spring-Fed and Surface-Fed Estuaries: Zooplankton, Ichthyoplankton, and Hyperbenthos. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Gunther, C.B., T.C. MacDonald and R.H. McMichael. 2011. Comparison of Nekton Community Structure Among Spring- and Surface-Fed Estuarine Rivers of Florida's West Coast. Report prepared by the Florida Fish and Wildlife Conservation Commission for the Southwest Florida Water Management District.

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Chris Zajac; Randy Smith; Yonas Ghile; Kristina Deak; Jordan D. Miller; Xinjian Chen; Gabe I. Herrick
Subject:	Please keep the Little Manatee minimum flows report as draft for a short bit longer
Date:	Thursday, October 12, 2023 8:24:21 AM
Attachments:	Overview and suggested text to describe technical reports about the Little Manatee River.pdf

Hello Kym and staff,

Congrats to the District on nearing the end of getting the Little Manatee River minimum flows report wrapped up. I thought the EAC meeting and result on Tuesday went well and appreciate that the District has considered my review comments over the last two years.

I am asking the District to leave the report as draft for just a few weeks to allow for an editorial review to catch some wording or statements that could get cleaned up a bit without affecting the findings or conclusions of the report. I have noticed a handful in the report that need some correction, but have not given the most recent version of the report a thorough read in that regard. I am heading to North Carolina later this morning until the 22nd of this month, and would like to submit a handful of editorial catches I have observed the following week, sometime before October 27th.

One example is on page 5, in describing the delineation of the upper and lower sections of the river, the District report twice states "the freshwater portion extends downstream of the US Highway 301 bridge, Peebles and Flannery 1992)". That statement obviously needs to be changed. On pages 25 to 28, the supplemental analyses report that I submitted to the District in January 2022 described that a tidal freshwater segment extends about 5 to 7 kilometers below the US 301 bridge, which was also described in the 2018 Janicki draft report for the lower river. A sentence on Page 17 of the current District draft report accurately describes that characteristic of the river, but somehow it got misinterpreted on page 5, which can be quickly edited. The fact that a short tidal freshwater zone extends below the US 301 bridge does not in any way invalidate the delineation of the upper and lower river at the US 301 bridge.

In addition to an editorial review, I still maintain the District could quickly add some paragraphs to describe other relevant ecological studies of the lower river that were funded by the District, particularly the phytoplankton and zooplankton reports by USF I have referred to in my presentations and written communications with the District. I have attached again my overview of other reports which I previously submitted to the District which describes those reports and even suggests some language that could be quickly added to the District report.

In addition, two journal articles that Dr. Huang wrote about residence time in the Little Manatee could quickly be referenced in the District report, literally with one sentence to describe their emphasis, such as "These researchers also wrote to two journal articles that describe the relationship of water age and estuarine residence time to freshwater inflow in the Little Manatee River." Xinjian should have copies of these papers, as he and I were both listed as co-authors.

So, please keep the minimum flows report for the Little Manatee River as draft for a bit longer to allow for an editorial review of the report and also consider adding some brief language that describes
previous technical studies of the Lower Little Manatee River.

Thanks again,
Sid

Text, tables, and graphics provided by Sid Flannery to the Southwest Florida Water Management District regarding review of the first draft Minimum Flows Report for the Little Manatee River (SWFWMD, 2021)

Content and Organization

This document complies various text, tables and graphics provided to the Southwest Florida Water Management District (the District) as part of a review of the draft minimum flows report for the Little Manatee River that was published in September 2021. These files were submitted to the District between Oct 2021 and September 2022. A revised draft minimum flows report for the Little Manatee River that addresses many of the topics identified in these files was published by the District in June 2023.

Other information not included

This document does not contain email correspondence with the District and miscellaneous files associated with that correspondence. Most notably, it also does not include analyses, results and discussion presented in an interpretive document provided to the District in January 2022 titled *Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows for the Little Manatee River (Flannery 2022)*, which can be provided upon request. Several technical points raised in that document were also addressed by the District in the revised draft minimum flow report.

This document also does not include a letter submitted to the District by the Florida Fish and Wildlife Conservation Commission (FFWCC) in April 2022 regarding nekton populations in the Little Manatee River and a review of the first draft minimum flows report. Similarly, many of the points raised by the FFWCC were also addressed in the revised draft minimum flows report for the Little Manatee River that was published in June 2023.

Next steps

Although the District has done a commendable job of addressing many of the topics identified in both the aforementioned Supplemental Analysis report those described on the following pages in this document, I believe there are some topics that still need further attention.

Prepared by

Sid Flannery, retired, formerly Chief Environmental Scientist with the Southwest Florida Water Management District

June 28, 2023

Public comments by Sid Flannery at the Little Manatee River minimum flows peer review meeting on 10/5/21 (not completed at the meeting due to time constraints)

Below is a transcript of the complete comments I had hoped to give at the peer review panel meeting on October 5, 2021, but ran short on time. I have added two paragraphs about the work by Dr. Gabriel Vargo and have supplied one additional slide I would like sent to the peer review panel with this document. The other two slides that were shown at the meeting are also submitted and all three slides are shown at the end of this document.

I encourage readers to review the information about Dr. Vargo's work and the important topic of separate flow thresholds for freshwater and estuarine sections of the river that starts on page 3, which I did not have time to cover in my public comments at the meeting.

My name is Sid Flannery, and as I introduced myself earlier, I am a retired Chief Environmental Scientist with the District's minimum flows program, where I worked many years on the hydrobiological flow relationships of the Little Manatee River. I managed nine different consultant research or analysis projects for the river and have probably spent 50 plus field days on the lower portions of the Little Manatee.

I want to first acknowledge how hard and conscientiously District staff works on the minimum flows reports, for they are under a very challenging schedule for the adoption of the minimum flow rules.

I quickly read through the minimum flows report for the Little Manatee, and based on further review, I will submit a series of questions and comments to the District. I will request that these questions and comments be provided to the peer review panel via the minimum flows web-board.

Today, I want to briefly discuss two aspects of the minimum flows report, the first of which I think is pretty easy to address, and the second which may require some new analyses.

The first topic is the report does not cite nor describe some important earlier technical reports that were prepared for the District about the Little Manatee River which provide very useful information regarding its ecological relationships with freshwater flows. I think these reports need to be cited and briefly summarized in the District report. Importantly, I don't think that concise summaries of these reports will change the recommended minimum flows and it should be fairly easy to incorporate them in the format of the District report. Inclusion of this material will improve the public and the technical community's understanding of the freshwater flow relationships of the Little Manatee River, and therefore better support the recommended minimum flows.

I have got two slides I want to show you in this regard *(a third slide has been added since I spoke).*

On page 70, the District report shows a land cover map for the lower, tidal reach of the Little Manatee River using the Florida Land Use, Cover, and Forms Classification System, also known

as FLUCCS. However, there is much better information available for the river, for in the 1990's the District contracted the State of Florida Marine Research Institute to do detailed mapping of vegetation communities in five tidal rivers, including the Little Manatee.

This slide (at end of this document) shows the vegetation communities that were mapped as part of that project. Note that compared to the FLUCCS codes shown in the District report, the low salinity plant communities are identified with much greater resolution, including *Typha*, *Cladium*, *Acrostichum*, freshwater marshes and other communities. It is worth noting that on the Little Manatee and other tidal rivers, the District has rightly emphasized the protection of low salinity zones, such a < 2 psu salinity. This is particularly relevant on the Little Manatee for it has a highly braided zone above kilometer 12, which has a very high degree of shoreline length per river kilometer. This zone of the river is one of the real unique areas in southwest Florida and its health is closely linked to the minimum flows. This is the map that needs to be used in the District report and work that produced it needs to be cited.

Also, in 1988 and 1989, the District received grants from the Florida Department of Environmental Protection to examine the linkages between the Little Manatee River watershed and its receiving estuary. That project included a two-year study of ichthyoplankton communities in the tidal reach of the river, which involved the early life stages of estuarine fishes. This was conducted by Dr. Ernst Peebles of the University of South Florida College of Marine Science and it is briefly described on page 99 in the District report, followed by a table of the 30 most abundant fish life stages captured during the study. It should be noted this study also quantified the abundance of many invertebrates caught in the plankton net that are important fish food organisms.

There are other valuable findings from this project that could also be briefly summarized in the District report. The next slide is from that project. I think If there is one slide that best supports the District's minimum flows program for tidal rivers, this is it. It shows mean salinity at capture for the immature life stages for five species of fish in the Little Manatee, with age increasing toward the right. The first three are larval stages, as many important estuarine dependent species spawn in the bay or gulf or near the mouths of rivers.

As these fishes grow to juveniles and develop stronger swimming ability, they move into low salinity waters. This, about as effectively as anything, justifies the use of the low salinity habitats as a parameter for establishing minimum flows. There are some other aspects of the ichthyoplankton report for the Little Manatee that are valuable, but at a minimum this graphic needs to go into the District report.

There are four other papers or reports (one a group of three related reports) that need to be cited and summarized in the District report. Of particular significance is important primary production work done by Dr. Gabriel Vargo of the University of South Florida College of Marine Science.

On page 56, the District report shows yearly mean chlorophyll *a* concentrations at five stations in the Little Manatee monitored by the Environmental Protection Commission of Hillsborough

County, including four in the estuarine reach of the river. The report states the spatial pattern shown between these stations is typical of tidal rivers. Well not exactly, the Little Manatee is unusual in that regard and there are reasons for it. The table below, which is also submitted as a slide, is adapted from a report that Dr. Vargo prepared for the District that compares chlorophyll and phytoplankton relationships in the Little Manatee, Alafia, and Peace Rivers.

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.

		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

The Alafia and Peace have the more typical pattern of high chlorophyll *a* concentrations at the 6 and 12 psu zones, while the Little Manatee frequently has its highest values near the freshwater/brackish water interface. This is likely due to comparatively longer residence times in the braided reach of the river which allows phytoplankton blooms to develop. The effects of changes on freshwater inflows on excessive phytoplankton blooms can be an important factor to consider in minimum flows analyses, as was done for the Lower Alafia. I think we are okay on the Little Manatee in that regard, but the three reports that Dr. Vargo prepared for the District need to be cited and briefly summarized in the minimum flows report.*

The citation and summaries of these and a few other reports can be very brief, one or two paragraphs with a figure or table. These concise and informative summaries will improve the public and technical community's understanding of the freshwater inflow relationships of the Little Manatee River and better support the technical justification of the minimum flows.

Assessment of separate thresholds for flow-based blocks for the freshwater and estuarine sections of the Little Manatee River

I want to change topics now and discuss the use of flow-based blocks in the District report. I strongly support the use of flow-based blocks, but they probably should be identified separately for the freshwater and estuarine reaches of the river. For most rivers, the District has previously produced separate reports for the freshwater and estuarine reaches of each river using different analytical methods, such as for the Alafia, Peace and Myakka Rivers. For many

* **The District report cites a paper by Vargo et al. (1991) in the Proceedings of the BASIS 2 Symposium, but the reports for the District provide other valuable findings with the third report completed after BASIS 2.**

years the District used a seasonal block approach for the freshwater rivers, with three seasonal blocks corresponding to low, medium, and high flows. For example, if it was February, you assumed flows were in the medium range and you applied the minimum flow percentages for that time of year.

On page 103 the District report makes a good case that this method has serious limitations, for flows in any season can be above or below the expected seasonal flow range for prolonged periods of time. A much simpler and more direct way to avoid this is to use flow-based blocks, in which minimum flow percentages are defined for different flow ranges, an approach which the District has recommended for the Little Manatee, which I strongly support.

Flow based minimum flows have previously been determined by the District for estuarine rivers, such as the Lower Pithlachascotee and the Lower Peace. In these rivers, the relationships of variables to freshwater inflow within the estuary were examined to determine ranges of flows where different percent withdrawal limits should be applied. Combined with a low flow cutoff, this is a very effective way to largely preserve natural flow characteristics, protect the estuary from significant harm, and make water proportionately more available as flows increase.

The problem with the Little Manatee River report is that flow thresholds of 35 and 72 cfs were based solely on environmental analyses of the freshwater reach of the river. These flow thresholds are then applied to the estuarine reach of lower river as well. This is a first, as the District has never done this before, and it is probably not the best approach.

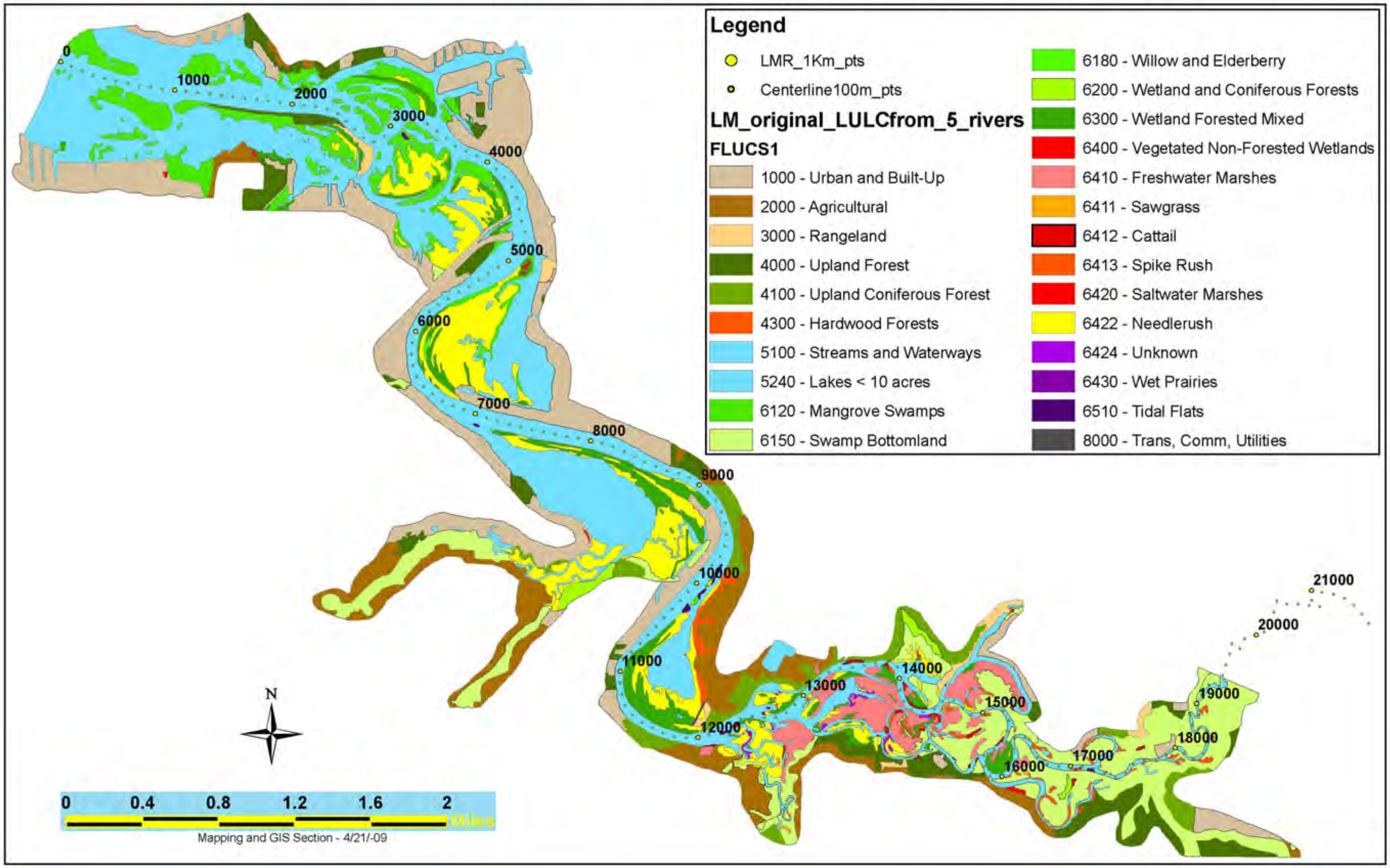
As was done for the Lower Pithlachascotee and Lower Peace Rivers, the response of key variables in the estuary to freshwater inflows should be examined separately for a series of flow ranges. Flow thresholds can then be identified to switch percent allowable flow reductions. Practical and ecologically effective flow thresholds for the estuarine portion of the Little Manatee might be similar to the flow thresholds identified for the freshwater reach, but you don't know until you analyze the data in that manner.

If necessary, the application of separate thresholds for flow-based blocks for the freshwater and estuarine reaches of a rivers is very feasible from a management perspective and can easily be applied, especially on a small river like the Little Manatee.

I recommend the District conduct further analyses to examine the response of low salinity zones and the environmental favorability functions for fishes in the lower river to freshwater inflow, and determine if separate thresholds for flow-based blocks in the estuarine section of the Little Manatee River are needed. The Lower Little Manatee River is an Outstanding Florida Water, an Aquatic Preserve, and is the jewel of tidal rivers flowing to Tampa Bay. It warrants a high degree of protection and the best analyses possible.

Three slides begin on the following page

Major Vegetation Communities along the Lower Little Manatee River



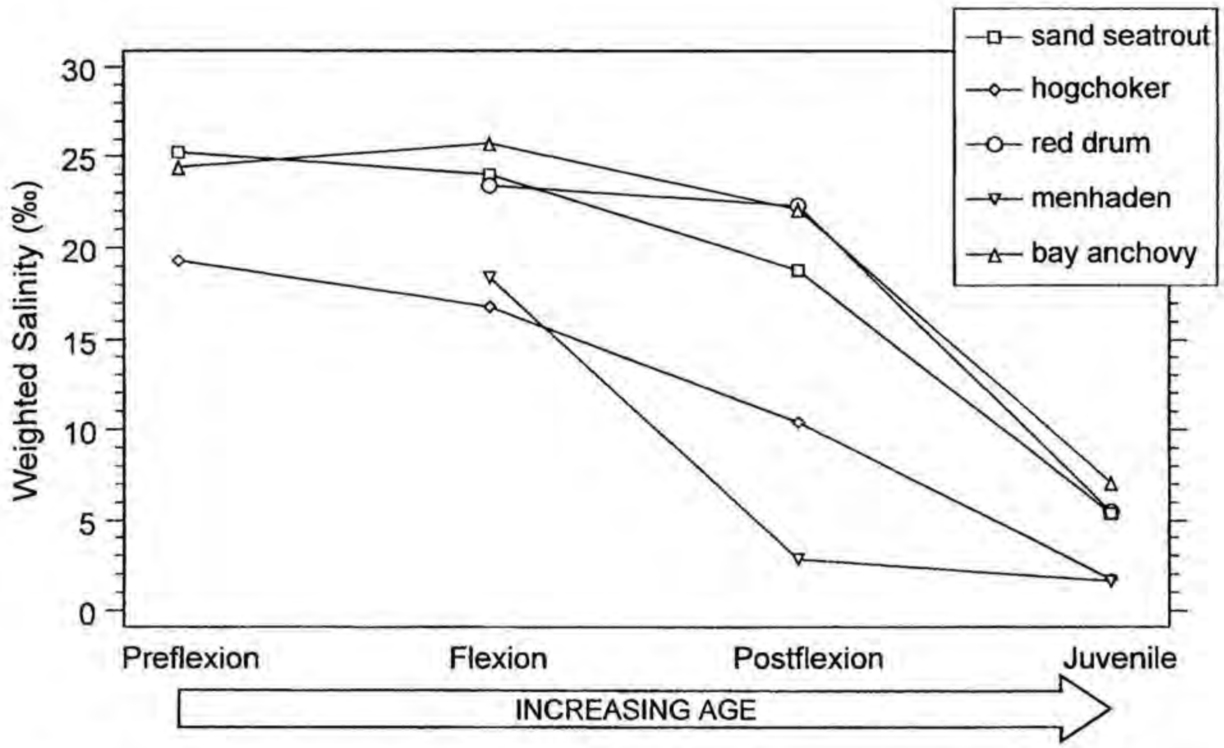


Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

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.					
		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

Technical review of the description and analysis of the freshwater flow regime of the Little Manatee River presented in the 2021 SWFWMD minimum flows report

Submitted by Sid Flannery, October 14, 2021

The comments contained in this document pertain to the characterization of the freshwater flow regime of the Little Manatee River presented in the current draft minimum flows report for the river. Some of the comments pertain to the discussion of factors that can affect those flows such as land and water use, climate, and permitted surface water withdrawals and discharges. In a week or two, I will submit additional comments related to the response of various biological and water quality variables in the estuarine portion of the river to freshwater inflow.

In the meantime, the comments below are intended to clarify and enhance the material presented in the District's draft minimum flows report so that readers have a better understanding of the flow regime of the Little Manatee River and how it is related to the ecological characteristics of the river and the potential effects of the proposed minimum flows.

The primary consultant, Janicki Environmental Inc. (JEI), has a done a very good job in justifying the use of flow-based blocks, which I strongly support. Also, the method they developed to adjust the gaged flows to develop a baseline flow record is very good and better than the method presented in the first minimum flow report (Hood et al. 2011).

I realize the District wants to produce minimum flows reports that are concise, but for some topics (e.g., the Florida Power and Light withdrawals), I think the hydrologic characterizations presented in the first minimum flows report are more informative than the material presented in the current report. I suggest the review panel read pages 4-1 and 4-6 to 4-32 to in the first minimum flows report. That report is provided as Appendix A with the current minimum flow report, and possibly in some cases the current report could say something like "See Appendix A for further details on …..". In that regard, I preface some my suggested edits with "At a minimum" and suggest the current report make reference to material presented in the first report. I don't think that is the best solution, but the District could go that route on some items to direct readers to the first minimum flows report for more information on a certain topic.

Organization

In several other minimum flows reports including the Lower Alafia, the Pithlachascotee and the Lower Myakka, the section on the baseline flow adjustment was in the same chapter as the hydrologic characterization, which flowed nicely as the baseline adjustment was described after the presentation of historic trends in rainfall, flows, and anthropogenic factors.

On the other hand, in the current report rainfall and flows are discussed in Chapter 2, while the flow blocks and generation of the baseline flow record are in Chapter 5, as was done for the Lower Peace River minimum flows report. I found this a bit hard to follow, but it is workable and suitable the District did it that way. However, for understanding the potential ecological changes that can result from applying the percent-of-flow method, it is helpful to see some other basic

hydrologic data reductions such as a bar graph of average monthly flows and a flow duration curve of baseline and observed flows. Some suggestions in that regard are presented below, along with other edits to the parts of the report that deal the freshwater flow regime of the river. Another day I will submit comments pertaining to the estuarine results presented in the report.

Suggested edits

Page (P) 18, Lines (L) 4 to 5. This sentence could shortened and slightly revised to read "Compared to other rivers in the region, flow in the Little Manatee watershed has a relatively high mean runoff rate normalized by contributing area. See page 4-10 in the previous minimum flows report (Apppendix A), where average areal based runoff rates for the Little Manatee are listed along with values for five other rivers."

Regarding the second half of this same sentence on page 18, I don't think the Little Manatee has a moderate to high baseflow fraction compared to other rivers such as the Hillsborough, Alafia and Withlacoochee, which all receive some springflow and other flow from the upper Floridan aquifer.

For example, from the minimum flows report for the Lower Alafia River, which is located about 14 miles north of the Little Manatee, the 10th percentile flow of the Alafia is 16.2% of its mean flow. If flows from Lithia and Buckhorn Springs are added to the gaged flows, the 10th percentile flow for the Alafia is 21.9% of its mean flow. In contrast, the 10th percentile flow for gaged flows on Little Manatee for 1996 to 2019 period (24 cfs) listed on page 144 in the current report is 14.4% of the mean flow (167 cfs) for that period.

Keep in mind the baseflow in the gaged record of the Little Manatee has been supplemented by excess agriculture irrigation water and the mean flow I just cited was not corrected for withdrawals from Florida Power and Light. So, the baseflow fraction for natural flows corrected for agricultural flows and FP&L withdrawals would be even lower. Therefore, I would not characterize the Little Manatee has having a moderate to high baseflow fraction. Simply drop that part of the sentence, which will agree better with the statement two sentences later about flows in the river having spiky behavior and low relatively low surface storage, which is accurate.

P28 – 30. I have reservations about over postulating about the effects of the Atlantic Multidecadal Oscillation (AMO). In the more recent warm AMO period (Figure 2-12), which is supposed to result in more rainfall, some of the worst multi-year droughts in the region occurred, including the year 2000 and early 2001 and an eight-year period from 2006 to 2013 when yearly rainfall was below normal for seven years (Figure 2-14). The report says there is not a lot of surface or surficial aquifer storage in the Little Manatee River basin and it responds quickly to rainfall events. In that regard, the time series graph of moving 20 -year average rainfall does not have as much to do with variations in flows the Little Manatee River as it might with rivers with more surface and groundwater storage like Pithlachascotee or the Withlacoochee. A moving average yearly rainfall hydrograph of shorter length would be more appropriate for comparison to flow trends in the Little Manatee. The previous minimum flows report used a moving three-year average rainfall hydrograph (Figure 4-4 on page 4-6).

P38 Section 2.5 (Little Manatee River Flow History) This section of the current report starts off describing the effect of agriculture on past flows, then follows with two short paragraphs and four hydrographs about the gaged flow record, then turns to a discussion of groundwater flow modeling. I suggest it would be better to start of with a description of the flow record and present the hydrographs and discuss the temporal patterns shown in them, then switch to possible causative factors including the groundwater modeling discussion.

P39. Figure 2-24. This figure plots average yearly flows on a semi-log scale with a fitted polynomial trend line. The range of yearly flows appears to be from about 40 to 400 cfs, which should plot fine on an arithmetic scale and would give the readers a better sense of the natural variation in yearly flows. If the polynomial trend was fitted to log transformed data, the current hydrograph could also be shown, but I think would be helpful to also show the flows on an arithmetic scale (see page 4-1 in the previous minimum flow report).

Monthly flows are plotted on a semi-log scale in Figure 2-25, which is helpful as there is much greater range in values. The report says there appears to be no significant long-term trend in monthly flows, but the occurrence of low monthly flows prior to the mid-1970s seems apparent, which is supported by other findings presented in the report. The report does suggest there appears to be a slight increasing trend in dry season flows (October to May), but not wet season flows. As with Figure 2-24, the time series plots of yearly average dry and set season flows on an arithmetic scale would be valuable.

Though the data end in the year 2010, there are very informative hydrographs and trend tests presented in previous minimum flows report by Hood et al. 2011. Having worked in estuarine ecology, I think the eight-month October to May dry season discussed in the current report is too broad for some ecological applications, and examining trends in other flow parameters can be meaningful from a resource management perspective. On pages 4-22 to 4-29, the previous minimum flows report showed some interesting results for trend tests and hydrographs for various yearly percentile flows, which clearly show a rise in values for the yearly 10th, 25th, and 50th percentile flows starting in the mid-1970s. As concluded in the current report, the previous report found no significant change in the higher flows. However, trend tests on monthly flows showed an increase for the dry season months of November, December, April and May. The previous report also showed hydrographs and trend results for moving average flows for various durations from 3 to 120 days, which clearly showed significant increases in their yearly minimum values (e.g, the lowest 60-day moving average flow within each year).

Frankly, I think it would be valuable to repeat such graphical and trend analyses for key flow parameters in the current report and see what the updated results look like, but will defer to the District. However, at a minimum, the current report should at least refer to some of the findings in the previous report, acknowledging the flow data end in 2010.

In the discussion of the effects of agriculture on flows in the river, the current District report should cite and briefly mention the paper by Flannery et al. (1991). I am not saying this to see my name in lights, but rather this was a very large effort that was funded by grants the District received from the Florida Department of Environmental Protection that involved the District, the University of South Florida, the USGS, and land use mapping specialists from the Florida Marine Research Institute. The USGS installed three new streamflow gages in the watershed and baseflow and runoff rates were compared from six sub-basins. Extensive water quality monitoring was conducted and nutrient loading rates were compared from these sub-basins. Water quality sampling of 21 sites was also conducted in May 1988 and May 1990, which showed where mineralized water of groundwater origin was entering the river.

The current report can qualify that these data were collected when the quantities of excess agricultural water entering the river was near maximum. On page 4-31, the previous District report has a very short paragraph about this study, and in a previous section described that since that report was produced there have been improvements in agricultural water use practices and a reduction in excess irrigation water entering the streams. The current District report provides a good summary of changes in land use and water use efficiency and the plot of residuals from the baseline flow analysis (Figure 5-2 on page 105) is very effective. Overall, the findings of the watershed assessment in the late 1980s supports the District's findings and that paper (Flannery et al. 1991) should be cited and quickly summarized in a short paragraph in the current report. A pdf of that paper is submitted along with this review.

Florida Power and Light

Because they utilize an off-stream reservoir and have long used withdrawal schedules linked flow rates, the FP&L facility has been an example of progressive water resource management. Along with the Peace and Alafia Rivers, ecological results and management applications from the Little Manatee River are featured in the 2002 journal article about the percent-of-flow method (Flannery et al, 2002), which is also submitted with this review.

Having said that, the withdrawal schedule that FP&L now uses will have to be revised to comply with the proposed minimum flows, and the description of their withdrawal schedule in the previous minimum flows report is much more informative than the discussion in the current report. In particular, the frequency that the emergency withdrawal schedule has been used and the quantities that were withdrawn from the river is well described in the previous minimum flows report. Again, the District could update and enhance the discussion of the FP&L withdrawals in the current report, or at a minimum, refer to the previous report (Appendix A) which provides a history of the changes in the diversion schedule and the frequency of use for the emergency schedule, acknowledging those data end in 2009.

At a minimum, the District needs to support their statement on page 44 that FP&L withdrawals have been less in recent years. The previous report listed an average water withdrawal by FP&L of 9.1 cfs for the 1976-2009 period, pointing out that includes the initial filling of the

reservoir. The previous report also mentioned this average withdrawal rate was largely driven by the diversion of high flows, as no withdrawals occurred on 71 percent of the days during that period. The District could easily characterize diversions by FPL during recent years, and at an absolute minimum, report an average diversion value for 2010 to 2020.

I was very involved in the re-evaluation and the revision of the FP&L withdrawal schedule, and toward the end of this peer review process, will offer some thoughts on further revision of their schedule to comply with the minimum flows. As a sneak preview, I think it would ecologically counter-productive to restrict FP&L to the 13% and 11% allowable freshwater flow reductions at flows in block 3. Reasons will be presented later, but if the final percent allowable reduction for estuarine minimum flows is greater at high flows, that is what FP&L should be regulated on. Tentative for now, but should be the way to go.

Mosaic land use and diversions

On page 44, the current report has a short paragraph about the permitted discharge by Mosaic Company for their phosphate mining operations and cites a report from 2012 (FDEP, 2012) to support the statement that the discharge has been limited for several years. Clearly, any characterization of discharges from the D-001 outfall needs to be updated.

As with FP&L, a good description of Mosaic's land use and hydrographs and characterization of the discharges for 1996 to 2009 is provided in the previous District report (pages 4-18 to 4-22). That report described why it would be difficult to create a baseline flow record adjusted for these discharges, so that was not done as part of that study. On page 4-20, the previous report shows an excellent map that showed the status of various categories of the Mosaic Company's lands (e.g., mined, reclaimed, preserved) and described the status of these land use categories and the percentages of the river watershed they represented.

In Section 2.2, the current District report generally characterizes extractive land covers, but provides no information on the status of those lands, such as what is currently and previously mined, reclaimed, preserved, or other. The land use maps that are shown have Extractive land use included as part of Urban and Built-Up, but Table 2-1 has the acreages of Extractive separately quantified over time. The previous District report states that Mosaic owns 26% of the Little Manatee River watershed. Given that a quarter of the watershed is owned by a phosphate mining company, it would improve the current District report to provide a more comprehensive update on the status of Mosaic's land holdings and the projections for future mining.

The District could cite the section on phosphate mining in the previous minimum flows report, but qualify that those results and projections are out of date and may no longer apply. At a minimum, the District needs to access the discharge records for the D-001 outfall and present an updated hydrograph and statistics for those discharges.

Nitrogen trends

In Section 3.3.2 (pages 54-56) the current report presents information on concentrations and trends for various forms of nitrogen measured by the Environmental Protection Commission of Hillsborough County (EPCHC). With the exception of organic nitrogen at freshwater station 113 at the Highway 301 bridge, concentrations were either decreasing or showed no trend. These results are encouraging, and it is good that the tidal section of the Little Manatee River has very little hypoxia (low dissolved oxygen concentrations). With regard to chlorophyll *a*, concentrations generally do not indicate impairment, but as will be discussed in the next review I submit, there are periodically very high chlorophyll *a* concentrations in the upper reaches of the tidal river and the potential effects of flow reductions need to be examined further. But that is for another day.

For now, I think it would be useful for the minimum flows to very briefly point out while that nitrogen concentrations have generally been either decreasing or non-trending in recent years, water in the Little Manatee River is nitrogen enriched compared to decades prior to the 1970s. Historical data presented as part of the late 1980s watershed assessment (Flannery et al. 1991) found that nitrate-nitrite concentrations have increased greatly since the mid-1970s, which corresponds to the increase in agricultural land use. The previous minimum flows report also reported an increase in nitrate-nitrite concentrations measured by the USGS, but the data ended in 1999 (pages 5-4 and 5-5). Increases in specific conductance, which are shown in Figure 12 in Flannery et al. (1991) and Figure 4-23 in the previous minimum flows report, show this same temporal trend, indicating the effect of agricultural land and water use on the river.

Also, during the 1988-1989 study period, the phosphate mining operations were largely inactive and the Ft. Lonesome station in the river upper river sub-basin served somewhat as a control site. Nitrogen concentrations and loading rates from that sub-basin were much less than from downstream sub-basins where there was much more agriculture. The point of this is the current minimum flows report could have one or two sentences that say that although nitrogen has been non-trending or decreasing in recent years, historical data indicate the the river is nitrogen enriched compared to before the 1970s (Flannery et al. 1991, Hood et al. 2011)

P 103 – **Excess flows and adjustment of the baseline flow record**.

The consultant (JEI) did a very nice job on the method for adjusting the gaged flows to develop a baseline flow record, which was an improvement over the method used in the previous District report. However, it is interesting the previous peer review panel did not criticize the method for adjusting the baseline record in the first minimum flows report, but they waxed at length about the use of benchmark flow periods. Regardless, the current method for adjusting the gaged flow to come up with baseline flows is very useful and the plot of residuals and the LOESS curve plotted in Figure 5-2 (page 105) is very informative. Also, with regard to benchmark flows issue, that is handled well in Section 6.5 in the current report in which the estuarine fish habitat analyses were conducted over four different multi-year periods.

Figure 5-3 on page 106 in the current District report is interesting in that there are large increases in excess flows during July to September, when irrigation rates are small or not occurring. This likely occurs because the excess irrigation raises water levels in the surficial aquifer, which can persist into the wet season and increase runoff potential. Also, the change from more natural land covers to agriculture can result in greater runoff from rainfall events.

In Figure 5-3 (page 106) the current District report cites the Lower Myakka River minimum flows report (Flannery et al. 2007). However, all the work on the excess flows was done by Interflow Engineering, which was presented and cited in the District's Lower Myakka River report. The current Little Manatee report should cite their work, such as Interflow Engineering LLC (2008 or 2009). Panel member Dr. Loper who conducted that work, can review the District's Lower Myakka minimum flows report and conclude which of the three references for Interflow Engineering cited therein should be used.

Also, the caption for the figure should say agricultural excess flows in the Myakka River, because Interflow also simulated total excess flows from all land use changes. In that regard, since it was based on overall rainfall runoff relationships, the baseline corrections done by Janicki Environmental are for total excess flows, though I suspect the predominant source of the excess flows results from agricultural land and water use.

A few basic graphics of a table to describe the flow regime of the Little Manatee River

The current report could benefit from presenting a few simple graphics and a table to describe the basic streamflow characteristics of the Little Manatee River. Such hydrologic information is important for not only understanding the seasonal and flow duration characteristics of the river, but also for understanding how application of the minimum flows will affect the ecology the river.

A plot of average monthly flows needs to be included to characterize the seasonal flow characteristics of the river. Two figures from page 4-12 in the previous minimum flows report are presented on the following page. This should be updated for the current report. Obviously, the yellow line in the second figure mimics the average monthly flows in the top graphic, but it is helpful to demonstrate how flows are lagged with regard to seasonal rainfall during some months of the year.

Also, as previously described, the Little Manatee River has a relatively high rate of basin runoff, a spikey response to rainfall events, and a relatively low rate of baseflow. These flow characteristics are manifested in the graphs on the following page where the difference in average monthly flows between the spring dry season and late summer flows is among the highest in the region. As will be described later in this review, the springtime dry season is especially important to the ecology of the freshwater river and the estuary and flow reductions must be managed very carefully during that time of year.

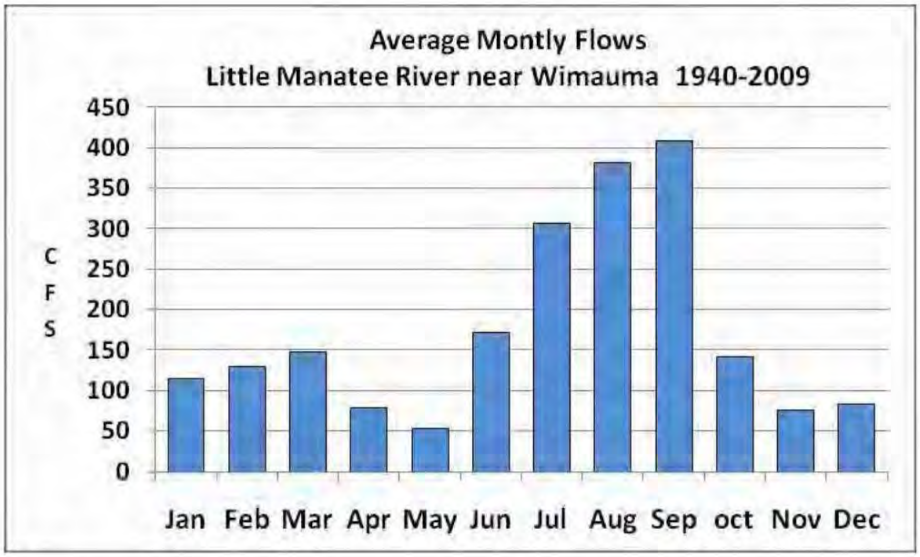


Figure 4-9. Average monthly rates of flow for the Little Manatee River near Wimauma for the years 1940-2009.

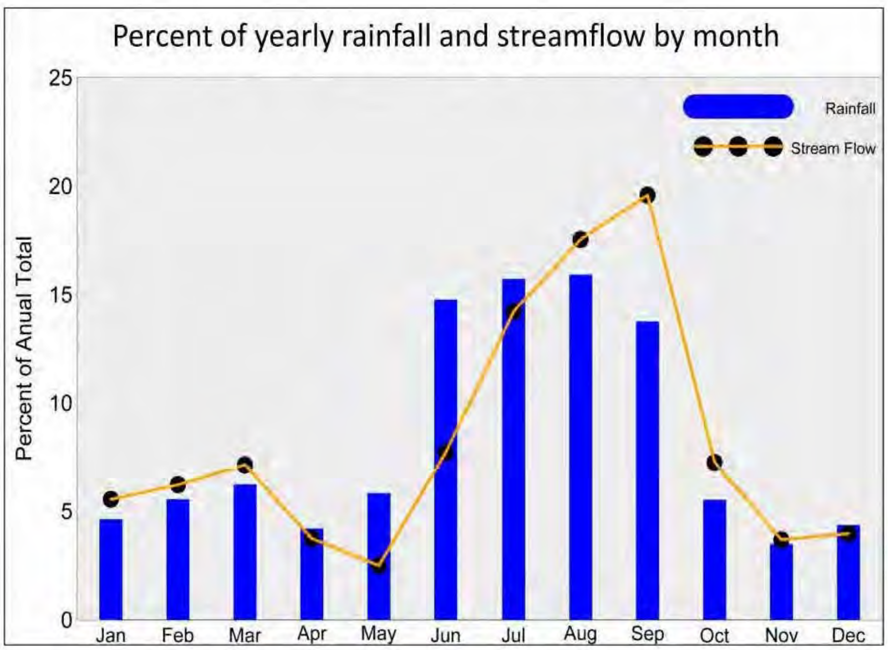


Figure 4-10. The percentage of yearly rainfall and streamflow by month for the Little Manatee River watershed and the LMR Wimauma gage.

4-12

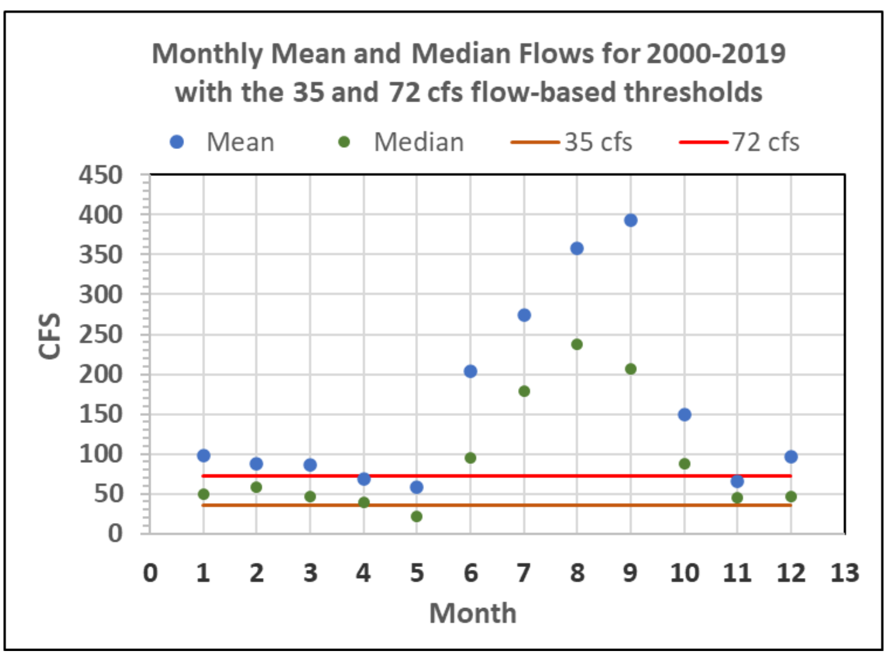
Figures 4-9 and 4-10 from the previous minimum flows report (Hood et al., 2011)

Also, in application of the percent-of-flow method it is very important to understand the seasonal flow duration characteristics of the river, particularly how often the different flow-based blocks will be in effect. In the second paragraph on page 103 the current report states "For reference, 35 cfs is the 34th non-exceedance percentile and 72 cfs is the 60th non-exceedance percentile." This is one of the most important findings in the report, and in general, the amounts of time that flows will be within the various flow-based blocks needs more description and emphasis in the report.

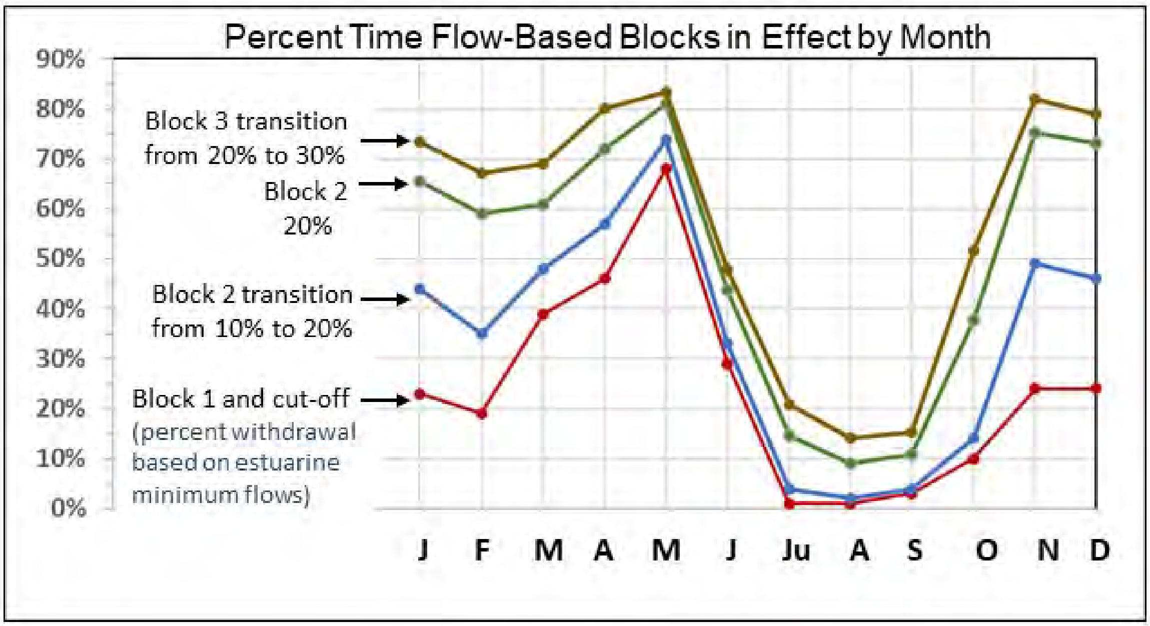
As part of such a description, it would be also helpful to see present a flow duration curve (cumulative distribution function) for the baseline and uncorrected flows for the 1976 to recent period. Both data sets should include corrections for FP&L withdrawals from the river. Also, various percentiles from these two flow records could listed in in a table, as in Table 2 in the first peer review report (Appendix B) or Table 4-2 (page 4-11) in the previous minimum flows report. The current report does show a flow duration curve and some percentile flows for the unadjusted flows at the USGS streamflow gage for four different time periods, but a similar table for baseline and observed flows together would be helpful.

Also, this critical hydrologic information is included in the Sections 5 and 6 of the report. It is probably too late now, but reorganization of the report to put the hydrologic characterization, including the adjustment for baseline flows, in Chapter 2 would be helpful, from where it could be referred to as needed later in the report.

Although flow durations for the entire period of analysis are important, it also useful to see how the flow-based blocks correspond to different seasons in the year. The 35 cfs threshold between blocks 1 and 2 and the 72 cfs threshold between blocks 2 and 3 are show in the figure below along with the average and median flows for each month for a recent 20-year period. It is apparent there are very large differences between months in how frequently flows in the river will be within the different flow-based flows, which has important implications for the ecological effects of the minimum flows.



The figure below shows how often the flow-based blocks would be in effect on a monthly basis. Note that lines are included for the transition between blocks 1 and 2 and between blocks 2 and 3. This is because the full percentage flow reduction for a given block cannot be achieved until flows get to a certain flow rate. For example, using the proposed minimum flows for the estuarine lower river, a 30% flow reduction at 77 cfs in block 3 would result in less flow than a 20% flow reduction at 70 cfs in block 2. Therefore, minimum flows rules typically provide for a transition range between blocks. This operations plan is feasible and is how water user permits for withdrawals from rivers using the percent-of-flow method are currently managed, as the utilities know for each rate of daily flow the amount they can withdraw.



The region below each line is the percent of time that flow reduction, or a lesser flow reduction, will be in effect. For example, in January flows are less than the block 1 cutoff 35 cfs threshold 23 percent of the time. Flows are in the block 2 transition 21 percent of the time, which is the difference between the blue and red lines (44% and 23%, respectively). Full block 2 flow reductions for January will be in effect of 22 percent of the time (66% minus 44%). Flows are fully in block three above the brown line, or 100 percent minus the value of the brown line, which would be 27% of the time (100% – 73%) for January.

Given the large differences in seasonal flows, it is striking how often the different flow blocks will be in effect in the various months. On average, flows are below the 35 cfs low flow cutoff 68% of the time in May, but only 3% of the time in September. Conversely, flows are in block 3 for 85% of the time in September. However, it is emphasized that these are average conditions over 20 years, and flows can be above or below a given threshold for longer periods of time in a specific year.

Seasons are still relevant

As previously described in this review and the document I submitted on October 6th, the District has gone to flow-based blocks for both the freshwater and estuarine reaches of the river. This is a first, for the District has previously used seasonal blocks for freshwater systems.

I support this approach, but emphasize the District continue to consider seasonal factors in their minimum flows analyses. I was not involved in the earlier PHABSIM evaluations of for freshwater systems, but apparently some freshwater fish species have a strong seasonal component to their reproductive cycles and habitat use patterns.

There are also strong seasonal factors in estuaries, with two figures shown below as examples. It has been repeatedly shown in tidal rivers, with and example shown for the Lower Alafia, that the number of larval fish taxa increases rapidly in the spring due to seasonal fish spawning. Based on estuarine considerations, the journal article by Flannery et al. (2002) suggested that flow reductions should be most restrictive in the spring (article submitted with this review). On the other hand, as shown below, the migration of red drum juveniles into the Little Manatee River occurs in the fall and winter (from MacDonald et al. 2007 cited in the current minimum flows report).

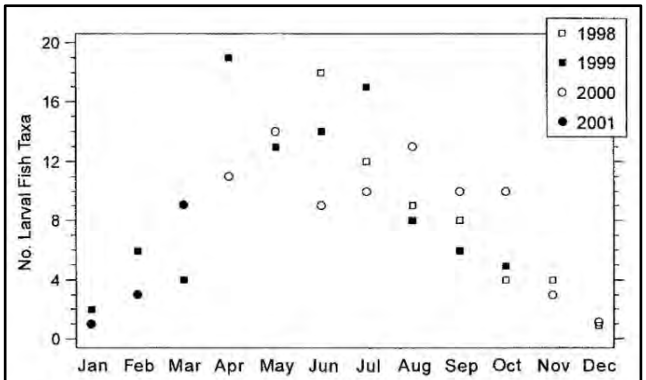
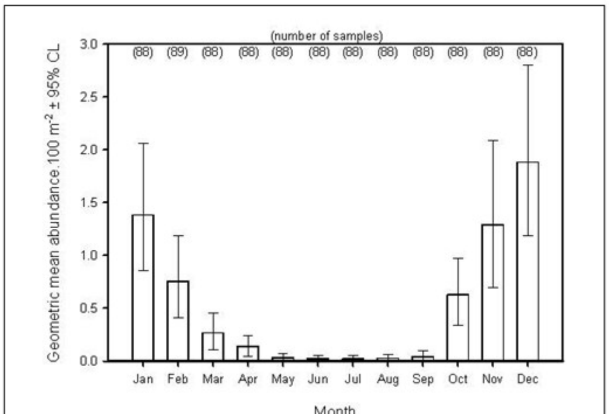


Fig. 9. The seasonal distribution of approximate larval richness in the tidal Alafia River (data from Peebles 2002a).



Red drum, all size classes (primarily juveniles)

Seasonal factors are also important for water quality in estuaries, as hypoxia is often most frequent in the summer during times of high water temperatures. Similarly, low flows and increasing water temperatures often contribute to large phytoplankton blooms in the spring.

All things considered, I think the flow-based approach proposed for the Little Manatee River is appropriate for the tidal portion of the river, in part because using the percent-of-flow method withdrawals in the springtime will be very low. However, as I recommended in the review submitted on October 6th, I strongly recommend that flow-based blocks be evaluated separately for the freshwater and estuarine sections of the river.

I also think the flow-based approach has important advantages for the freshwater section of the river, but I have not worked on the freshwater biological communities in the river and I defer to the District and the review panel. However, for both freshwater and estuarine systems, I suggest the District continue to evaluate seasonal factors and incorporate them in the minimum flows as needed.

Summary Points

- For some topics, the previous minimum flows report is very informative and the current report should refer to it, although it would be better to repeat those analyses or presentations
- It is probably too late, but the report could be reorganized to put the method for baseline flow creation and flow duration characteristics in Chapter 2 with the other hydrologic information
- The differences between seasonal low and high flows in the Little Manatee are among the highest in the region, so it should not be characterized as having moderate to high baseflow
- The discussion of the AMO has less relevance to the Little Manatee than some other rivers
- Chapter 2 should be slightly reorganized to present the flow hydrographs first, then discuss possible causative factors
- Some time series plots of flows on semi-log scale should be changed to an arithmetic scale
- Some of the trend analyses for flow parameters presented in the first minimum flows report should be repeated or as least referred to
- The report should reference the watershed assessment done by the District in the late 1980s as it was a very large effort that supports the District's current findings regarding flows in the river
- The description of Florida Power and Light's withdrawals from the river should be expanded, or at least refer to the previous District report and list an average withdrawal rate since 2010
- The description of the current status of Mosaic Company's land holdings and rates of outfall discharge should be expanded, or least refer to the previous District report and update the discharge records at the outfall
- The report should acknowledge that while water quality trends in recent years are encouraging, the Little Manatee River is nitrogen enriched compared to decades prior to the 1970s
- The report should cite Interflow Engineering regarding excess flows in the Myakka River
- The report should include some graphs of the basic hydrologic characteristics of the Little Manatee and a flow duration curve and table of percentiles for observed and baseline flows.
- The report should describe how often flows will be within the various flow blocks by month or season
- Seasons are important for biological use of both the freshwater and estuarine sections of rivers. The District should continue to evaluate seasonal relationships in their minimum flows analyses and incorporate seasonal factors in proposed minimum flow rules as necessary
- The flow-based blocks seem to work well for the Little Manatee River, in part because the resulting maximum allowable flow reductions will be small in the springtime.
- The District should establish flow-based blocks separately for the freshwater and estuarine sections of the Little Manatee River

Public comments given at second Little Manatee River minimum flows peer review meeting by Sid Flannery, Oct. 20, 2021

As I mentioned at the kickoff meeting two weeks ago, I am a retired Chief Environmental Scientist with the District's minimum flows program where I worked extensively on the Little Manatee River. I have submitted three sets of comments to the District regarding the minimum flows report. The first set of comments were posted 12 days ago, the second two days ago, and the third set today.

Regarding my second set of comments, I think the District could easily improve parts of the report that describe the streamflow characteristics of the Little Manatee to make it more understandable and comparable to the ecological characteristics of the river. For example, for understanding the ecology of the lower river estuary, a useful piece of information is a simple bar graph of average monthly flows, but one does not appear in the report

Also, for assessing both the ecological and water management aspects of minimum flows that are based on the percent-of-flow method, it is very informative to view the flow duration characteristics of a river on a seasonal and monthly basis, and how often the different flow-based blocks would be applied. I have included a couple of graphics of such values in my comments that I think you will find interesting.

My review also points out that the withdrawals by Florida Power and Light and the phosphate mining operations by the Mosaic Company, which are still ongoing, were described in much better detail in the previous minimum flows report. The District should expand the description of phosphate mining in the current minimum flows report and update the discharge records for Mosaic's point source outfall.

I also recommend the District cite, and with one short paragraph, summarize a paper that resulted from a FDEP funded watershed assessment that the District and other agencies performed in the late 1980s, as it provides valuable information that supports the hydrologic results presented in the minimum flows report.

The comments that were uploaded today discuss published biological studies I think the District should cite and briefly describe in the minimum flows report. Even though estuarine minimum flows are sometimes based on the modeling of just a few parameters, it benefits and improves minimum flows reports to describe the other ecological characteristics of a tidal river estuary that are related to freshwater inflow and minimum flows.

There are five informative reports that need to be cited the minimum flows report. For example, a zooplankton study of the lower river was conducted by the University of South Florida. Zooplankton are an important food source for young fish, and they play a critical role in the nursery function that estuaries provide for sport and commercial fisheries. Among other findings, the USF report shows plots of zooplankton density vs. salinity and the rate freshwater inflow, which are obviously relevant to minimum flows.

There are four reports that are cited in minimum flows report that could benefit from a bit more description. For example, on page 78 the report has a single sentence that says a survey of mollusks in river was performed, but does not mention any findings. In the document that was posted today, I've included a graphic from the mollusk report that clearly shows strong spatial partitioning of species along the river's salinity gradient. Also, the mollusk report describes the distribution of oyster reefs in the lower river, which comprise a key biological community whose health is related to the quantity of freshwater inflow.

So, in the document that was uploaded today, I have provided an overview of these reports and provided text, sometimes with a figure or table, the District could include in the minimum flows report to better describe the biological characteristics of the lower river that are related to salinity and freshwater inflows. These findings do not invalidate, but instead provide important justification for minimum flows. The text I have provided is fairly brief and should be fairly easy to incorporate. I also want to point out the Lower Little Manatee Rive is a State of Florida Aquatic Preserve, and it would be very helpful for the minimum flows report to cite and briefly describe valuable biological information that is available for it.

There is one section of my comments that were uploaded today that do not concern biology. Section 5.1 of those comments concerns residence time simulations that were conducted as part of the development of the EFDC hydrodynamic model of the lower river by Drs. Huang and Liu of Florida State University. That residence time work was described in the final project report by Dr. Huang and needs to be mentioned* in the minimum flows report. Residence time is directly related to rate of freshwater inflow, and as demonstrated by model simulations and analyses that Xinjian and I conducted on the Lower Alafia River, changes in residence time can affect water quality in tidal rivers.

So, that concludes my verbal comments for today. Next week I will speak to the need to develop flow thresholds for switching between low, medium, and high flow blocks separately for the freshwater and estuarine sections of the river. That topic was discussed in my first comments that were uploaded 12 days ago, so please consult that document for an overview of that topic.

* On page 125, residence time is mentioned in a sentence with two other objectives the FSU project addressed with the EFDC model, but a brief discussion of the residence time work is needed

Overview of selected technical reports about the Little Manatee River and suggested text, figures, or tables for the District's minimum flows report

Prepared by Sid Flannery, October 19, 2021

This document provides an overview of technical reports about the Lower Little Manatee River that were prepared for the District by staff from the State University System, the Florida Marine Research Institute, or Mote Marine Laboratory. I have also prepared paragraphs or single pages of text that include a figure or table that can be inserted into the minimum flows report to present findings from these reports that describe important relationships of the lower river to freshwater inflows.

These findings support the technical basis for the recommended minimum flows and provide valuable information on the physical, chemical and biological characteristics of the Little Manatee River. As described in the 2002 paper in the journal *Estuaries*, the Little Manatee was one of the three rivers on which the development of the percent-of-flow approach for minimum flows was initially based (Flannery et al. 2002). Furthermore, the tidal reach of the Little Manatee River is a State of Florida Aquatic Preserve and one of the most valued natural resources in the Tampa Bay region. As such, it would be beneficial for the report to briefly describe its biological characteristics, especially as they relate to freshwater inflows that will be affected by the proposed minimum flow rules.

1.1 Overview of Phytoplankton Reports

Dr. Gabriel Vargo of the USF College of Marine Science published two reports for the District about phytoplankton related parameters in the Little Manatee River based on just over two years of sampling from December 1987 to January 2000 (Vargo, 1989, 1991). In a separate report, he compared these data to phytoplankton related data collected from the Lower Peace and Alafia Rivers that used a similar salinity based sampling design (Vargo et al. 2004). None of these three reports are currently cited in the draft minimum flows report, but it does cite a paper that Dr. Vargo submitted to the proceedings of the BASIS 2 conference (Vargo et al. 1991).

Combined, these three reports are very informative about the relationships of different salinity zones to phytoplankton related parameters in tidal rivers, particularly the unusual characteristic of the Little Manatee in which the highest phytoplankton counts and chlorophyll *a* concentrations typically occur at the interface of fresh and brackish waters (0.5 psu), compared to other rivers where the highest phytoplankton counts and chlorophyll *a* concentrations typically occur in mesohaline waters.

In a week or so, I will present data that indicate that relationships of chlorophyll *a* to the rate of freshwater inflow and residence time in the lower river could be important to determining flow thresholds to switch between low, medium, and high minimum flow blocks for the estuarine section of the Little Manatee.

References for the three phytoplankton reports are below, including brief overviews of that work. This is followed text on page 4 that I suggest be inserted into the minimum flows report regarding the phytoplankton work on the Little Manatee River.

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

> Nutrients, chlorophyll *a*, and primary production were monitored on a bi-weekly basis for one year at four moving salinity based stations in the Little Manatee River and two fixed location stations; one near the mouth of the river in Tampa Bay and one in Ruskin Inlet, an urbanized inlet to the middle reaches of the Little Manatee River estuary. Among the salinity based stations, mean chlorophyll *a* and primary production rates were greatest at the 0.5 psu station and lowest at the 18 psu station. The Little Manatee has very low N:P rations due to high inorganic phosphorus concentrations in the river water.

Vargo, G.A. 1991. Phytoplankton studies in the Little Manatee River and Tampa Bay: Species Composition, Size Fractionated Chlorophyll, Primary Production, and Nitrogen Enrichment Studies. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> During the second year of a two-year study of phytoplankton populations in the Little Manatee River and adjacent waters of Tampa Bay, nutrients, size fractionated values for chlorophyll *a* and primary production rates were monitored monthly at a moving 12 psu salinity station in the river and a fixed location station in Tampa Bay. Phytoplankton populations were found to be nutrient sufficient or borderline nitrogen limited with respect to short-term photosynthesis, but long-term growth and biomass were clearly nitrogen limited based on bioassays of natural populations.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> Phytoplankton populations, nutrients and chlorophyll *a* concentrations were compared from similar, salinity based sampling designs in the Lower Alafia, Peace, and Little Manatee Rivers. Samples were collected on at least a monthly basis at the locations 0.5, 6, 12, and 18 psu surface salinity values in each river, with exception of the location of 20 psu being sampled in the Peace River. Mean phytoplankton counts were highest at the 12 psu station in the Alafia, the 6 psu station in the Peace, and the 0.5 psu station in the Little Manatee (see figure on next page). Phytoplankton counts were frequently an order of magnitude higher in the Alafia compared to the other rivers, presumably due to high nutrient loading from that watershed. In the figure on the next page, note separate axis for the Alafia River, which is an order of magnitude greater.

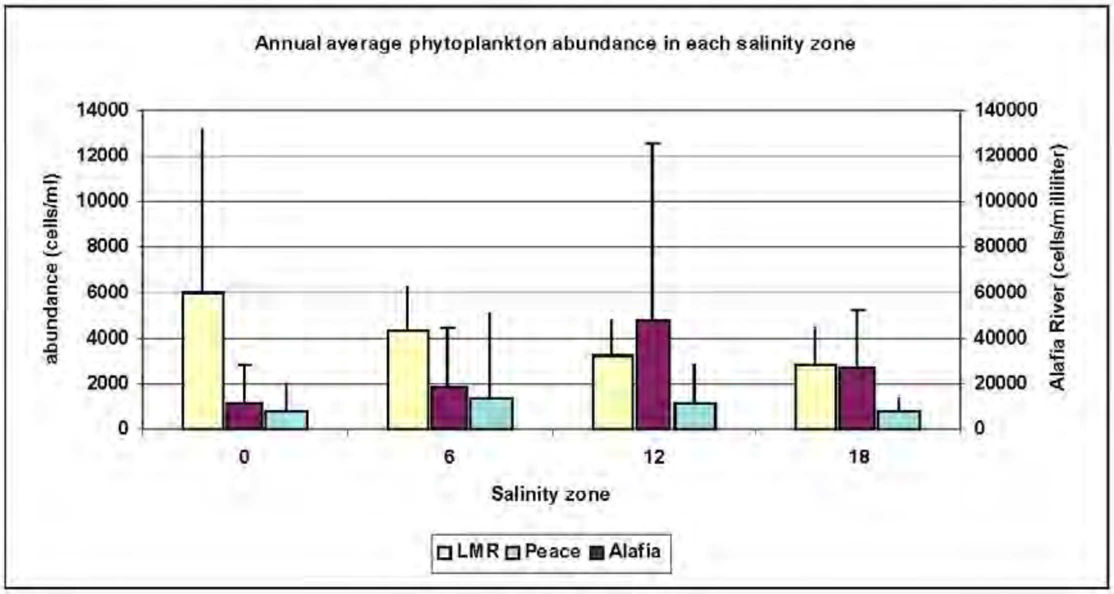


Figure X. Annual average phytoplankton abundance in the Little Manatee, Peace, and Alafia Rivers by salinity zone (20 psu for the Peace grouped with 18 psu). The Alafia is shown on a separate axis since the counts are an order of magnitude greater than the other rivers. From Vargo et al. (2004)

Mean values for chlorophyll *a* concentrations during the phytoplankton sampling periods for these rivers are listed on the following page. The much higher chlorophyll concentrations in the Alafia River are apparent, especially in mesohaline waters. Similar to the phytoplankton count data, the pattern for high chlorophyll *a* in the very low salinity zone (0.5 psu) in the Little Manatee River is again apparent, as are the high concentrations in the mesohaline zones for the Peace and Alafia. Although cell counts are higher in the mesohaline zone in the Little Manatee than in the Peace, chlorophyll *a* concentrations were higher in the Peace due to differences in the species composition of the phytoplankton between the rivers.

Comment - I think that differences in residence time for the Little Manatee contribute to it having its highest phytoplankton abundance and chlorophyll *a* concentrations at the 0.5 psu zone. The upper reaches of the Little Manatee are braided, and given the smaller rates of freshwater inflow, water moves more slowly through the tidal freshwater and oligohaline zones of the Little Manatee compared to the other rivers. All of these rivers (Peace, Alafia and Little Manatee) have residence time values that were generated from hydrodynamic model simulations.

Suggested page for phytoplankton. I think the Little Manatee minimum flows report could contain one page that ties the findings from these reports together. As an example, I have prepared three paragraphs and a table on the following page.

1.2 Phytoplankton (suggested text)

Based on just over two years of sampling spanning 1988 and 1989, the University of South Florida College of Marine Science produced two reports describing phytoplankton related parameters in the tidal reaches of the Little Manatee River and a nearby station in Tampa Bay (Vargo 1989, 1991). Data for nutrients, light penetration, chlorophyll *a*, phytoplankton species composition and primary production rates were measured at four moving salinity-based stations in the river and a fixed location station near the mouth of the river in Tampa Bay (Vargo 1989). Nutrient concentrations in the Little Manatee were characterized by very low nitrogen/phosphorus ratios (generally less than 2) due to high phosphorus concentrations in the inflowing river water. The second of these reports concluded that increased nitrogen loading could result in increased algal biomass and eutrophication in the tidal river (Vargo 1991).

In a subsequent report, (Vargo et al. 2004) compared data from the Little Manatee to phytoplankton related data collected in the Lower Peace and Alafia Rivers that were collected using a similar moving salinity-based design. The highest phytoplankton counts and chlorophyll *a* concentrations typically occurred at the interface of fresh and brackish waters (0.5 psu salinity) in the Little Manatee, whereas the highest cell counts and chlorophyll *a* concentrations typically occurred in mesohaline waters (6 and 12 psu salinity) in the Peace and Alafia (Table x). Using a separate data set for the Alafia, Vargo et al. (1991) compared chlorophyll *a* concentrations and primary production rates for the Little Manatee, the Alafia, and a nearby station in Tampa Bay.

Table X. 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

The high chlorophyll *a* concentrations at the freshwater/brackish water interface in the Little Manatee may be related to comparatively long residence times there, which were simulated as part of the development of the hydrodynamic EFDC model for the river (Huang and Liu 2007, Huang et al. 2010, 2011). These comparatively long residence times are related to the braided morphology of the river between kilometers 12 and 16, where the water slows compared to the upstream freshwater reach. These findings and data presented in this report indicate chlorophyll *a* concentrations in the upper reaches of the tidal river could be sensitive to the effects of freshwater flow reductions.

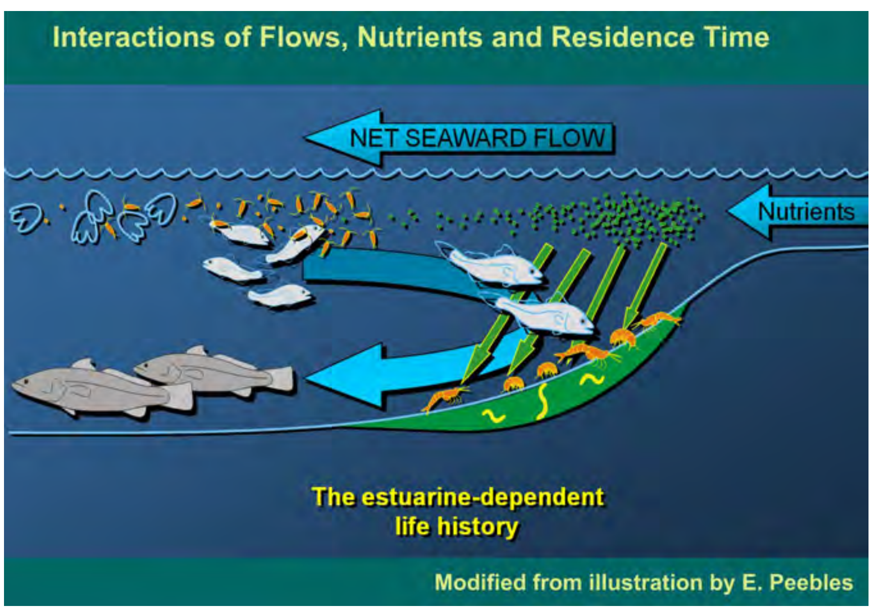
2.1 Overview – Zooplankton Report

Zooplankton were sampled in the estuarine section of the Little Manatee River during 1988 and 1989 concurrently at the same stations as the ichthyoplankton work performed by Dr. Ernst Peebles. Five stations were sampled ranging from the mouth of the river to kilometer 14.2, with another station located at a nearby site in Tampa Bay. The second of these two reports is the more comprehensive of the two and should be briefly described in the District report.

Rast, J.R. and T. L. Hopkins. 1989. The Zooplankton of the Little Manatee River Estuary, Florida. First yearly report. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Rast, J.P., M.E. Flock, T. T. Sutton and T. L. Hopkins. 1991. The Zooplankton of the Little Manatee River Estuary: Species Composition, Distribution, and Relationships with Salinity and Freshwater Discharge. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

In contrast to fish and benthic macroinvertebrate studies, which have been conducted in many rivers, this is the only true zooplankton study in the region's tidal rivers and it is very informative. The second report describes the abundance and distribution of zooplankton, which for many species are more abundant in the lower reaches of the tidal river. Following the tidal river engine concept developed by Peebles (illustration below), this is where the larval stages of many fishes are concentrated early in their life history when they feed on zooplankton. As they grow to juveniles, these fishes migrate to lower salinity waters and feed more on benthic oriented prey. See the illustration below, all evidence I've seen indicates this conceptual model is generally true.



The abundance of zooplankton in higher salinity waters in the lower river probably also results in increased grazing of phytoplankton and contributes to the tendency for chlorophyll *a* concentrations to be lower and more stable near the mouth of the river. Conversely, ungrazed phytoplankton blooms in lower salinity waters probably results in more deposition (see illustration).

The District minimum flows report could briefly summarize the zooplankton study. Along with one table, this would fit on one page and not substantially affect the pagination of the report. Suggested text for a brief discussion of the zooplankton is provided on the following page

Go to next page

2.2 Zooplankton (Suggested text)

Zooplankton in the Lower Little Manatee River were studied during 1988 and 1989 by the University of South Florida College of Marine Science (Rast et al. 1991). These data were collected concurrently with the ichthyoplankton work in the lower river (Peebles and Flannery, 1992), at the same five locations that ranged from kilometers 0 to 14.2, plus a nearby station in Tampa Bay. This project provides valuable information for the abundance and distribution of major zooplankton groups in the lower river, including; holoplankton (entire life cycle in the water column), meroplankton (in the water column for only a portion of their life cycle), tychoplankton (swept off of the river bottom) and hypoplankton (swim off the bottom for a limited amount of time).

Average values for the abundance and estimated biomass of these zooplankton groups are listed in Table X. Holoplankton and meroplankton had their highest values and biomass near the mouth of the river and Tampa Bay, whereas combined tycho-hypoplankton had highest values in the middle and upper parts of the lower river (year 1 only as two stations were discontinued in year 2).

Table X. Average density (numbers/m3) and biomass (in parentheses as mg dry weight/m3) for total holoplankton, meroplankton and tycho-hypoplankton for 25 trips from 1/29/88 – 1/31/89

	Bay or River Kilometer					
	Tampa Bay	**0.0**	**3.8**	**7.1**	**10.3**	**14.3**
Holoplankton	309,000 (147.7)	235,000 (87.6)	177,000 (44.5)	150,000 (34.4)	84,300 (15.1)	29,700 (5.7)
Meroplankton	40,900 (23.8)	12,000 (6.5)	4,350 (3.9)	3,540 (1.7)	4,220 (3.6)	1,490 (1.0)
Tycho-hypoplankton	1,520 (3.7)	1,290 (3.5)	1,390 (22.6)	5,820 (11.3)	4,590 (12.7)	1,530 (3.1)

Zooplankton are very important prey for the early life stages of many fishes, and their abundance in the river is important to the nursery function provided for many estuarine dependent fish species. Based on 48 total samples, the report by Rast et al. (1991) provided informative plots of zooplankton density versus salinity and the rate of freshwater inflow for eleven dominant species or taxonomic groups (e.g., *Acartia tonsa*, *Oithona colcarva,* copepod nauplii, polychaete larvae).

The numbers and biomass of the major zooplankton groups were were also plotted vs. salinity and freshwater inflow at the five stations in the river and Tampa Bay. The response of the different species or groups to inflow and salinity differed, with the abundance of several taxa or groups associated with the lower part of the river increasing upstream with decreased freshwater inflow. On the other hand, benthic harpacticoid copepods maintained relatively high abundance in the upper river stations except for very high flow events. In general, this project provides very useful information on how zooplankton species and communities respond to changes in salinity and freshwater inflow, which can affect fish nursery use of the lower river and is related to the establishment of minimum flows.

3.1 Overview – Mollusk Report

Dr. Ernest Estevez of Mote Marine Laboratory performed a field intensive survey of the distribution of mollusks in subtidal and intertidal habitats in the Little Manatee River during August 2006. The draft minimum flows report has one sentence on page 78 that cites Estevez (2006) and states this work was performed, but mentions no findings from the study.

The minimum flows report should provide one table and a brief description of the findings of the Mote study for three reasons. First, the mollusk communities show clear gradients with regard to salinity in the river, which supports the District's use of salinity as a parameter for determining the minimum flows. Secondly, the report describes the distribution of oyster bars in the river, which are important for shoreline stability, improving water quality, and creating habitat for reef associated fauna in the tidal river. Lastly, as previously discussed, the Lower Little Manatee River is an aquatic preserve and the District report should describe the biological communities of the lower river, especially as they relate to freshwater inflows and the determination of minimum flows.

Based on mollusk studies conducted within the District, noted invertebrate biologist Dr. Paul Montagna of Texas A&M University was the senior author of the journal article below that assessed the relationship of salinity to the distribution of mollusk species in tidal creeks and rivers in the region. This study can also be cited along with a discussion of the Mote Marine Study.

> Montagna, P. A., E. D. Estevez, T. A. Palmer and M. S. Flannery. 2008. Meta-analysis of the relationship between salinity and molluscs in tidal river estuaries of southwest Florida, U.S.A. *American Malacological Bulletin* 24:101-115.

Two short paragraphs about the Mote study and Montagna et al. findings are provided on the following page, including one figure. I suggest that this text or something similar, including the figure, be included in minimum flows report to enhance the biological information presented for the river and provide additional support of the recommended minimum flows

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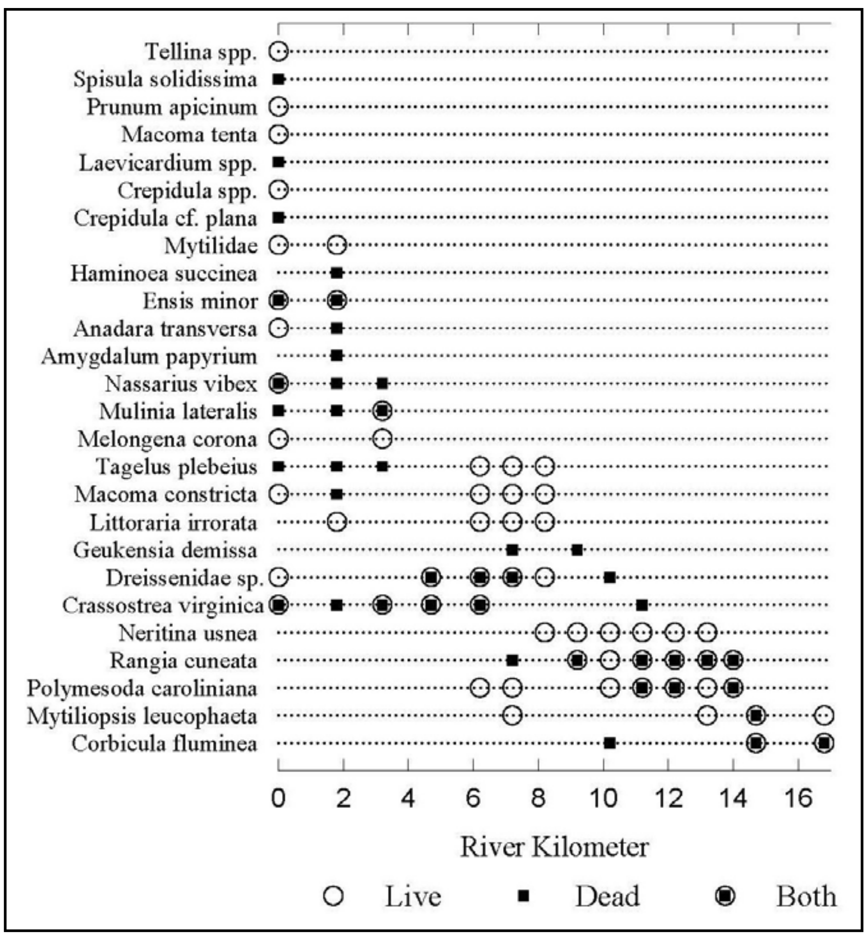
3.2 Mollusks (Suggested Text)

In August of 2006, Dr. Ernest Estevez of Mote Marine Laboratory performed a survey of the distribution of mollusk species in subtidal and intertidal habitats in the Lower Little Manatee River that identified both live mollusks and dead mollusk material (Estevez 2006). Sampling transects were established at 15 locations in the river ranging between river kilometers 0.4 and 16.8 In addition to their presence within the sampling transects, the distribution of oysters in the river was visually described, with large oyster reefs most conspicuous between kilometers 3 and 5 and in the back bays. Smaller oyster reefs with mostly dead material were near the river mouth, with small reefs widely distributed upstream to near kilometer 11, where only dead material was found.

A total of 26 mollusk species or taxa were found (Table x), which is similar to the species richness found using similar methods in other tidal rivers in the District. Mollusk species showed district distributional patterns in relation to salinity gradients in the lower river. In a study of mollusk communities from eleven tidal tributary systems within the District, Montagna et al. (2008) found that salinity was the primary factor affecting the distribution and species composition of mollusk communities.

Figure X. Distribution of mollusk species vs. kilometer in the Little Manatee River, including subtidal and intertidal samples with live mollusks and dead mollusk material, from Estevez (2006).



4.1 Overview – Vegetation in the lower river floodplain.

Section 4.1.2 in the draft minimum flows report describes vegetation communities along the tidal reach of the Lower Little Manatee River. The first sentence in the section says that estuarine conditions extend 15 miles (24 kilometers) upstream from the river mouth, but that is incorrect. Based on extensive field work, Peebles and Flannery (1992) report that brackish waters (>1 psu) typically do not extend farther than 16 to 18 kilometers upstream. Also, as described on page 17 in the minimum flows report, minor tidal fluctuations in water levels can sometimes occur about 1 kilometer upstream of the US 301 bridge, but brackish water does not extend nearly that far.

The description of vegetation communities in the river on pages 69 and 70 in the draft report is pretty good and it references the previous minimum flows report from 2011 (Hood et al. Appendix A). Such a description may be in Hood et al., but I ran out of time and could not find such a discussion in that report which focuses on the freshwater section of the river. However, other reports that can be cited that describe vegetation along the lower river (Peebles and Flannery 1992, Clewell et al. 2002).

Most importantly, vegetation communities along the tidal reach of the Little Manatee River were mapped by the Florida Marine Research Institute (FMRI 1997), with reference the given below. This study focused on five tidal rivers including the Little Manatee. Ground truthing was conducted on the Little Manatee and the report contains a very detailed map of vegetation communities along the river and a discussion of the distribution of plant species and communities.

> Florida Marine Research Institute. 1997. Development of GIS-based vegetation maps for the tidal reaches of five gulf coast rivers. Report prepared by the Florida Department of Environmental Protection Florida Marine Research Institute for the Southwest Florida Water Management District.

I showed a slide of the vegetation map from this project at the kick-off meeting of the peer review panel on October 5th. I strongly recommend the minimum flows report include the FMRI map and the cite the report that produced it, at it is much more detailed than the FLUCCS vegetation map shown in the draft report. In that regard, it better supports the District's recommended minimum flows that are based on the maintenance of low salinity habitats. The aerial photography on which the FMRI map is based was taken in 1990, but from my frequent trips on the river it does not appear that vegetation in this part of the river had changed or been altered significantly since that time.

If the District prefers, it could still include the FLUUCS map shown on page 70, but also present the more detailed FMRI map. The report could qualify that map was based on photography from 1990, but it is unlikely that vegetation in this section of the river has changed significantly since that time. This map is impressive and I suggest it be displayed full page with landscape orientation as shown on the following page. This would follow nicely the discussion on pages 69 to 71 in the draft minimum flows report. That discussion could possibly be slightly improved in a second round of edits, but getting the FMRI map and citation in the minimum flows report is very important, in no small part because he District should highlight the excellent work it has funded.

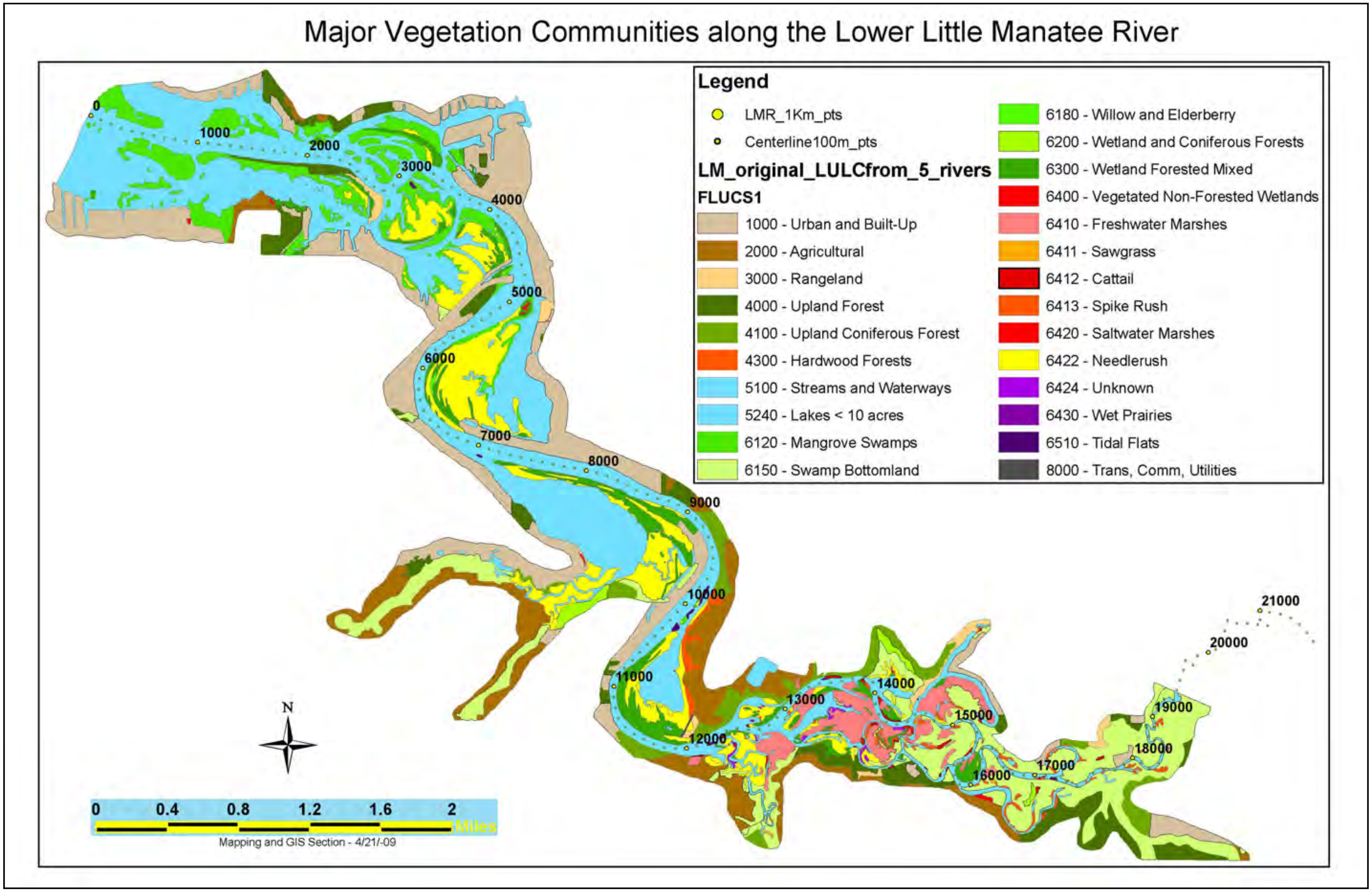


Figure X. Major vegetation communities along the Little Manatee Rive from FMRI (1997), with channel distances in meters.

5.1 Overview - Residence time analyses

In Section 5.4.5 the draft minimum flows report has a good description of EFDC hydrodynamic model for the Lower Little Manatee River that was developed by faculty and staff from FSU (Huang and Liu 2007). As in other tidal rivers (Alafia, Myakka, Lower Peace), model simulations of changes in salinity were a key analytical approach used to determine the minimum flows.

What the minimum flows report does not describe is that this project also included residence time simulations for the lower that were described in the project report (Huang and Liu 2007). This was pursued because the earlier minimum flows analyses for the Lower Alafia River found relationships between residence time (as water age) and very high chlorophyll *a* concentrations in sections of that tidal river. Since then, the District has made a point of having residence time simulations performed for tidal rivers, including the Lower Peace and the Little Manatee.

The project by Huang and Liu simulated residence time as Estuarine Residence Time (ERT) and Pulse Residence Time (PRT), with values of water age at ten locations in the tidal river used to calculate PRT at those locations. Two journal articles concerning residence time in the Little Manatee were also produced from this work (Huang et al. 2020, 2011), for which references are listed below.

> Huang, W., X. Liu, X. Chen and M. S. Flannery. 2010. Estimating river flow effects on water ages by hydrodynamic modeling in the Little Manatee River estuary. *Journal of Environmental Fluid Mechanics* 10(1-2):197-211.
>
> Huang, W., X. Liu, X. Chen and M. S. Flannery. 2011. Critical flow for water management in a shallow tidal river based on estuarine residence time. *Water Resources Management* 25(10): 2367-2385.

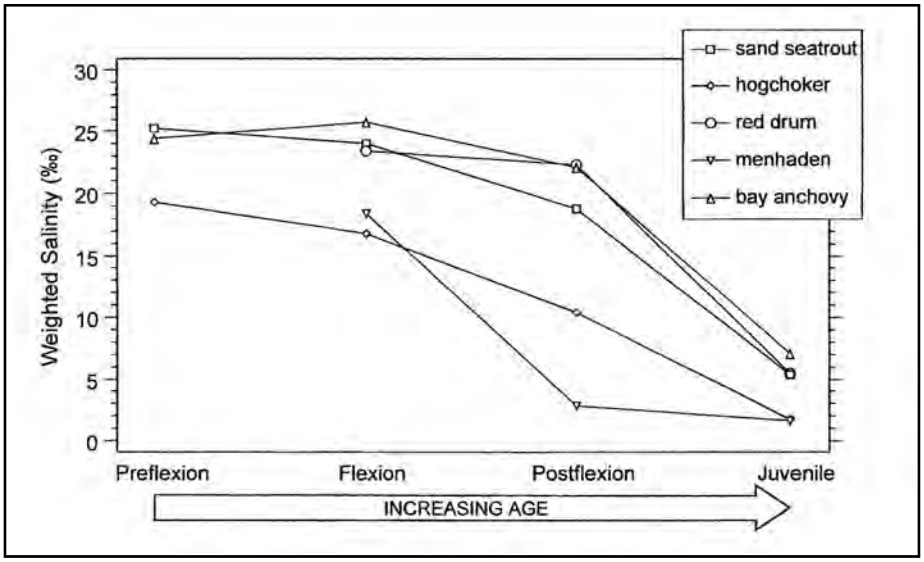
In comments I will submit in a week or so, I will recommend that further analyses be performed to evaluate flow thresholds for switching between low, medium, and high flow blocks specific to the lower river. At present, the thresholds for the flow blocks for the estuarine section of the river were based solely on freshwater analyses, which the District has never done before. This is probably not the best approach and needs to be addressed with additional analyses specific to the lower river.

In that regard, I think that examination of residence time as a function of freshwater inflow needs to be conducted, including evaluating the effects of various flow reductions on residence time. Next week, I will present some information concerning residence time (as water age) and the occurrence of high chlorophyll *a* concentrations in some segments of the tidal Little Manatee River.

But that is for another day. At this time, I recommend that the minimum flows report reference the residence time work performed by Huang and others, possibly showing the results of some residence time simulations in the minimum flows report.

6.1 Overview and suggested text for ichthyoplankton reports

On page 4.3.3 the report has one paragraph that summarizes the Ichthyoplankton work performed by Dr. Ernst Peebles of the University of South Florida College of Marine Science. This summary is good and well written, but I recommend two additions. First, the figure from Peebles and Flannery (1992) below be shown in the minimum flows report. As I mentioned at the peer review kick-off meeting, I think if there is one figure that best justifies the District's minimum flows program for tidal river estuaries, this is it.



Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages, from Peebles and Flannery (1992)

To reference this figure, the text could be added to say something like "Based on detailed microscopic work that identified early life stages as eggs, larvae, or juveniles, density weighted mean salinity values for different life stages were calculated. For a number of species, this showed a movement from higher salinity to lower salinity waters located further upstream as the species matured from larval to juvenile stages (Figure x). This occurs as these fish develop stronger swimming ability and have a change in food habits, switching from diets rich in zooplankton near the mouth of the river to more benthic food resources further upstream (Peebles 2005)." A reference for this second report is below.

Peebles, E. 2005. Review of feeding habits of juvenile estuarine dependent fishes and blue crabs: Identification of important prey. Report prepared by the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

The second addition I suggest pertains to the report by Peebles (2008). At present the draft minimum flows report has one sentence that says "These data were re-evaluated in 2008 using newly developed analytical methods (Peebles 2008)." Some of these findings in the 2008 report are very interesting and are relevant to freshwater inflow management. I suggest the District and JEI review

the summary section for this report and select two or three findings to briefly mention in the minimum flows report.   I suggest “These data were re-evaluated in 2008 using new analytical methods that included analyses of organism dispersion as a function of freshwater inflow and organism associations with water masses of varying water age. The study also assessed community heterogeneity as a function of freshwater inflow and mean salinity at the sampling stations in the river.”

6.2 Overview and suggested text for Nekton sampling conducted as part of the Fisheries Independent Monitoring Program of the Florida Fish and Wildlife Conservation Commission

The consultant has done a very good job of accessing and analyzing the extensive data for nekton (fishes and free swimming macroinvertebrates) in the estuarine section of the Little Manatee River collected by the Fisheries Independent Monitoring Program (FIM) of the Florida Fish and Wildlife Conservation Commission (FFWCC or FWC). On page 93 the draft minimum flows report provides a one sentence summary of a report produced by the FFWCC for the District based on these same data collected between 1996 and 2006 (MacDonald et al. 2007).   That sentence mentions this study “demonstrated the importance of the Little Manatee River estuary for providing habitat throughout the year, as peaks in juvenile abundance of offshore spawners, juvenile nearshore spawners, estuarine spawners, and tidal-river residents occurred in different seasons (MacDdonald et al. 2007).”

Though this characterization is helpful, I suggest the minimum flows report could mention a couple other analyses or data presentations from the MacDonald et al. (2007) report. Also, it is not critical, but one page of figures from that report could be shown to highlight the types of information that are presented in it.   I suggest something like below, including the figures for Red drum shown on the following page.

“This report also provides useful analyses and tabular and graphical presentations of the abundance and distribution response of various species in relation to freshwater inflow, plus the size classes, salinity at capture, and abundance of species in different sections and habitats in the lower river.   As an example, a series of graphics for the seine catch of Red drum (*Sciaenops ocellatus*) from MacDonald et al. (2007) are shown on the following page.”   (see figure on the following page).

Sciaenops ocellatus (Red drum), Seines

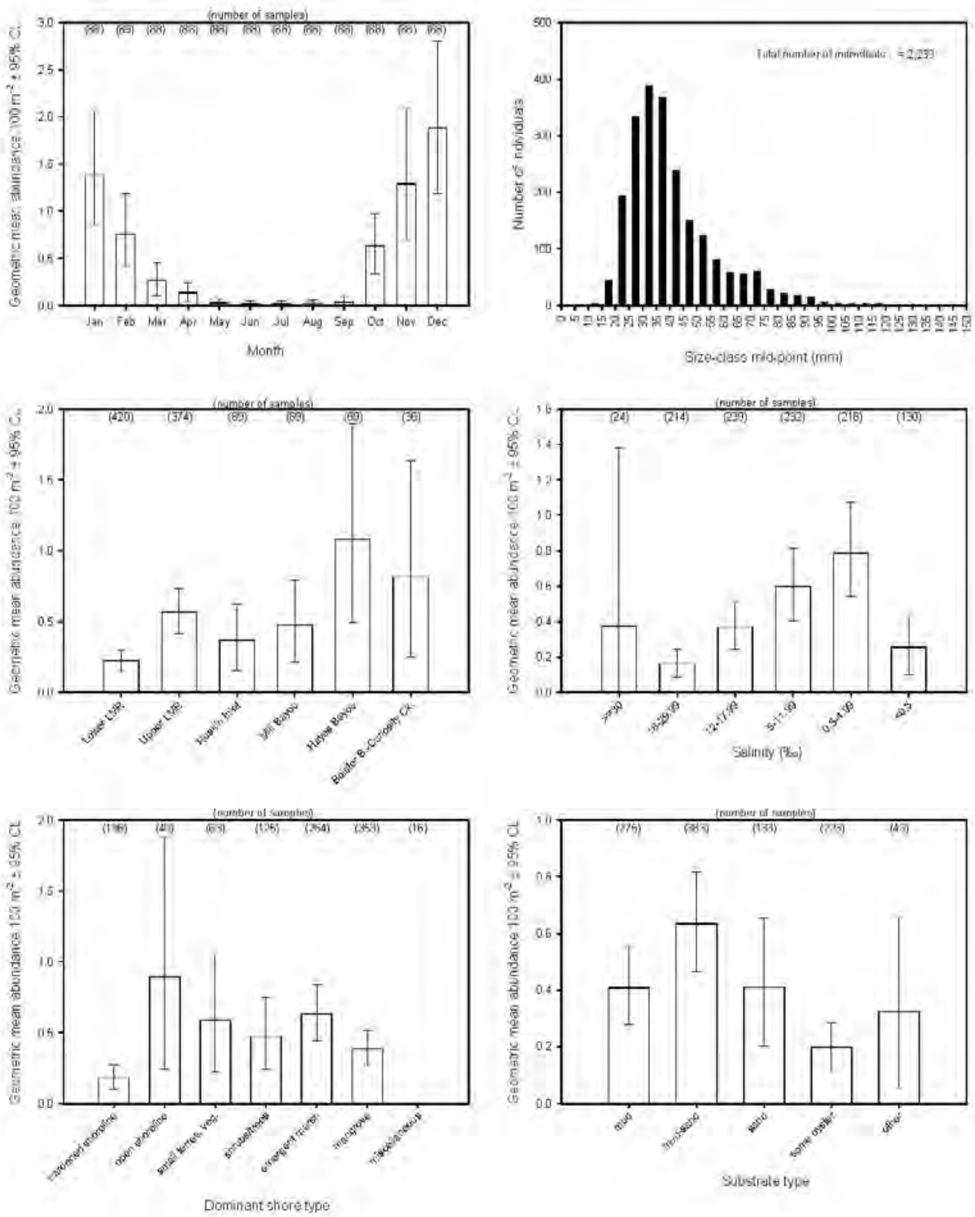


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

Figure X. Graphics for the seine catch of Red drum (*Sciaenops ocellatus*) in the Lower Little Manatee River reprinted from MacDonald et al. (2007).

6.3 Multi-River Fish Reports

Both FFWCC and USF prepared reports for the District that analyzed data pooled for the 18 or so rivers they studied for the District. The consultant might find some useful results in these reports that are relevant to the findings presented in the Little Manatee minimum flows report. References for these reports are below.

Hollander, D. and E.B. Peebles. 2004. Estuarine Nursery Function of Tidal Rivers in West-Central Florida: Ecosystem Analyses Using Multiple Stable Isotopes. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Peebles, E.B. 2005. Review of Feeding Habits of Juvenile Estuarine-Dependent Fishes and Blue Crabs: Identification of Important Prey. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Burghart, S.E. and E.B. Peebles. 2011. A Comparison of Spring-Fed and Surface-Fed Estuaries: Zooplankton, Ichthyoplankton, and Hyperbenthos. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Gunther, C.B., T.C. MacDonald and R.H. McMichael. 2011. Comparison of Nekton Community Structure Among Spring- and Surface-Fed Estuarine Rivers of Florida's West Coast. Report prepared by the Florida Fish and Wildlife Conservation Commission for the Southwest Florida Water Management District.

Verbal comments to be given at the Little Manatee River minimum flows peer review meeting, October 27, 2021

By Sid Flannery

Good afternoon. Today I would like to talk about the need to establish flow based, minimum flow blocks separately for the freshwater and estuarine sections of the Little Manatee River. I support the use of flow-based blocks, but on the Little Manatee the District based the thresholds for identifying low, medium, and two high flow blocks strictly on analyses of the freshwater section of the river, and then applied three of those same flow blocks to the estuary. Well this is a first, as the District has never done that before, and it is a serious misstep for the Little Manatee River and sets a bad precedent.

The District has previously used flow-based blocks to establish minimum flows for a number of estuarine rivers in the region. For example, last year, the District adopted minimum flows for the Lower Peace River for the second time, using three flow-based blocks that were based on salinity relationships in the estuarine section of the river.

The important thing is for these other tidal rivers, low flow cutoffs and flow-based blocks for the estuarine sections of the rivers were based on relationships of freshwater inflow to variables and parameters within the estuary.

An important factor to consider is that the response of many variables in estuarine rivers to freshwater inflow is nonlinear. Even if you take a fixed percentage of daily flow, say 20 percent, the relative effects of those withdrawals on habitats and other factors can be much greater at low flows than at high flows. Therefore, when applying the percent of flow method in a tidal river, you have to see if there are sensitive flow ranges for the response of different variables to freshwater inflow.

In that regard, I prepared a series of graphs of different variables vs. flow in the Lower Little Manatee that the District uploaded to the minimum flows WebForum this morning. I think the low flow cutoff of 35 cfs for the lower river is suitable, and similar to the 40 cfs cutoff currently in effect for the Florida Power Light withdrawals, which I was involved in evaluating years ago based on estuarine relationships.

However, the 72 cfs threshold for switching from medium to high flow blocks clearly looks to be too low for the lower river, as 72 cfs is in a very sensitive flow range for some important variables, particularly in the low salinity reaches of the river.

Also, based on gaged flows at US 301 for the last twenty years, flows would have been above 72 cfs fifty-two percent of the time. The estuarine section of the Little Manatee has a surface area of 2.2 square miles, and for the ecological functions, 72 cfs is not a high rate of inflow for an estuary of this size.

I strongly suggest the review panel recommend that flow rates to identify low, medium, and high flow blocks be evaluated separately for the fresh and estuarine sections of the Little Manatee. Given the modeling tools that have been developed, I think this could be done fairly quickly.

There is an interesting parallel to this. When minimum flows for the Lower Peace River were evaluated for the first time in 2010, the Section Manager wanted the minimum flows for the lower river to use seasonal blocks. As a check, we examined how the percent withdrawals for seasonal blocks 2 and 3 would perform if they were applied during low flows, which would have happened fairly frequently. We found that at low flows, the percentage withdrawals for seasonal blocks 2 and 3 would cause greater than a 15 percent change in salinity based habitats, but at higher flows they did not. Based on those findings, the first adopted rule for the Lower Peace River had a flow threshold that seasonal blocks 2 and 3 could not be applied until flows in the river went above 625 cfs.

That type of analysis could to done for the Little Manatee. For example, for a 30% withdrawal, for each day calculate the percent reduction in low salinity habitats relative to baseline, then plot these results vs. the corresponding rates of baseline flow. You will find that at some rate of increased flow, these withdrawals will not cause more than a 15 percent change in habitat, while at lower flows they will. You could examine these results to determine a threshold for identifying high flows. I expect that a similar approach could be taken the estuarine fish habitat analysis as well.

Also, From the water management perspective, it entirely practical to implement minimum flows rules that differ between the fresh and estuarine reaches of rivers, in fact that has been the standard District practice for years.

I hope the panel can review the documents that I have prepared for today and previous meetings, which can be found under the public comments section of the Webforum, as I think they provide very useful information pertaining to review of the draft report and the proposed minimum flows.

Finally, the Little Manatee River below Highway 301 is a State of Florida Aquatic Preserve and the crown jewel of the rivers flowing to Tampa Bay. If you are going to protect this valuable estuarine resource from significant harm, you need examine flow-based blocks that are analyzed specifically for this estuarine system.

Graphics related to the evaluation of flow thresholds for flow-based blocks for minimum flows for the estuarine section of the Little Manatee River

Submitted by Sid Flannery, October 27, 2021

Overview and organization of this document

This document provides a set of graphics and brief text related to the determination of flow rates that can serve as thresholds to identify flow, medium, and high flow blocks for minimum flows for the estuarine section of the Little Manatee River. It is being submitted as part of the independent peer review that is being conducted for the draft minimum flows report for the Little Manatee River published by the Southwest Florida Water Management District (the District).

As part of the review process, I have been commenting as a private citizen and have previously submitted three sets of documents to District staff and the peer review panel for their consideration. My comments that will be presented to the peer review panel meeting on October 27, 2021 are attached as an Appendix to this document.

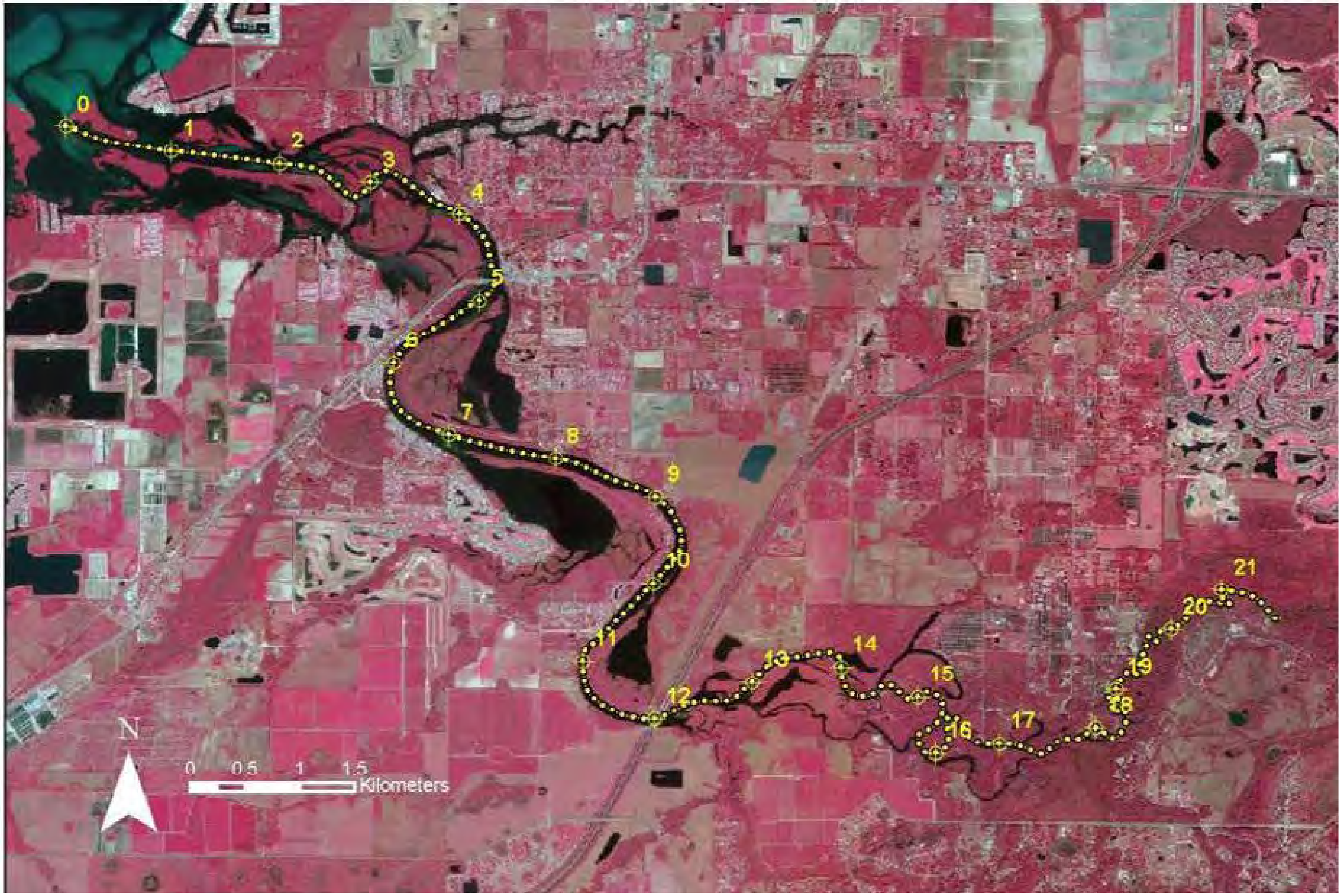
The draft minimum flows report for the Little Manatee identifies flow rates of 35 and 72 cfs to serve as thresholds to identify low, medium, and high flow blocks for the minimum flows. These flow rates were based solely on analyses of the freshwater reach of the river, but they are being applied to the estuarine reach of the river as well. As my comments in the Appendix state, the District has never done that before, and I strongly recommend that thresholds to identify flow-based blocks be evaluated separately for the freshwater and estuarine sections of the river. Those comments also describe a type of analysis that was done for the first determination of minimum flows for the Lower Peace River that I think should be performed for the Little Manatee to assess appropriate flow blocks for the estuarine reach of the river.

Given the very short time frame of the peer review process, the graphics presented in this document were put together very quickly and are by no means a comprehensive set of graphics related to this topic. I'm sure there are other relationships that could be examined. I did not have time to review biological information for the river in this regard, but plots of chlorophyll *a* vs. flow are included, which I think are very meaningful.

Many of the graphics have a reference line for 72 cfs, which was visually approximated using power point. As the Appendix states, I think the 72 cfs is clearly too low to serve as a threshold to identify the high flow block for the estuarine section of the Little Manatee. Some brief text is included with some of the graphics, particularly for chlorophyll *a*. All text was also was prepared quickly and is not a through treatment of these relationships.

For evaluating any apparent shifts or inflexion points in the data, readers should consider the following graphics essentially represent a baseline condition. That is, the application of minimum flows will reduce the flows, basically moving the relationships to the left. For example, with the proposed minimum flows, a flow of 70 cfs could be reduced to 56 cfs and a flow of 110 cfs could be reduced to 77 cfs. Therefore, in considering what might be an appropriate threshold to switch between flow-based blocks, the threshold should include a buffer that is slightly above the apparent inflexion point in order to best manage a sensitive flow range.

For reference, a centerline map of the Little Manatee River is shown on the next page.



Centerline map of the Lower Little Manatee River with distances in kilometers

Chlorophyll *a*

I have not had time to review appendices to the minimum flows report the deal with water quality, so I don't know if they contain graphics or analyses similar to what I have presented below. Regardless, it is very informative to plot chlorophyll *a* concentrations versus freshwater inflow in tidal rivers. When doing so, the relationships with inflow in the Little Manatee are similar to what have been observed in other tidal rivers for which there are abundant chlorophyll data (Lower Alafia, Lower Peace), with one difference that is discussed on the following page.

As part of the peer review process, I submitted a document titled *Overview and suggested text to describe technical reports about the Little Manatee River* that was posted on the minimum flows WebForum under public comments. That document provides citations and brief descriptions of District sponsored studies of phytoplankton related parameters (including chlorophyll *a*) in the estuarine reach of the Little Manatee, with one study also including data from the Lower Peace and Alafia rivers. I have not had time to access those data, but can make some comparisons and conclusions based on previously published findings.

The graphics below are taken from water quality sites monitored the Environmental Protection Commission of Hillsborough Country (EPCHC, often referred to simply as EPC) that were presented in the draft minimum flows report. The EPC is to be highly commended for expanding their water quality sampling network to add three new data collection sites in the Little Manatee, starting in 2009. These data, plus the longer-term site at Station 112, provide very extensive monthly water quality data at those four locations in the tidal Little Manatee River.

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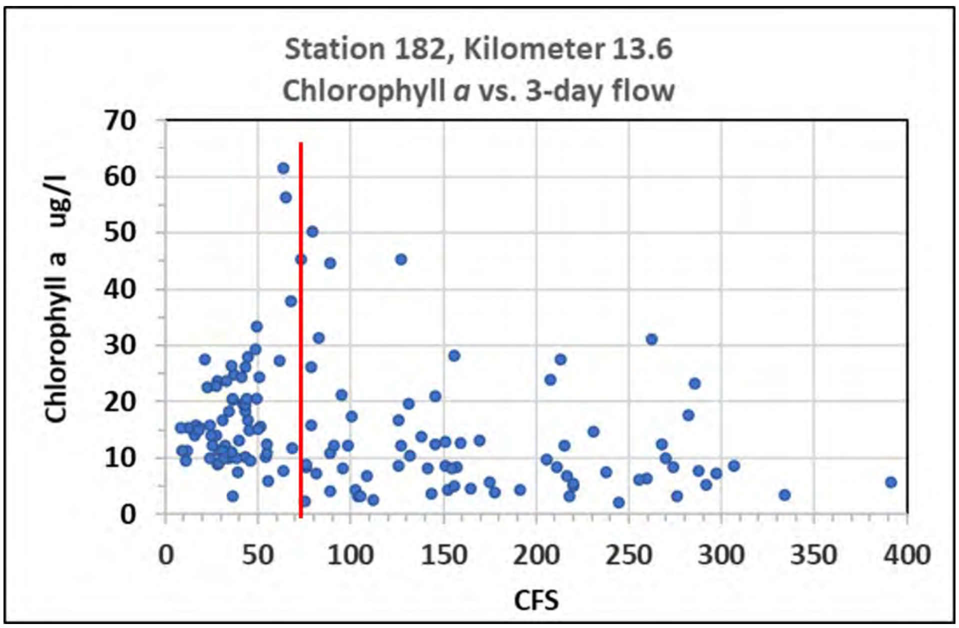
The figure below is from station 182, located in the braided oligohaline section of the river near kilometer 13.6. The pattern that is shown is typical of the upstream reaches of tidal rivers, in that high chlorophyll concentrations are not frequently observed at very low flows (20 to 30 cfs below) probably due to low nutrient loading. However, when flows increase, high chlorophyll concentrations can occur due to greater nutrient loading, with residence times that are still fairly long allowing phytoplankton blooms to develop.

However, at higher flows, high chlorophyll *a* concentrations are not frequently observed as water is moving through these upper reaches of the tidal river fairly rapidly with low residence times. Water color also increases at high flows, which limits light penetration. This tendency would be shown more clearly if the horizontal axis below was expanded to include higher flows, but the emphasis on this graphic is on lower flows. Three-day flow is the average flow for the day of sampling and the preceding two days.



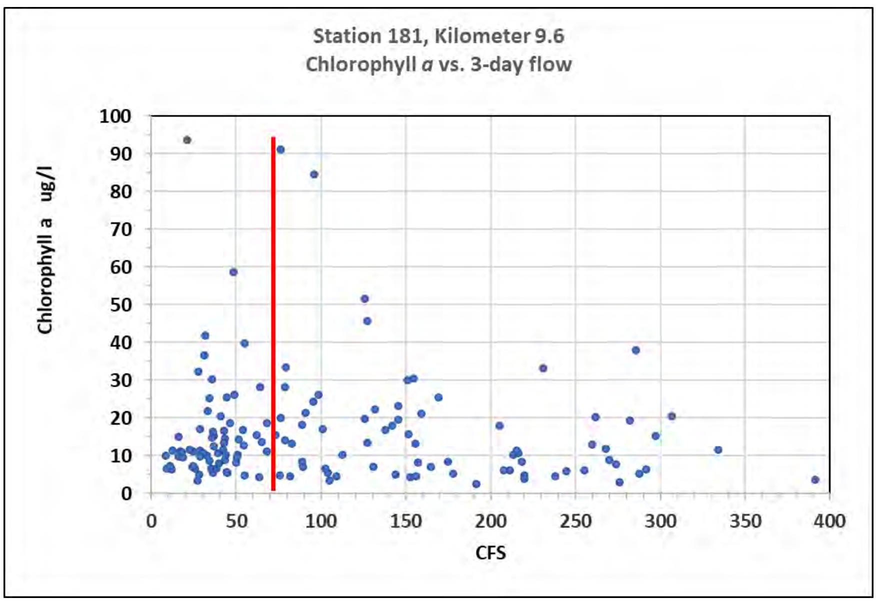
A red reference line is shown in the figure above at approximately 72 cfs, which is the threshold to switch from the medium to high flow block in the proposed minimum flows, which will allow a change in percent withdrawals from 20 percent to 30 percent. Again, this threshold was based solely on analyses of the freshwater reach of the river upstream of US highway 301. As shown in the figure above, 72 cfs is right in the middle of the flow range of when very high chlorophyll *a* concentrations can occur at this location.

What is interesting about the Little Manatee is that peak chlorophyll *a* concentrations often occur in very low salinity waters, even close to the tidal interface between fresh and brackish waters. As described in the *Overview and suggested text* document, peak chlorophyll *a* concentrations often occur in mesohaline waters in the tidal reaches of the Peace and Alafia Rivers. It appears

this difference in the Little Manatee is that water slows down considerably in the braided section of the river upstream of I-75, with longer residence times there compared to the upper reaches of other tidal rivers.

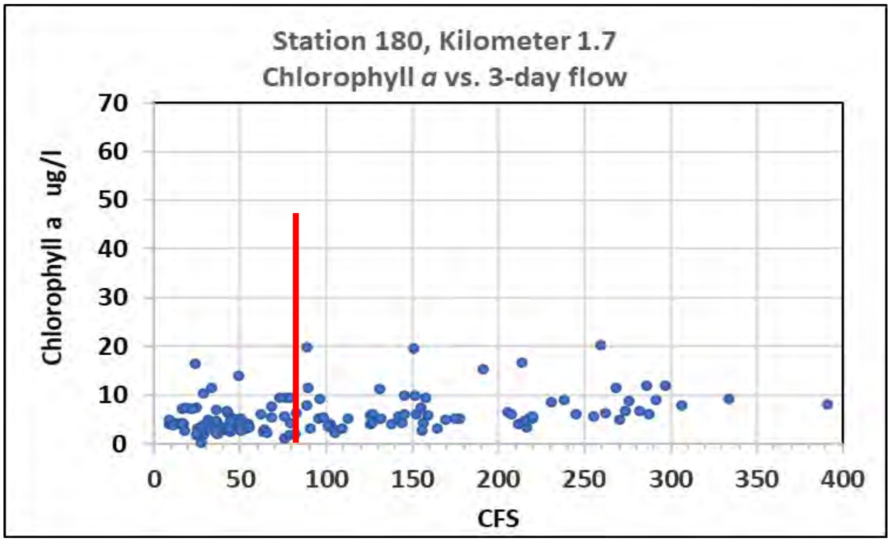
As part of the development of the EFDC hydrodynamic model for the Little Manatee, Drs. Huang and Liu of Florida State University did residence time simulations for the river that are summarized in the *Overview* document that was previously submitted. The District has also done residence time analyses in the Lower Peace and Alafia Rivers, with the minimum flows report for the Lower Alafia presenting a good discussion of the relationships of residence time to chlorophyll *a* in that river.

The relationship of flow to chlorophyll *a* will change at different locations in a tidal river due to changes in the volume of the estuary, residence time, available nutrients, light penetration and tidal exchange with the bay. Plots are presented for EPC stations 181 and 180 in the following discussion, with data shown below for station 181, which is located near kilometer 9.6.



The highest peak chlorophyl *a* concentrations in the Little Manatee recorded by the EPC are at Station 181. High concentrations above 80 µg/l were limited to when three-day average flows were less than 100 cfs, with two concentrations above 90 µg/l at flows below 77 cfs. The minimum flows report has a time series plot of yearly geometric means for chlorophyll *a* that shows that during some years, the FDEP impairment threshold of an annual geometric mean of 11 µg/l is exceeded at this station. I agree with some review panel comments that this threshold is probably too low for productive tidal rivers. However, individual chlorophyll *a* concentrations can be strongly affected by the rate of freshwater inflow, and the occurrence of problematic very high chlorophyll concentrations from large phytoplankton blooms can be exacerbated by flow reductions in sensitive flow ranges in various sections of a tidal river.

The graph below is for station 180, which is located near 1.7 kilometers upstream of the mouth of the river. For easier comparison to the other figures, the Y axis is taken up to 70 µg/l. It is obvious that chlorophyll *a* concentrations are much lower at this location and have a very different relationship with freshwater inflow, due likely to the volume of the estuary, tidal flushing from the bay, and limited available nutrients at low flows. However, at this location there is a tendency for slightly higher chlorophyll *a* concentrations at higher flows, as nutrient delivery from the watershed is increased.



It should be noted that the Little Manatee River has been enriched with nitrogen due to human activities in the watershed. The draft minimum flows report found that with the exception of organic nitrogen at one site, trends for various forms of nitrogen have either been showing no trend or decreasing at EPC stations in the lower river in recent years. However, as described in the document I submitted titled *Technical review of the Little Manatee River flow characterization,* as part of a large study of the Little Manatee River watershed that was conducted by the District and other agencies in the late 1980s, long-term nitrogen data indicated that agriculture activities have increased nitrate concentrations in the river considerably compared to decades prior to the mid-1970s. Given that the river is nitrogen enriched, it is important to carefully manage the effects of flow reductions on excessive phytoplankton blooms and high chlorophyll *a* concentrations in the river.

Again, I have not had time to review the appendices to the minimum flows report that deal with water quality, but the data for stations 181 and 182 in the mid to upper reaches of the tidal river indicate the 72 cfs threshold to switch to 30 percent withdrawals is too low, as it could exacerbate excessive phytoplankton blooms in that part of the river. New analyses should be conducted to develop a threshold for a high flow block for the estuary based on relationships in the lower river, rather than from the freshwater reach where the 72 cfs flow threshold was derived.

SALINTY

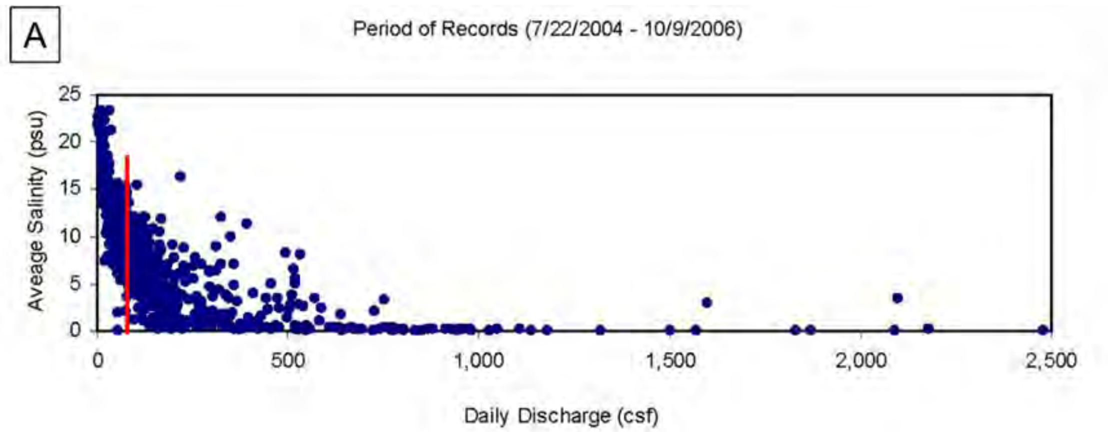
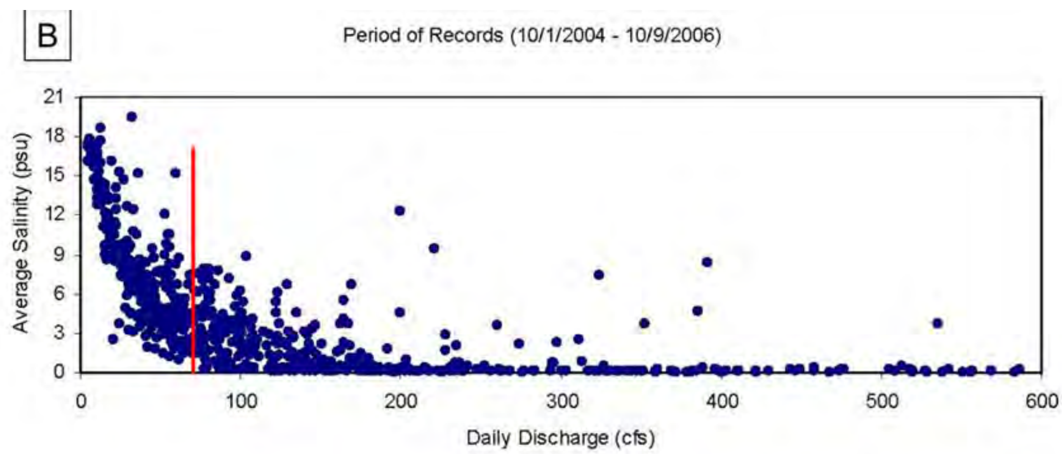


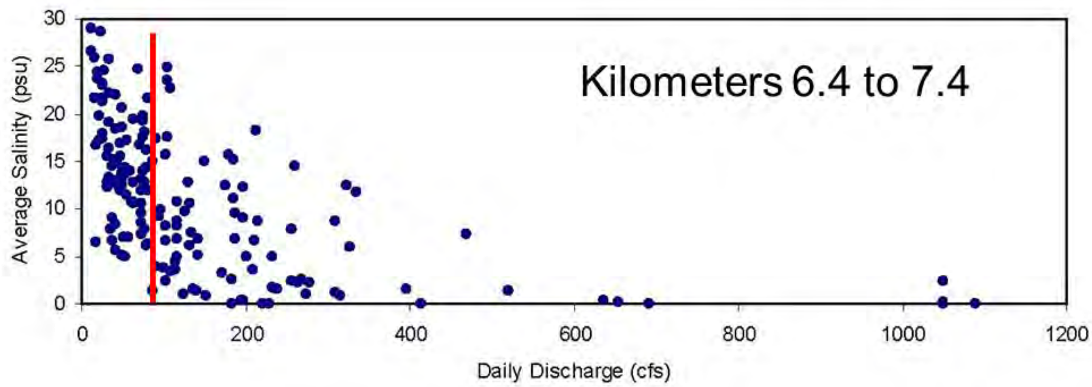
Figure 15. Salinity versus daily discharge for the USGS 02300546 gage, Little Manatee Rive at Ruskin, FL (RKM = 8.3)

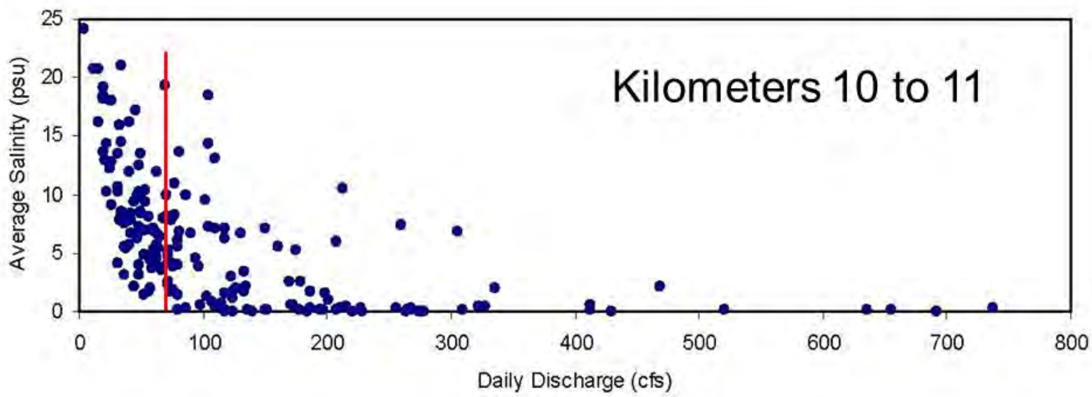


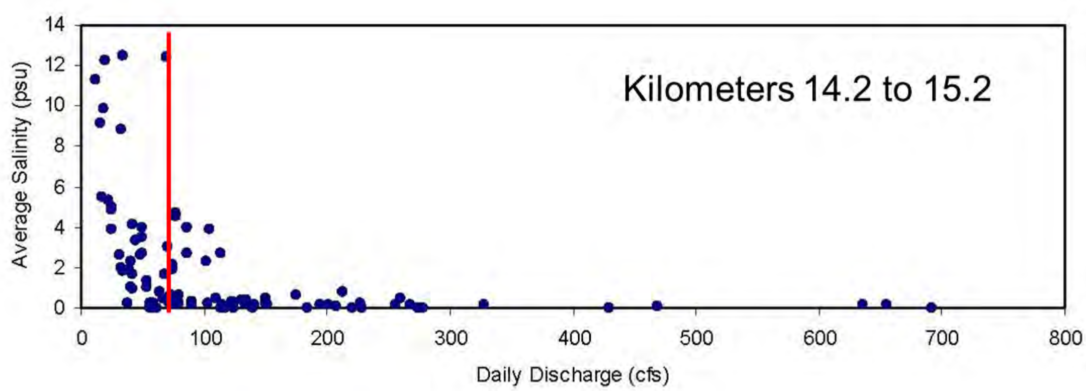
'igure 16. Salinity versus daily discharge for the USGS 02300542 gage, Little Manatee River at I 75 near Ruskin, FL (RKM = 12.1)

Red reference lines inserted at approximately 72 cfs

The USGS operated a series of continuous salinity recorders in the river to support the development of the EFDC hydrodynamic model for the river during 2004 to 2006. Plots of average daily salinity from the top and bottom sensors at each location are shown above for two recorders located at kilometers 8.3 and 12.1. The recorder at 12.1 is at the I-75 bridge, which is just downstream of the braided zone of the river that contains abundant oligohaline marshes that grade upstream to tidal freshwater marshes and forest. Salinity is very responsive to flow in the range of 72 cfs at this location, with the response dampening at higher flows.

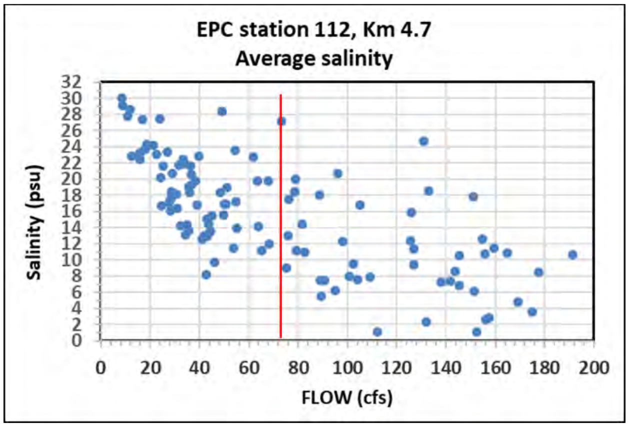


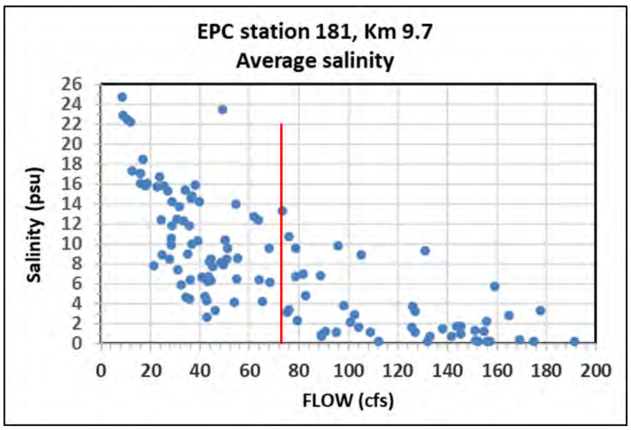


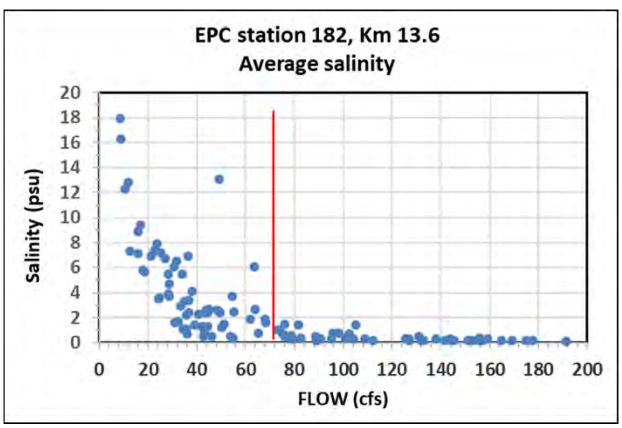


Red Line reference lines inserted at approximately 72 cfs

These graphics on this page are average salinity values from vertical profiles taken by the District and other parties between March 1985 and October 2006. I don't think that 72 cfs represents a good high flow threshold to increase withdrawals, as salinity is very responsive to flow reductions at these sites near that flow value, with a dampened and flatter response at higher flows. Considering that for the most recent twenty year period, 72 cfs has been exceeded 52 percent of the time, a higher threshold to identify high flows would be more appropriate for this estuarine system.







The graphics above are from the Hillsborough County EPC's water quality stations in the tidal river that have been monitored since 2009. At these stations, EPC measures salinity at top, middle and bottom depths, with the average of these values shown above. For station 181 (middle graph), 72 cfs again appears to be too low to serve as a high flow threshold compared to a higher flow rates. The data at station 182 seem more supportive of the 72 cfs threshold, but these salinity values are lower than some average values for kilometers 14.2 to 15.2 reported by the District shown on the previous page. This might be because the District frequently sampled near high tide, or possibly because the District took salinity profiles at surface and 1 meter intervals.

Management Approach for Unimpounded Rivers **1321**

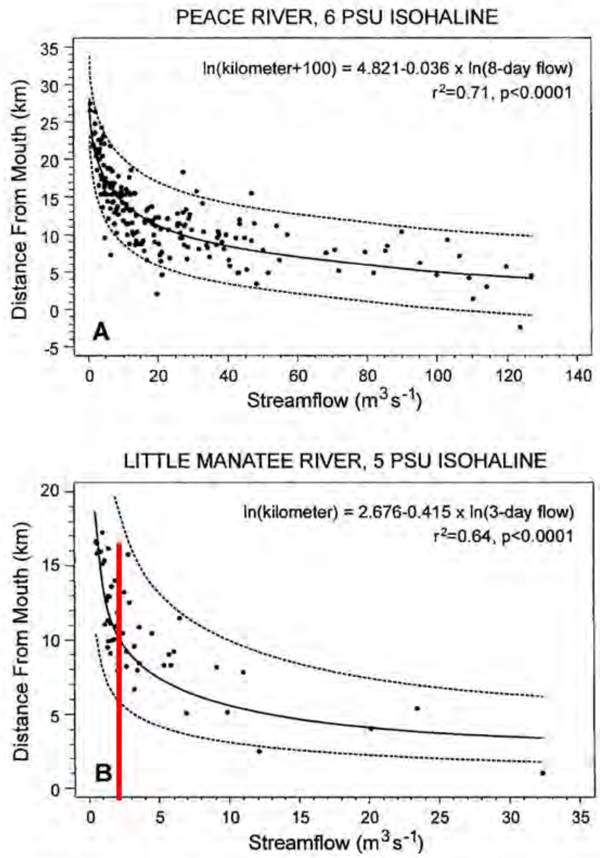


Fig. 3. Regressions of freshwater inflow with (A) the location of the 6 psu surface isohaline in the Peace River (adapted from Janicki Environmental 2001) and (B) the location of the 5 psu surface isohaline in the Little Manatee River (adapted from Peebles and Flannery 1992), with the 95% confidence limits for the predicted values. Regressions are plotted using non-transformed data.

The Figure above shows the strong nonlinear response that salinity isohalines can have with regard to changes in freshwater inflow. The red reference line for the Little Manatee River is near 2 m3/sec, which is equivalent to a flow of 72 cfs. Note there are three occurrences of the surface 5 psu isohaline between kilometers 13 and 16 near a flow rate of 72 cfs and others just below that flow rate. This graphic was taken from an article by Flannery et al (2002) in the journal *Estuaries* that dealt with the percent of flow method, which is referenced in the District's draft minimum flows report.

It should be noted the Little Manatee was one of the three estuarine rivers that provided data and findings that were very important to the initial development of the percent-of-flow method for regulating withdrawals and determining minimum flows for tidal rivers.

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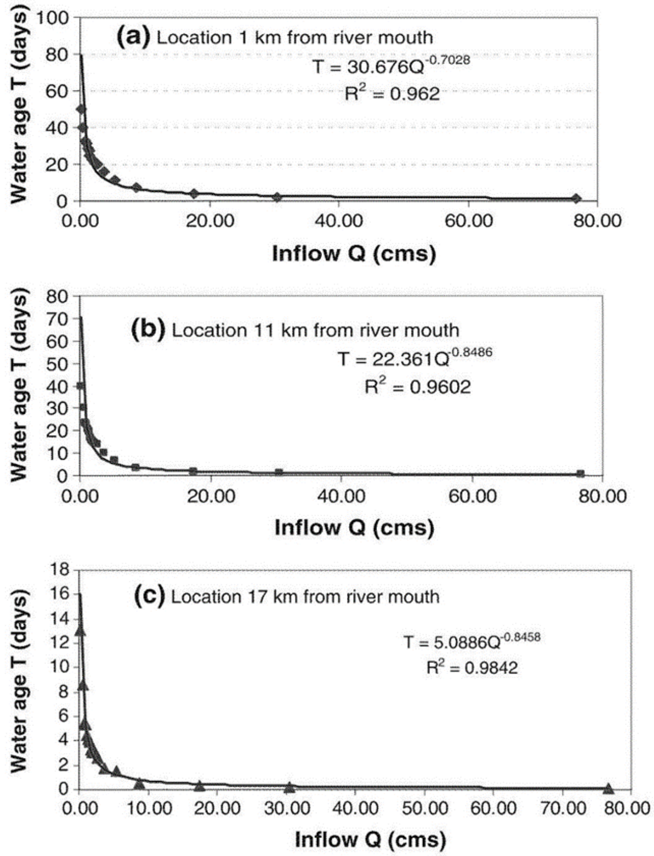


Fig. 9 Tidally-averaged water ages T (days) in responses to river inflows $Q(\mathrm{m}^3/\mathrm{s})$ at different locations along the river main channel. Least-square regressions were done by using power law. Data were obtained from hydrodynamic model simulations

The graphic above was taken from a journal article about water age simulations in the Little Manatee River by Huang et al. (2010) that is cited in the *Overview* document. Water age is a form of residence time, that is the travel time of fresh water from the head of the estuary to a given location, with three sites shown above. The horizontal axes in these figures cover a very high range of flows in m3/sec (for reference 72 cfs is equal to about 2 m3/sec and 4 m3/sec equal to about 141 cfs). Even so, the strong nonlinear response of water age at low flows river is clearly apparent at these locations. The Lower Alafia minimum flows report found that water age can be an important factor affecting very high chlorophyll concentrations.

I did not have time to analyze relationships between chlorophyll *a* and water age in the Little Manatee, but the relationships of chlorophyll *a* with flow shown on pages 5 and 6 are probably due in part to differences in water age at low, medium, and high flows. As such, the nonlinear response of residence time and water age to freshwater inflow should be considered in determining what are truly high flows for the estuarine section of the river. In my opinion, 72 cfs is too low a value for identifying high flows in that regard.

Finally, it interesting to note that the peer review panel for the previous minimum flows report included a graphic that indicated that simulations of residence time and water age can be important for assessing phytoplankton abundance in estuarine rivers. The graphic below was taken from page 9 in that report, with red arrows inserted to highlight the suggested work for hydrodynamic modeling for salinity and water age analysis.

I believe that in fairly short order, the data for the estuarine reach of the Little Manatee River can be reassessed to come up with a threshold to identify high flows that much better protects the lower river from significant harm, compared to the proposed 72 cfs threshold which is clearly too low.

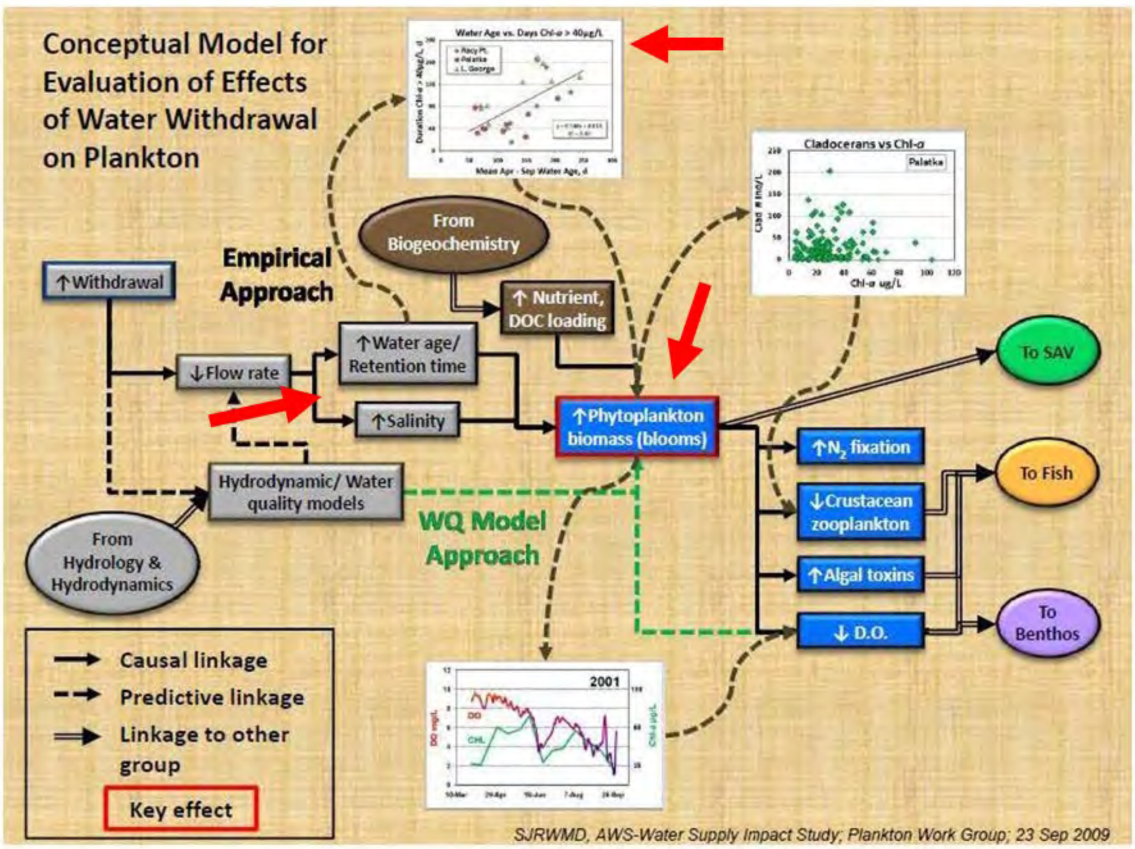


Figure 2. Multidisciplinary studies for assessing water withdrawal impacts on plankton. (SJRWMD 2009)

Figure adapted from Figure 2 in the peer review report for the previous minimum flows report for the Little Manatee River

Verbal comments for November 3 Little Manatee River minimum flows peer review meeting.

Prepared by Sid Flannery (ADDED PARAGRAPHS IN BLUE)

Today I would like to speak about how minimum flows are implemented using flow-based blocks. The review panel is considering whether the flow blocks should, or should not be, the same for the fresh and estuarine sections of the Little Manatee.

Well, they are not entirely the same in the currently proposed rule, which is shown in the table on your screen (below). Note than in Block 3 the freshwater minimum flows have a second high flow threshold of 174 cfs that is highlighted in yellow, which is not assigned to the estuarine minimum flows. You can subtract the numbers shown in red to calculate the percent withdrawals in each block. So, for block 3 in the freshwater section, flows cannot be reduced by 13 or 11 percent depending on the rate of flow   Further downstream, flows to the lower river cannot be reduced by more than 30 percent at flows above 72 cfs.

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		

So, lets hypothetically change the threshold to switch from block 2 to block 3 for the lower river to 120 cfs. We still have the 13 and 11 percent limits to withdrawals in block 3 in the freshwater section, but flow reductions to the lower river cannot exceed 20 percent until flows go above 120 cfs, when percent withdrawals can increase to 30 percent. This is very simple and straightforward and poses no water management complications whatsoever.

There are two factors that typically make the percent of flow method very workable within the District. Estuaries in the region are generally not as sensitive to ecological impacts from flow reductions as are freshwater rivers, and minimum flows adopted for estuarine rivers usually allow for the same, or more often, greater percent withdrawals than for the corresponding freshwater sections. And, it is an obvious point, but the estuary is always downstream. If these two types of ecosystems were interspersed along the river channel it could be complicated, but that is not the case.

If we are to protect both the freshwater and estuarine sections of our rivers, it is critical to first evaluate the most effective flow blocks separately for these two very different ecosystems, then write the rules accordingly. Based on years of experience applying the percent of flow method to existing water use permits, I don't think that having separate flow blocks for the fresh and estuarine sections of a river would cause complications for water management, and changing the block 3 threshold for the lower Little Manatee certainly would not.

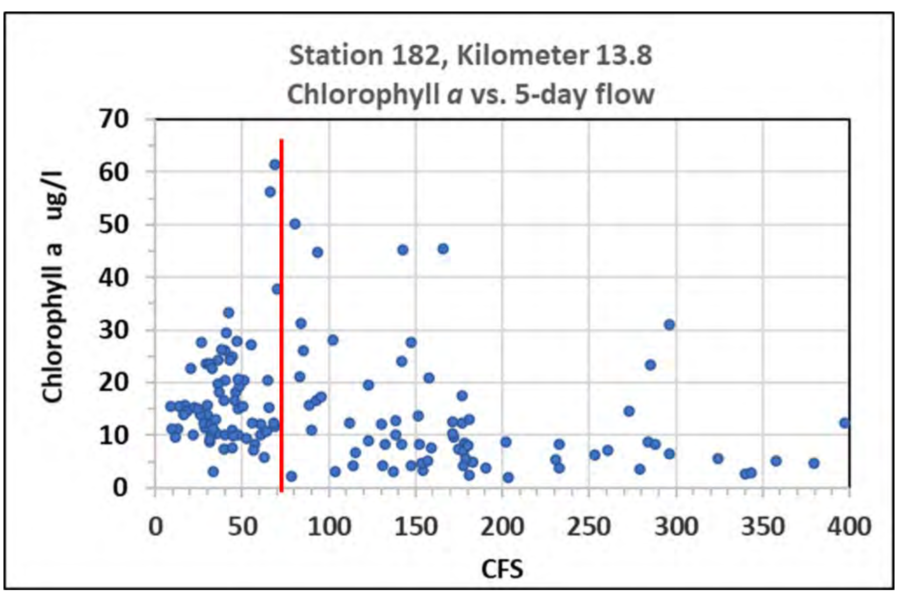
For years the District has included flow-based blocks in estuarine minimum flow rules based on analyses of relationships within those tidal rivers. However, with the Little Manatee, the District for the first time has assigned flow blocks developed for the freshwater section of the river to the estuarine section as well.

Assigning 72 cfs as the high flow block for the estuary does not allow for the evaluation of important ecological relationships in the lower river above that flow rate, which by the way, was near the median flow for the river for the last 20 years. Many of these relationships at higher flows are important to the ecological functions of the lower river, which could be evaluated to come up with a revised block 3.

For example, last week Dr. Ernst Peebles said that the combined zooplankton/ichthyoplankton catch in the lower river showed a shift in community heterogeneity around 100 cfs. Last week I also submitted to the WebForum a series of plots of salinity and other parameters vs freshwater inflow that showed these parameters respond strongly to freshwater inflow near 72 cfs, but less acutely at slightly higher flow rates, which could be evaluated to develop a revised block 3.

For example, upstream of I-75 there are widespread oligohaline marshes dominated by freshwater plants that have some salt tolerance such as sawgrass and cattails. The inundation of these marshes with fresh water in the wet season is important to their health and productivity. Plots of salinity versus flow in the graphics document show that salinity is very sensitive to flow reductions at 72 cfs in this reach of the river, but not so much at flows above 100 to 150 cfs.

The graphics document also includes plots of chlorophyll *a* concentrations versus flow at three locations in the river. Due to a combination of factors, the response of chlorophyll *a* vs. flow differs greatly between the lower and upper sections of the tidal river. At the two uppermost stations, 72 cfs is in the flow range where chlorophyll *a* is reaches peak values in the range of 40 to 90 ug/l (data from kilometer 13.8 shown below, some higher values observed at kilometer 9.6). It could be argued whether that represents an ecological imbalance or not, but in my opinion, 72 cfs is not a flow rate where there should be an increase in the percent withdrawal.



Also, a very useful analysis is to examine daily output from the EFDC model see in what flow range does a specific percent withdrawal rate cause usually reductions in low salinity habitats greater than 15 percent, similar to what was done for the Lower Peace River. I suspect the fish habitat analysis could be used in a similar manner.

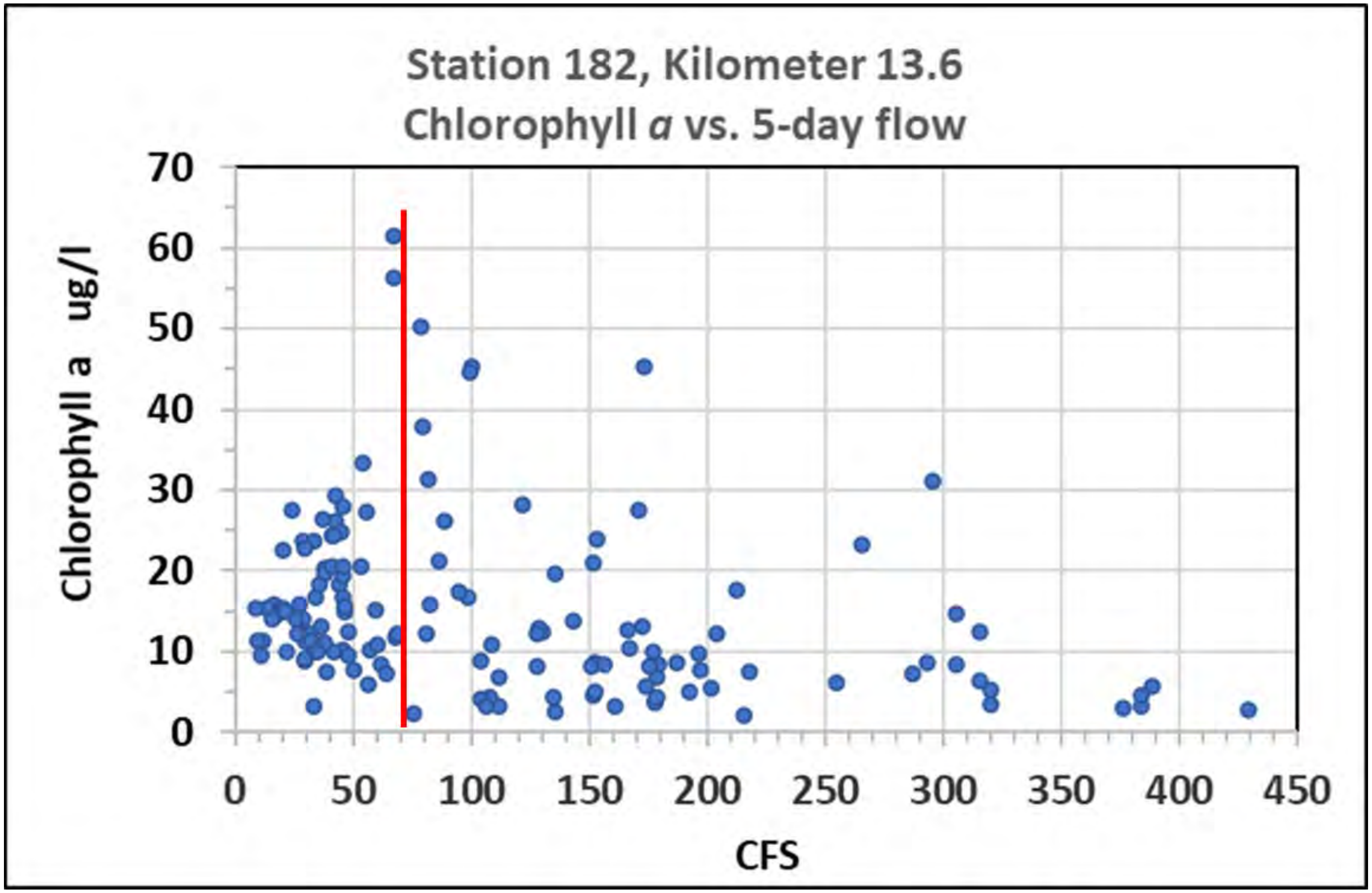
In closing, over the last 30 years the District had spent considerable time, effort, and money to conduct detailed technical investigations of the relationships of streamflow to the ecology of freshwater and estuarine rivers. In doing so, it has developed the very progressive percent of flow method, which has been successfully applied to many rivers.

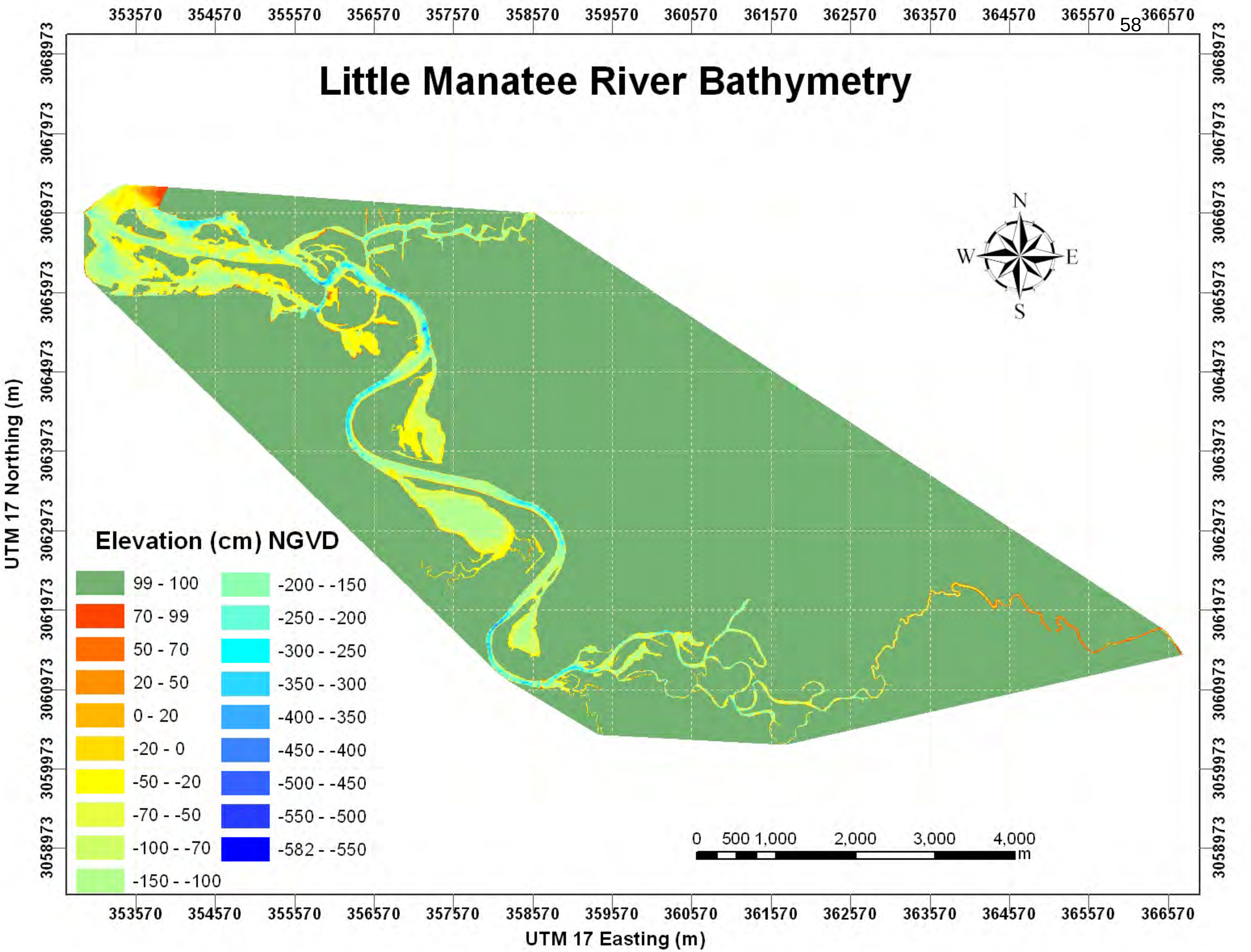
However, the percent of flow method is at a critical juncture right now. The topic of whether the flow blocks have to be the same for fresh and estuarine sections of rivers is extremely important and the Little Manatee could be viewed a precedent. Based on a number of ecological factors and practical water management considerations, I strongly believe that flow blocks for fresh and estuarine sections of rivers need to be evaluated separately. At a minimum, you don't want to simply apply the blocks that were developed for the freshwater section of a river to the estuary, as was done for the Little Manatee.

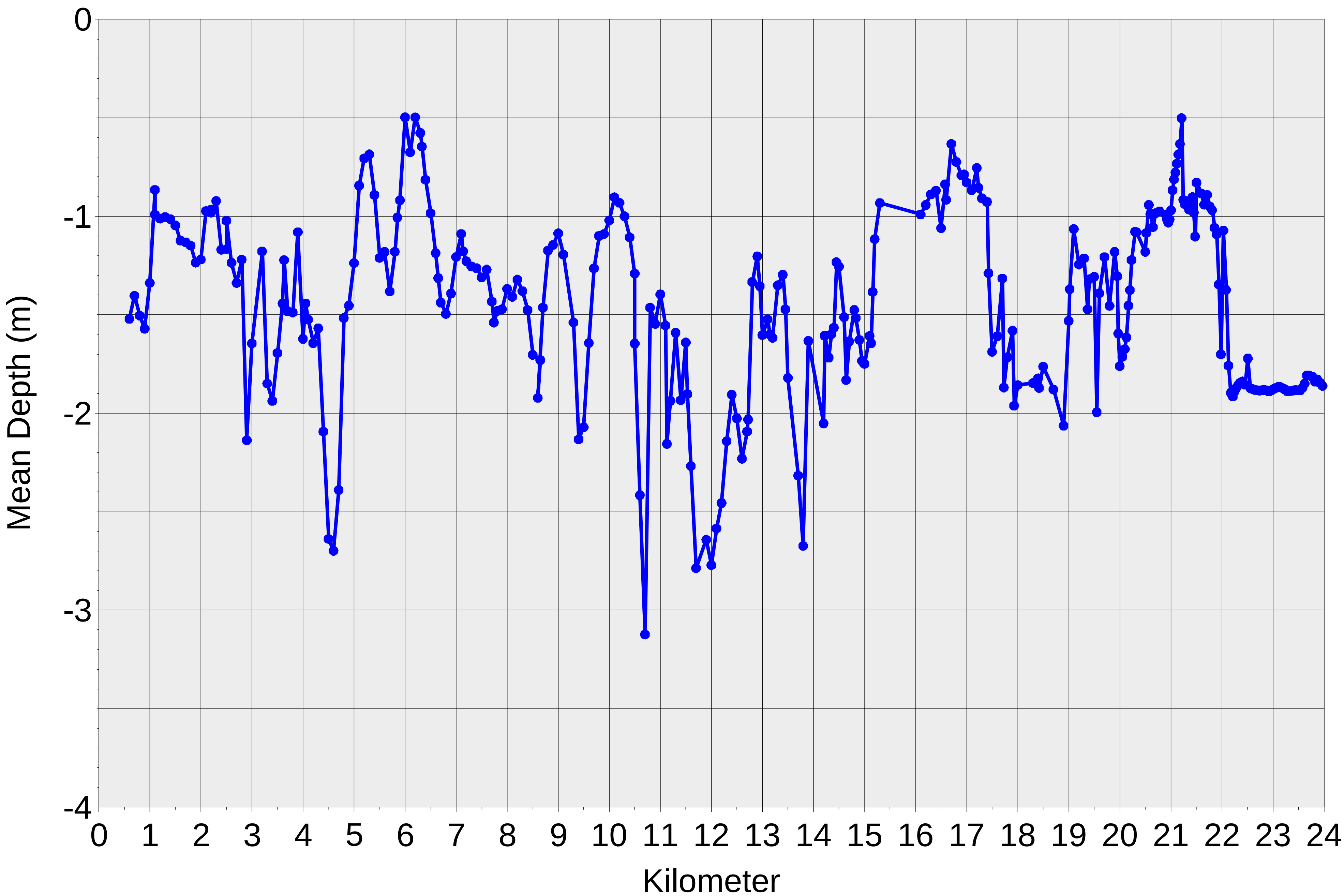
It looks like the review of the Little Manatee River minimum flows report is on a very fast track. I suggest the panel take additional time to consider further the flow blocks issue. The panel could get input from other parties, continue discussions with District staff, and consider some other analyses. There is no real need to hurry on this minimum flow on this very valuable river, and this is a critical factor that needs to be thoroughly assessed.

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

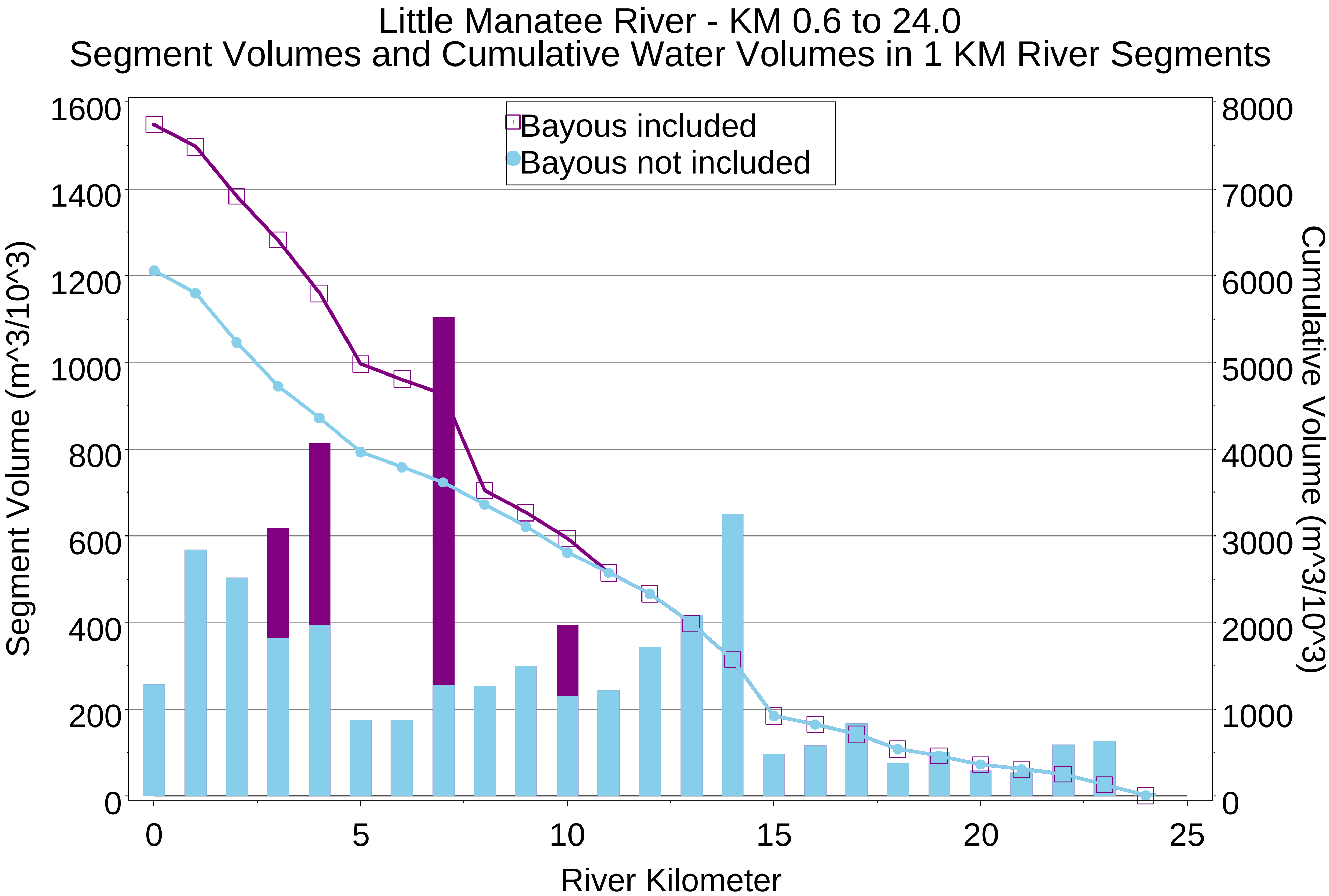
	Block 1 (< 35 cfs)	Block 2 (> 35 cfs and < 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	87% of the flow on the previous day when the previous day's flow was > 72 cfs and < 174 cfs, or 89% of the 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		


Station 182, Kilometer 13.6
Chlorophyll *a* vs. 5-day flow
Chlorophyll a ug/l
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
450
CFS

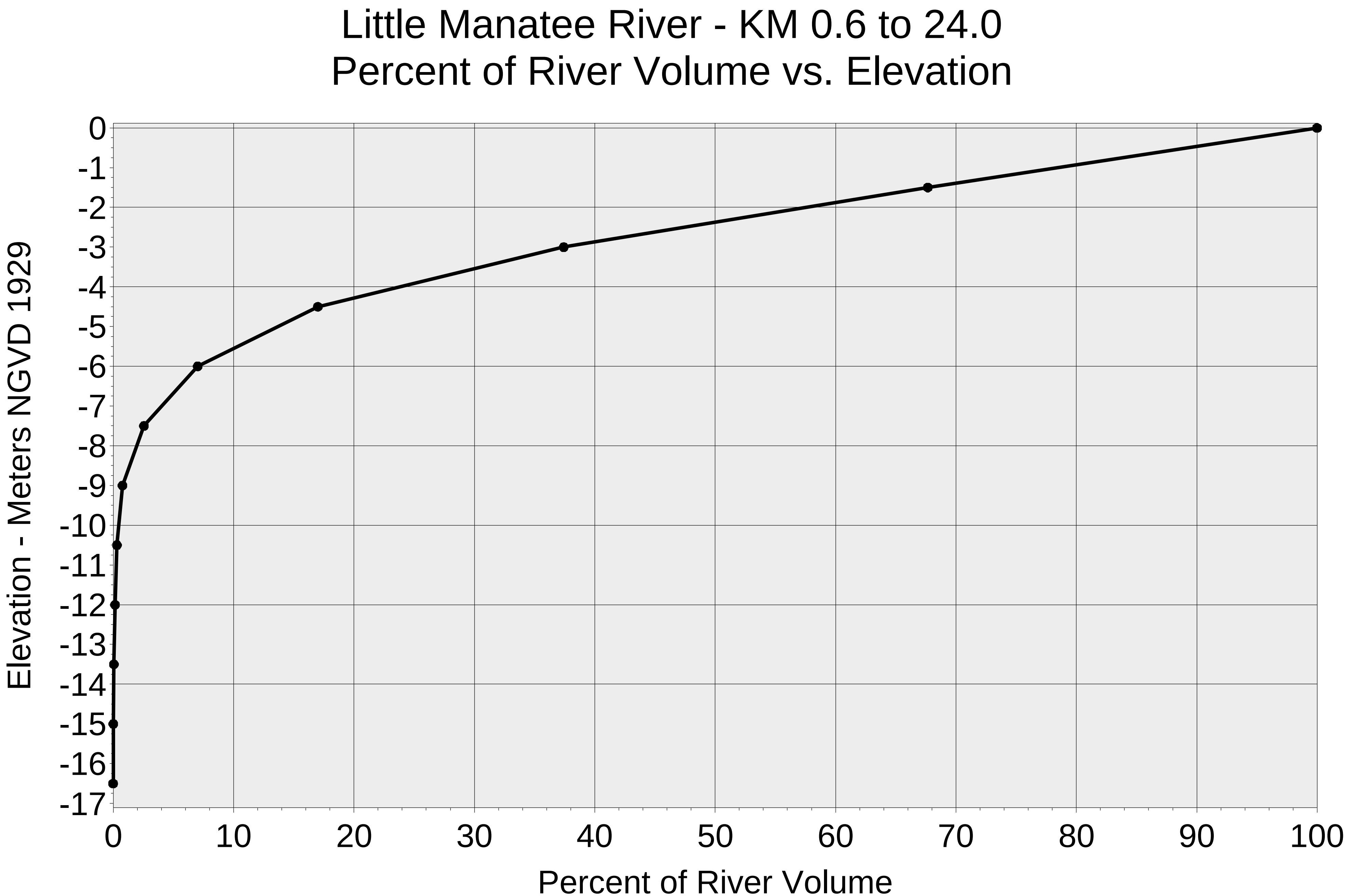

Little Manatee River Bathymetry
Elevation (cm) NGVD
99 - 100
70 - 99
50 - 70
20 - 50
0 - 20
-20 - 0
-50 - -20
-70 - -50
-100 - -70
-150 - -100
-200 - -150
-250 - -200
-300 - -250
-350 - -300
-400 - -350
-450 - -400
-500 - -450
-550 - -500
-582 - -550
N
S
E
W
0
500
1,000
2,000
3,000
4,000
m
353570
354570
355570
356570
357570
358570
359570
360570
361570
362570
363570
364570
365570
366570
3068973
3067973
3066973
3065973
3064973
3063973
3062973
3061973
3060973
3059973
3058973
UTM 17 Northing (m)
UTM 17 Easting (m)

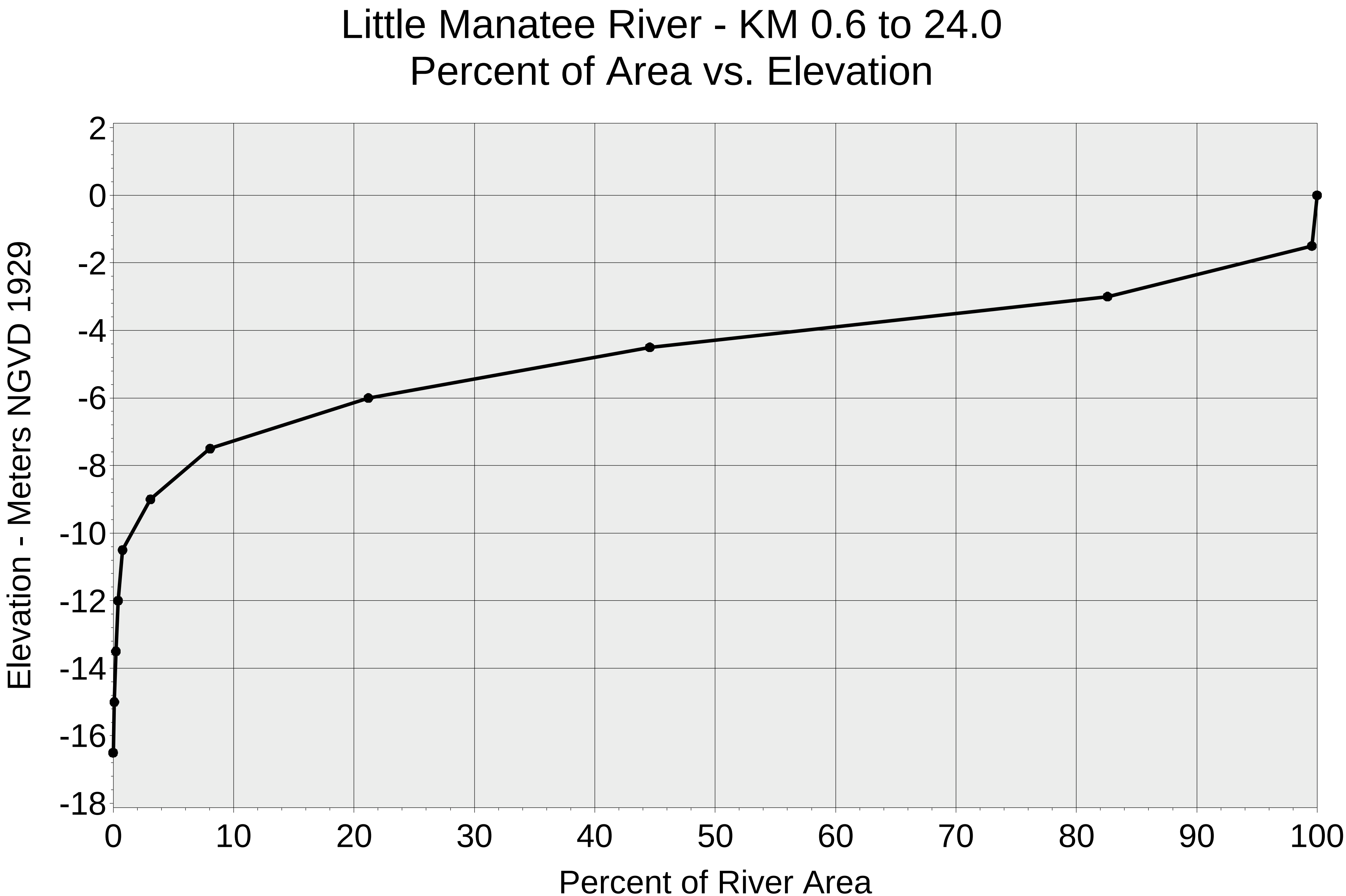


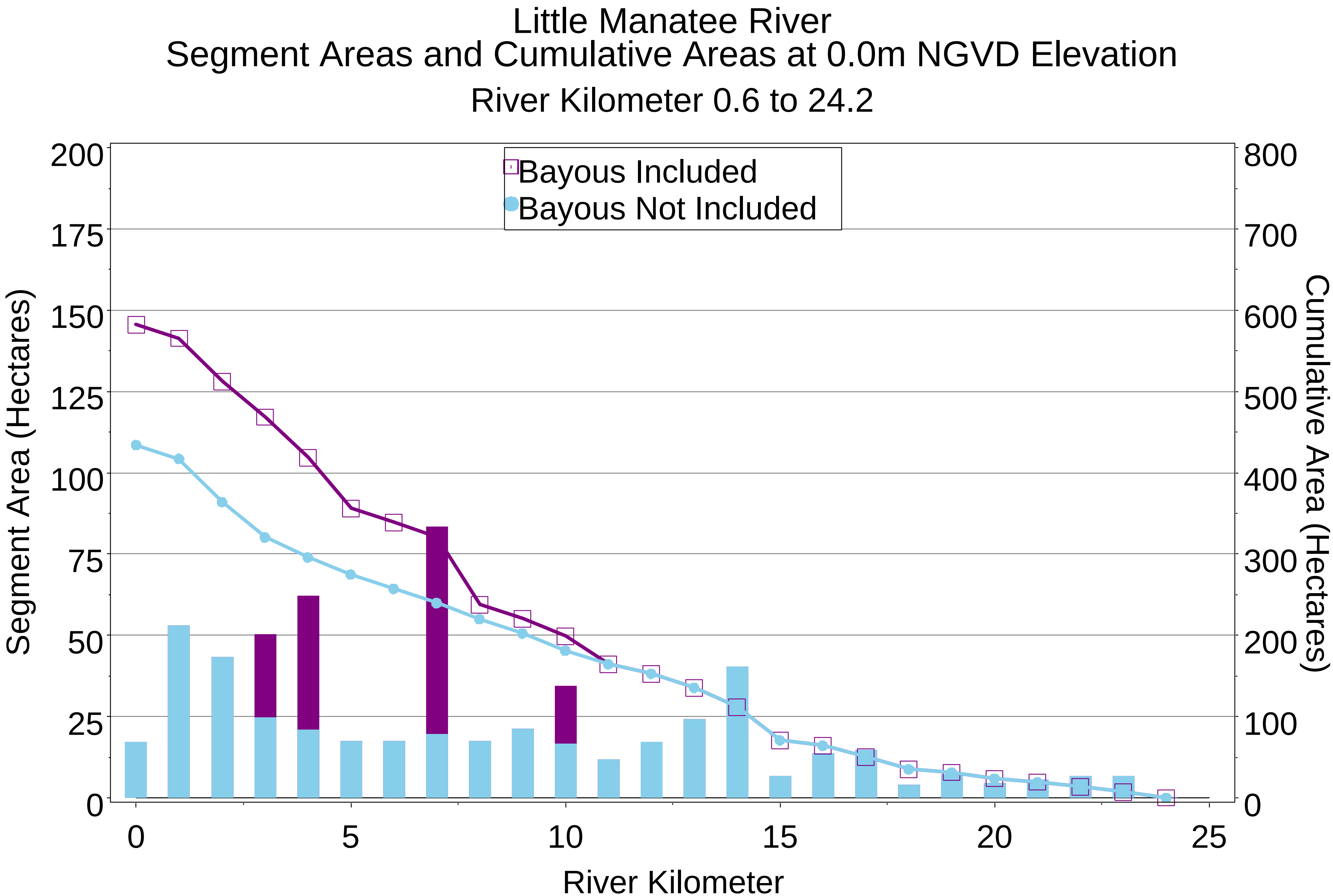
Mean Depth (m)
0
-1
-2
-3
-4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Kilometer



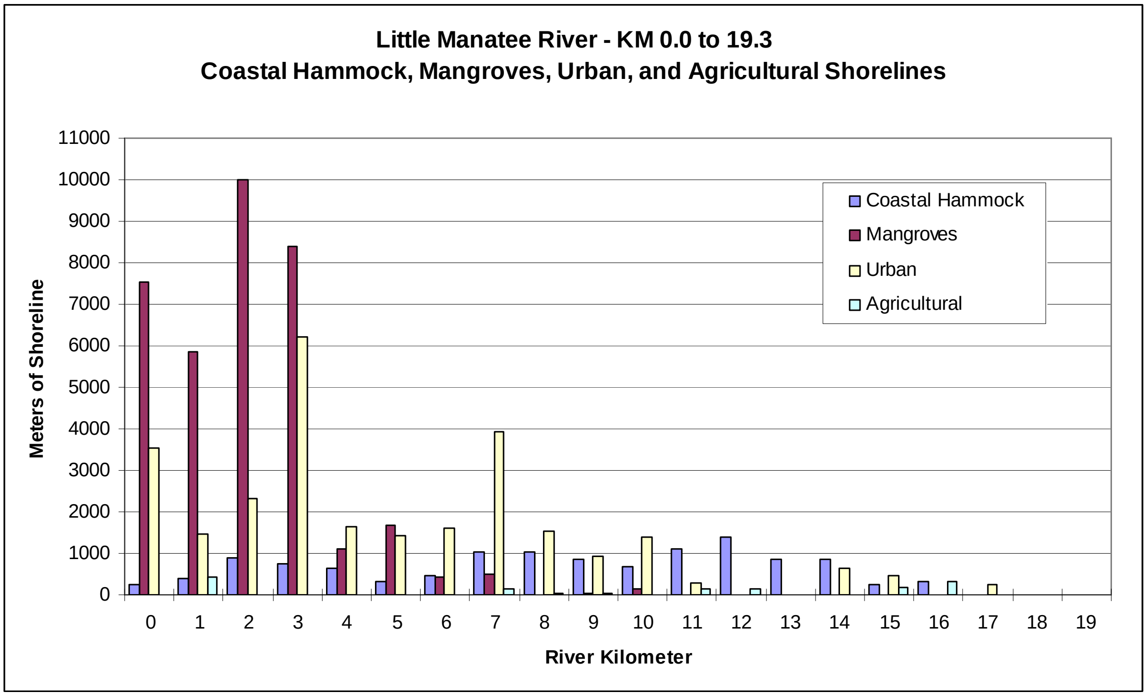
Little Manatee River - KM 0.6 to 24.0
Segment Volumes and Cumulative Water Volumes in 1 KM River Segments
Bayous included
Bayous not included
Segment Volume (m^3/10^3)
Cumulative Volume (m^3/10^3)
River Kilometer
0
200
400
600
800
1000
1200
1400
1600
1000
2000
3000
4000
5000
6000
7000
8000
5
10
15
20
25

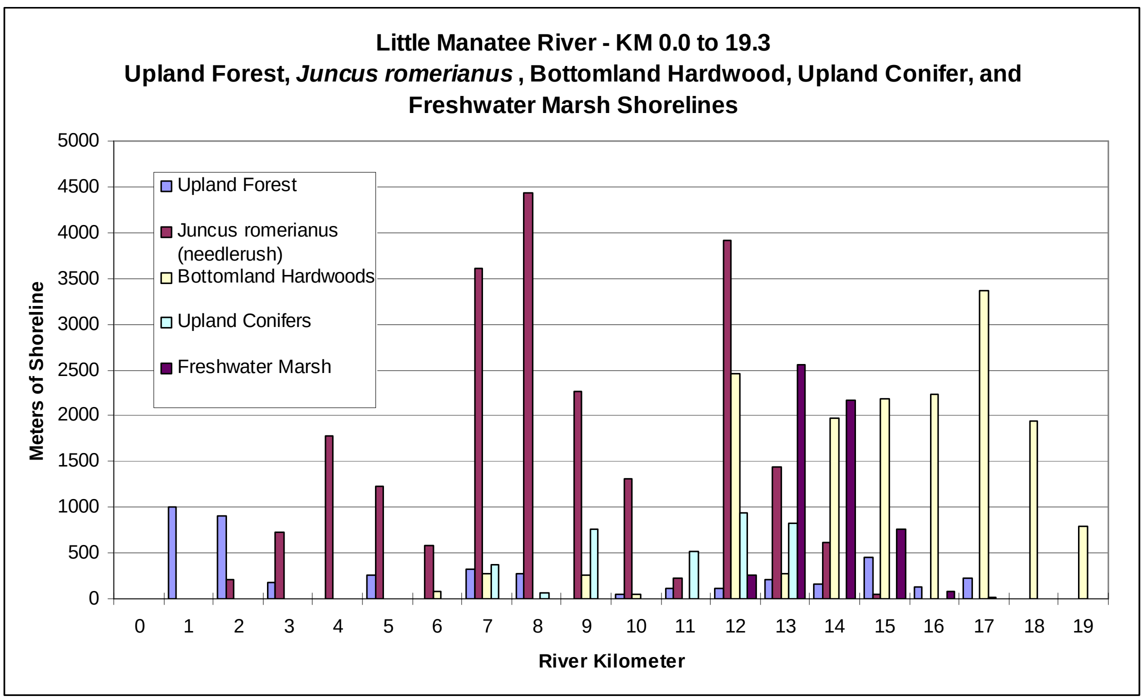

Little Manatee River - KM 0.6 to 24.0
Percent of River Volume vs. Elevation
Elevation - Meters NGVD 1929
Percent of River Volume
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
0
10
20
30
40
50
60
70
80
90
100

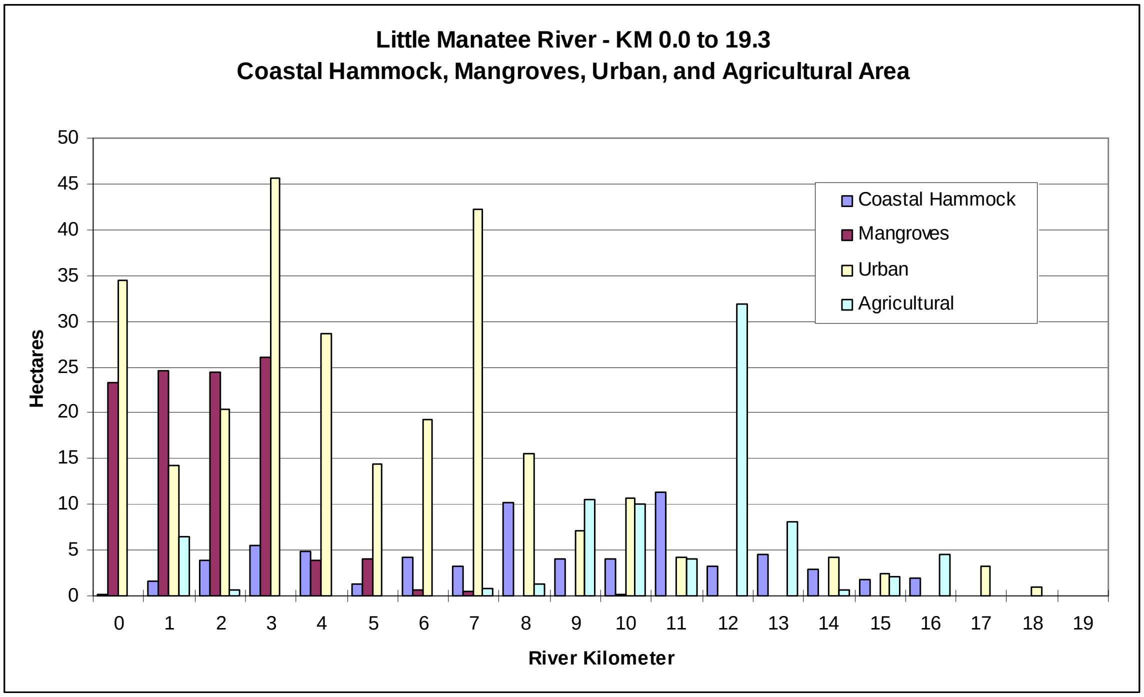

Little Manatee River - KM 0.6 to 24.0
Percent of Area vs. Elevation
Elevation - Meters NGVD 1929
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
10
20
30
40
50
60
70
80
90
100
Percent of River Area

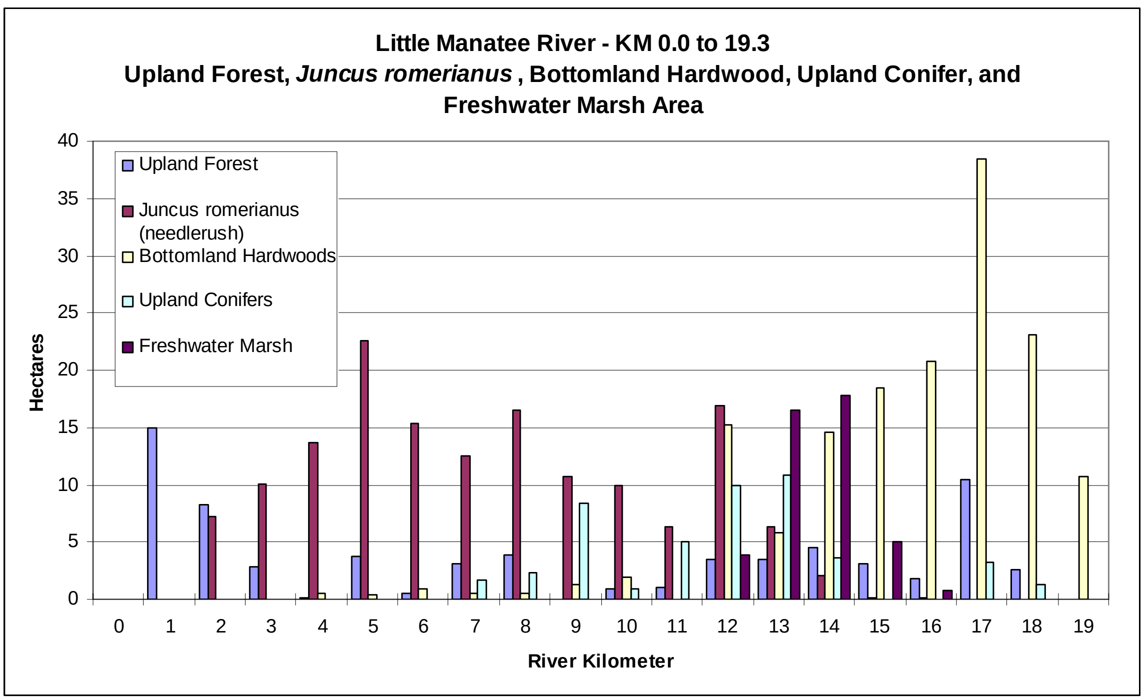


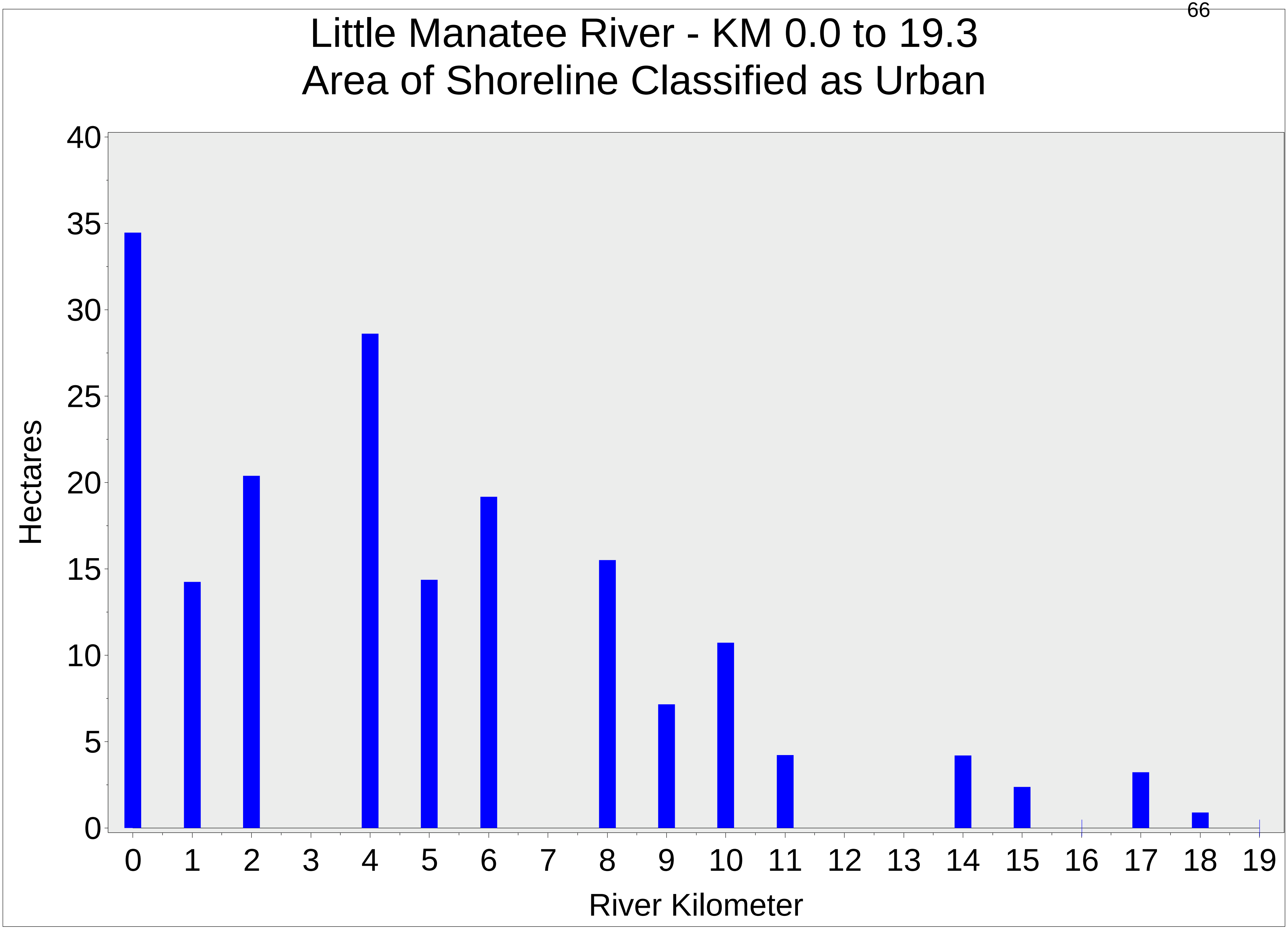
Little Manatee River
Segment Areas and Cumulative Areas at 0.0m NGVD Elevation
River Kilometer 0.6 to 24.2
Bayous Included
Bayous Not Included
Segment Area (Hectares)
Cumulative Area (Hectares)
River Kilometer
0
25
50
75
100
125
150
175
200
0
100
200
300
400
500
600
700
800
0
5
10
15
20
25

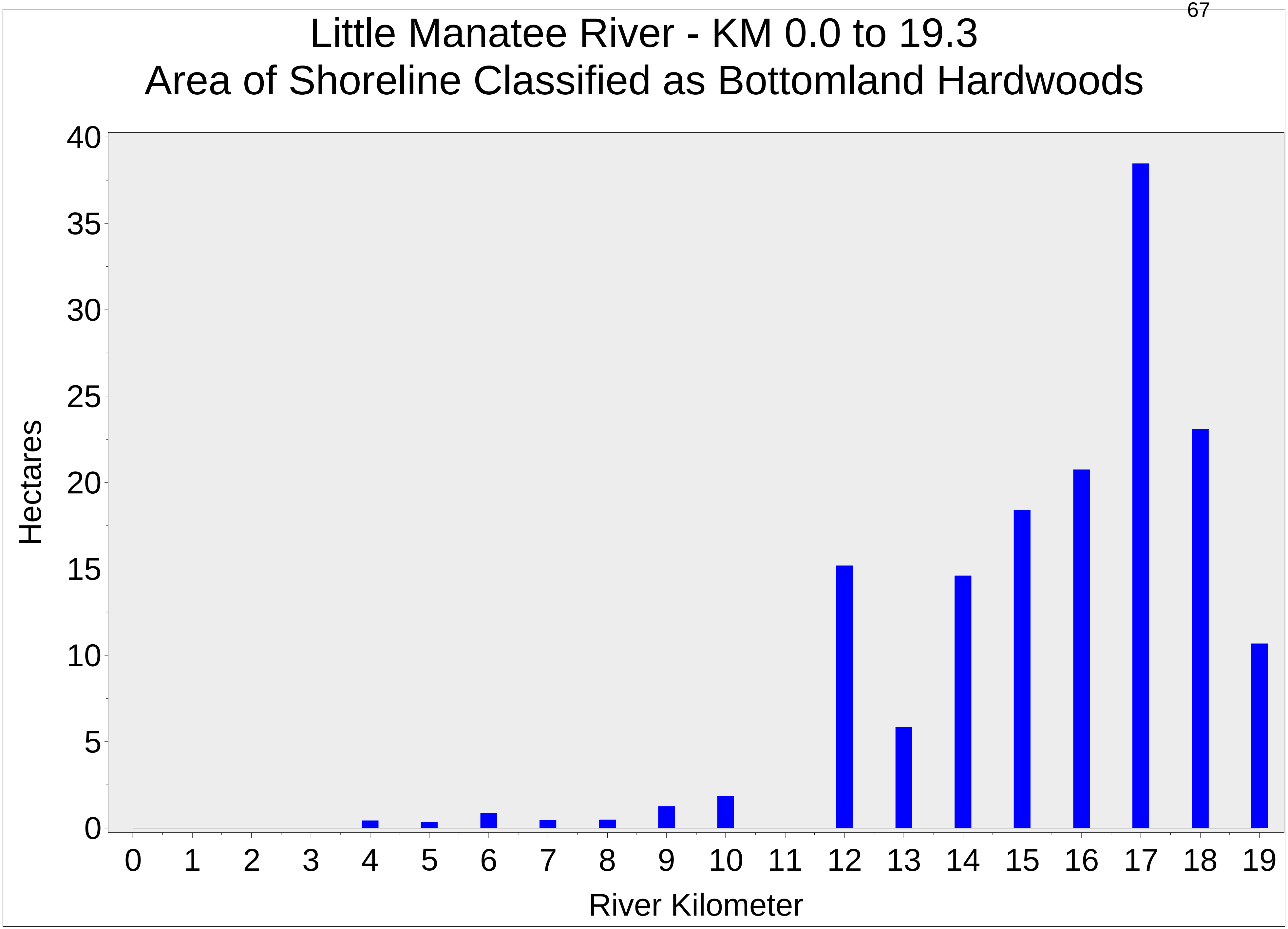

Little Manatee River - KM 0.0 to 19.3
Coastal Hammock, Mangroves, Urban, and Agricultural Shorelines
Meters of Shoreline
River Kilometer
Coastal Hammock
Mangroves
Urban
Agricultural
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

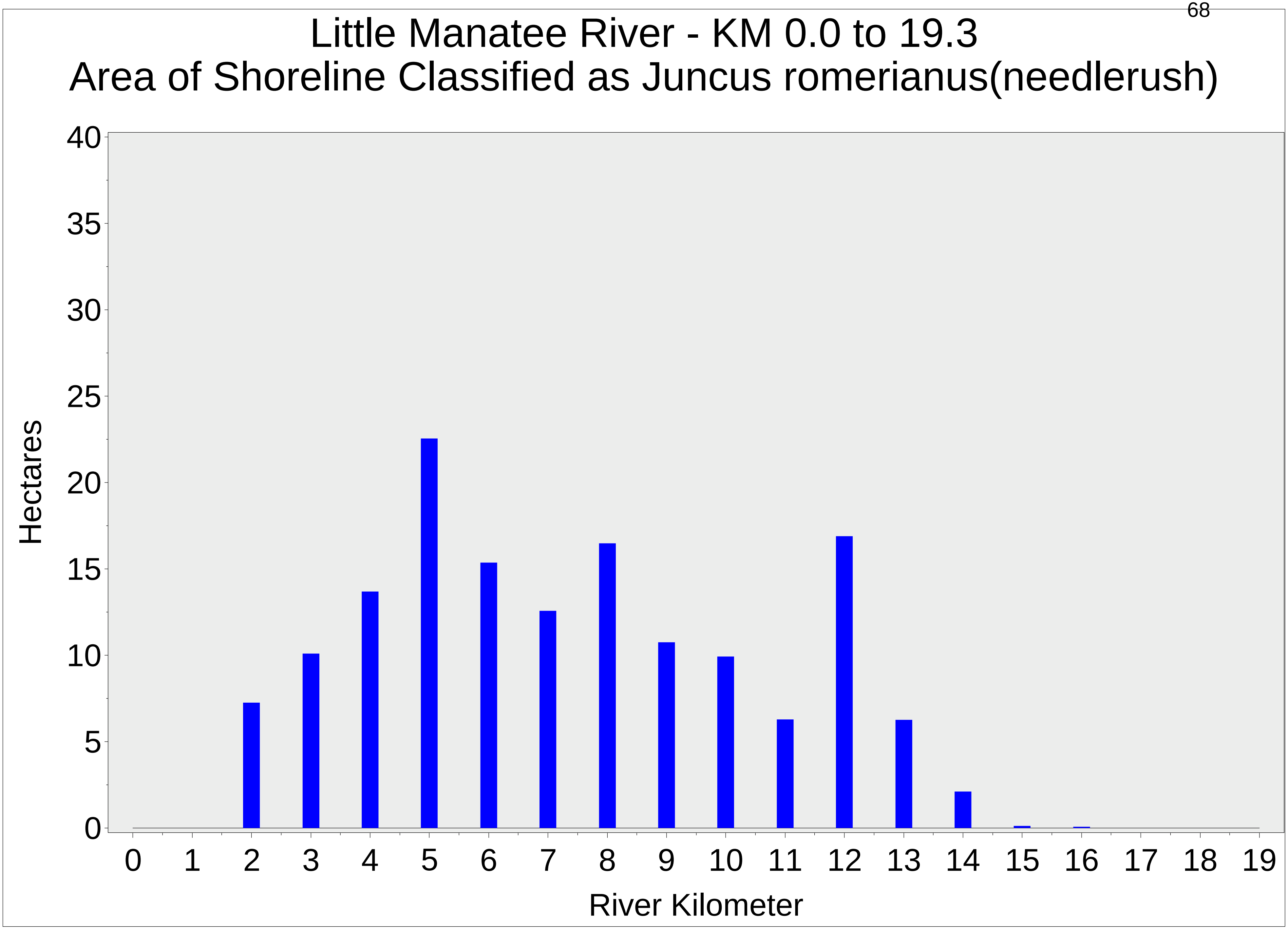

Little Manatee River - KM 0.0 to 19.3
Upland Forest, *Juncus romerianus* , Bottomland Hardwood, Upland Conifer, and Freshwater Marsh Shorelines
Meters of Shoreline
River Kilometer
Upland Forest
Juncus romerianus (needlerush)
Bottomland Hardwoods
Upland Conifers
Freshwater Marsh
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Little Manatee River - KM 0.0 to 19.3
Coastal Hammock, Mangroves, Urban, and Agricultural Area
Hectares
0
5
10
15
20
25
30
35
40
45
50
Coastal Hammock
Mangroves
Urban
Agricultural
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

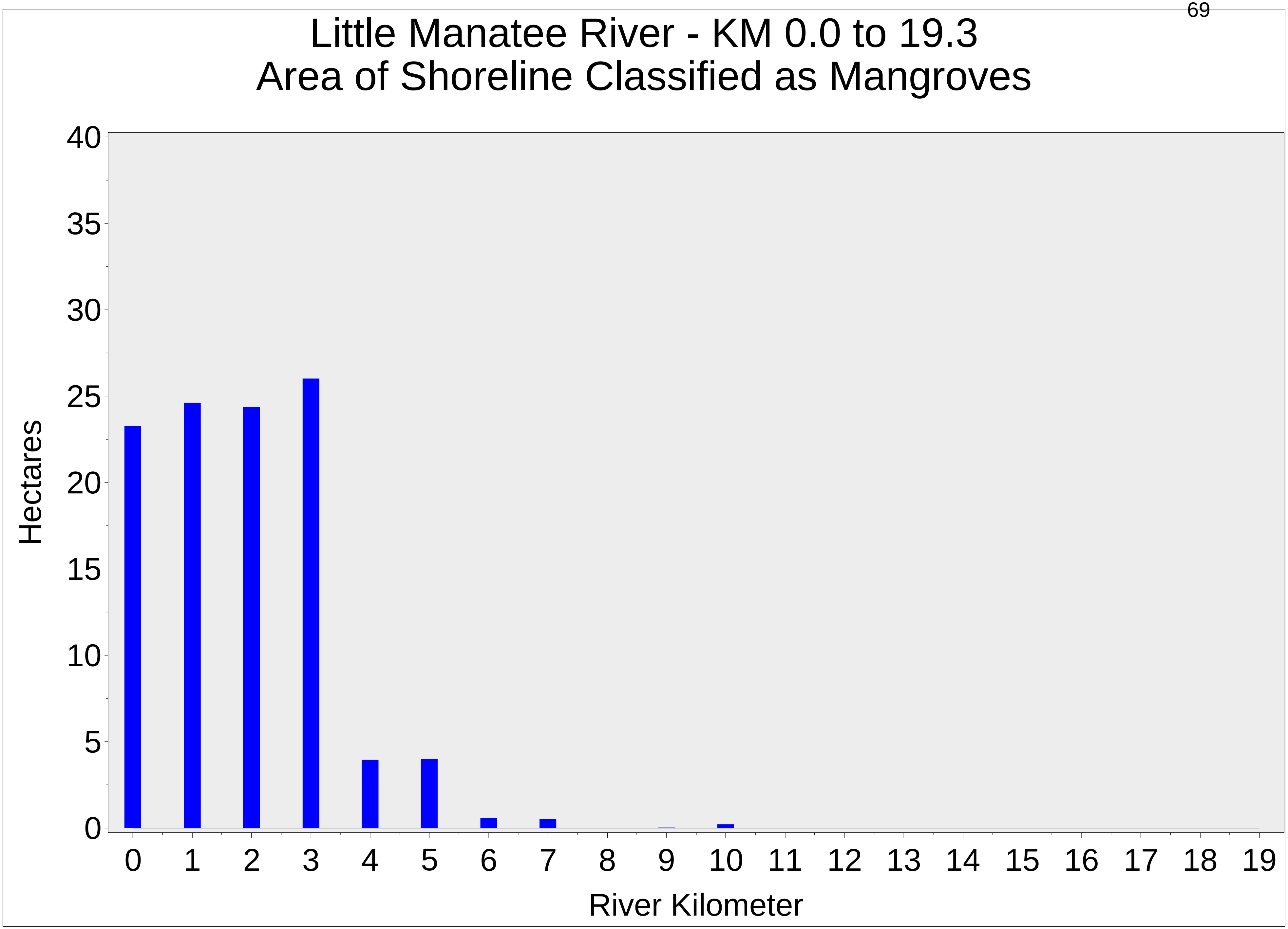

Little Manatee River - KM 0.0 to 19.3
Upland Forest, *Juncus romerianus* , Bottomland Hardwood, Upland Conifer, and Freshwater Marsh Area
Hectares
0
5
10
15
20
25
30
35
40
Upland Forest
Juncus romerianus (needlerush)
Bottomland Hardwoods
Upland Conifers
Freshwater Marsh
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

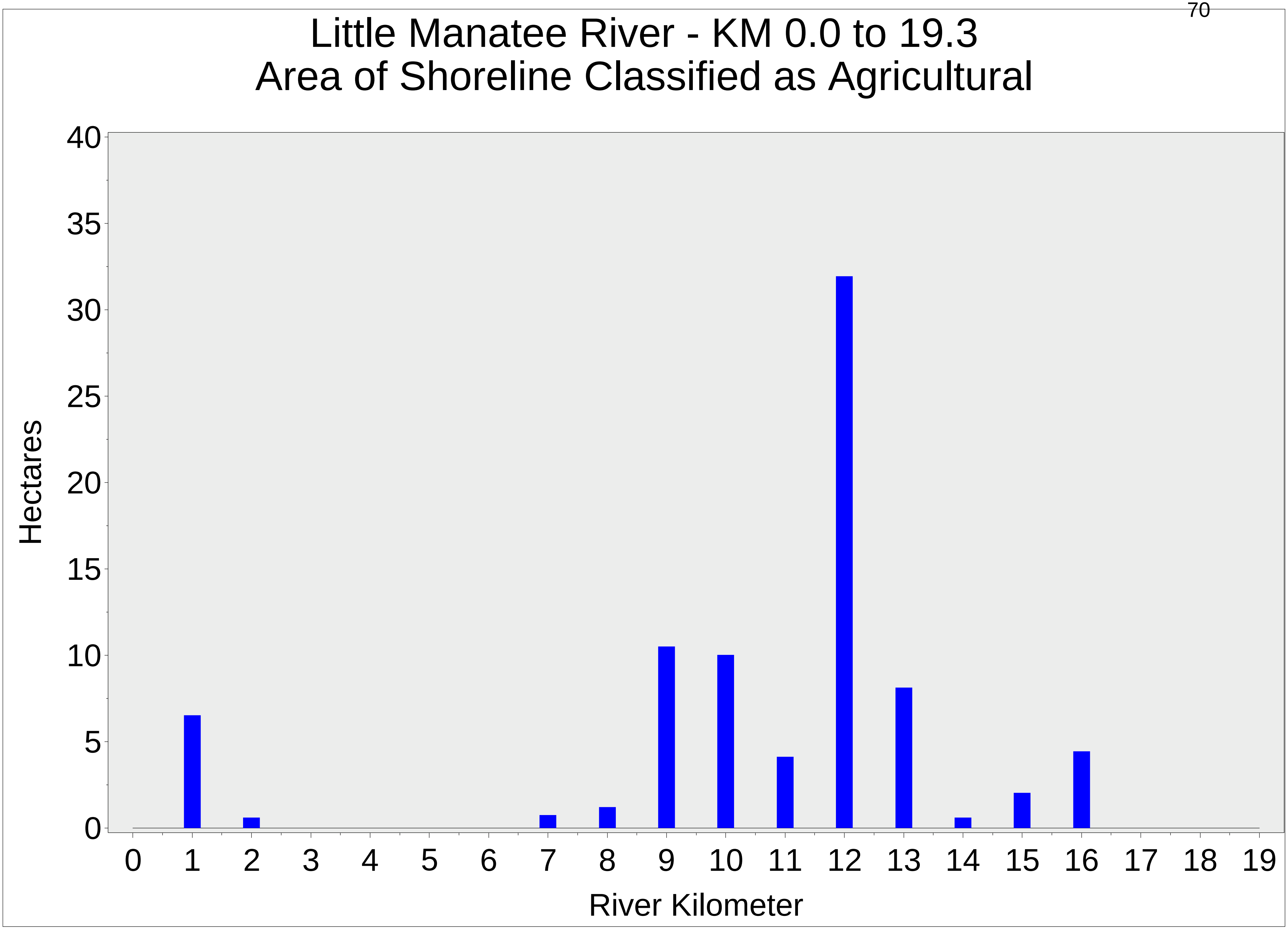

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Urban
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Bottomland Hardwoods
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer



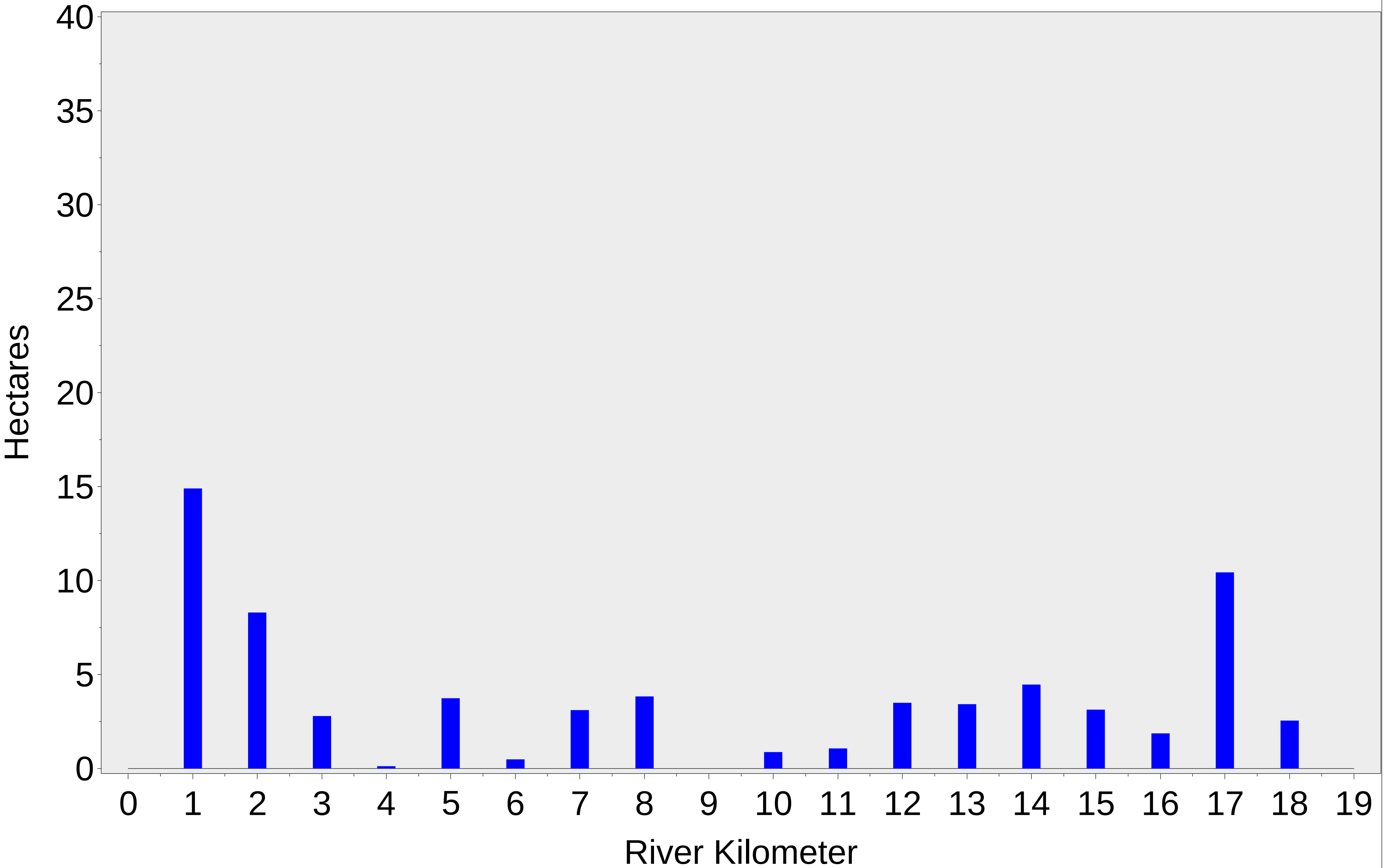
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Juncus romerianus(needlerush)
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

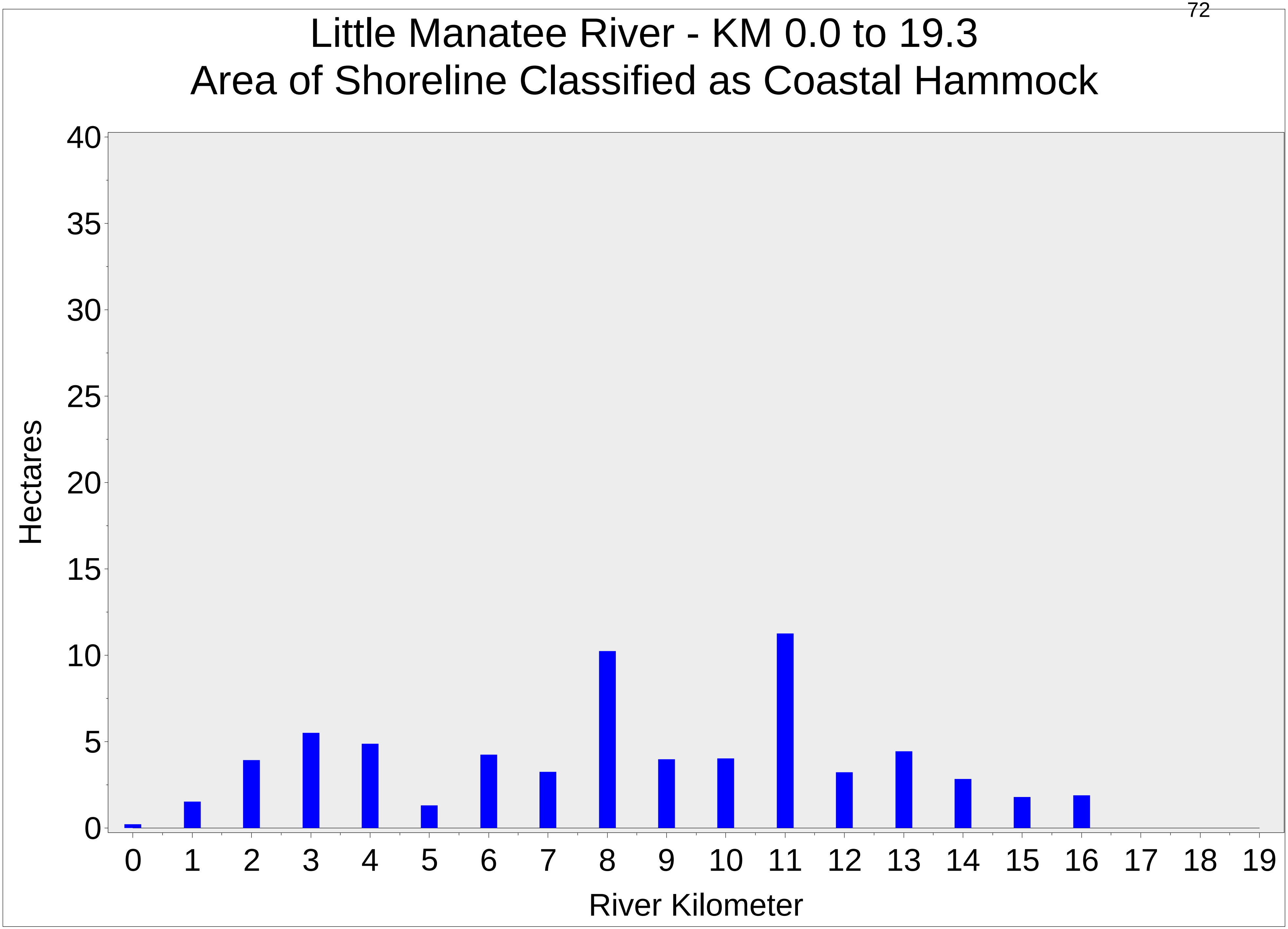

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Mangroves
Hectares
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
River Kilometer



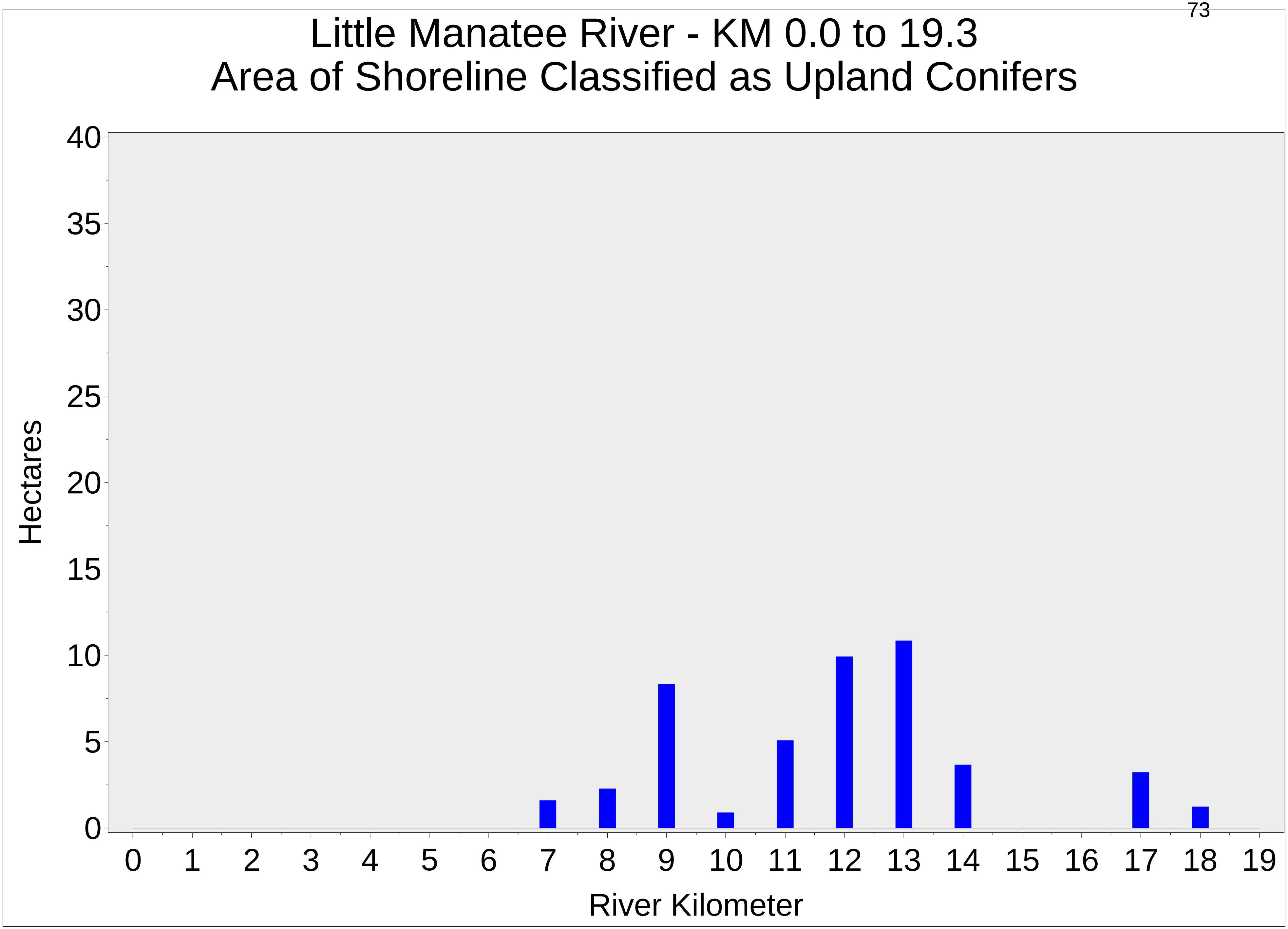
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Agricultural
Hectares
River Kilometer
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

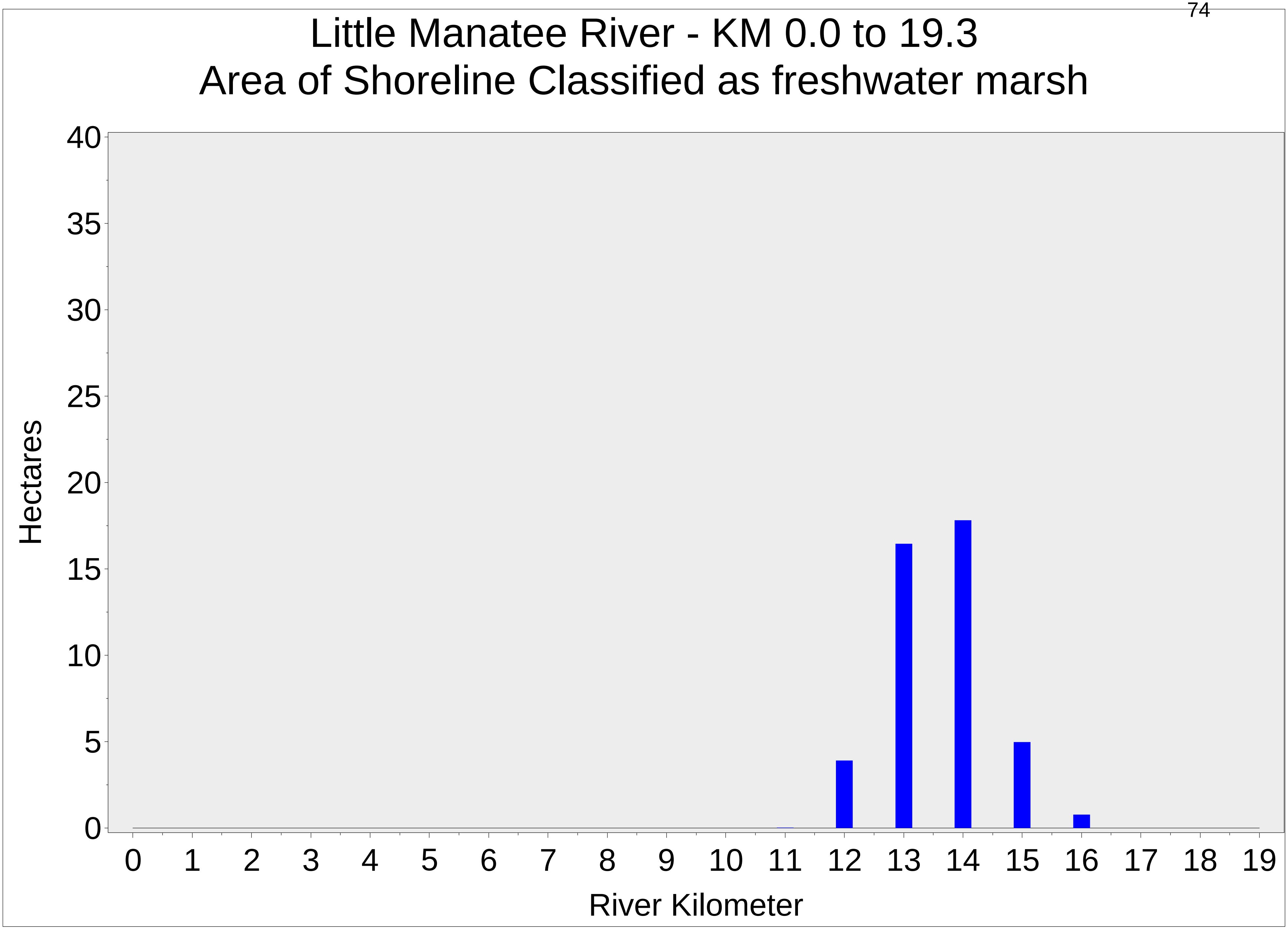
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Upland Forest



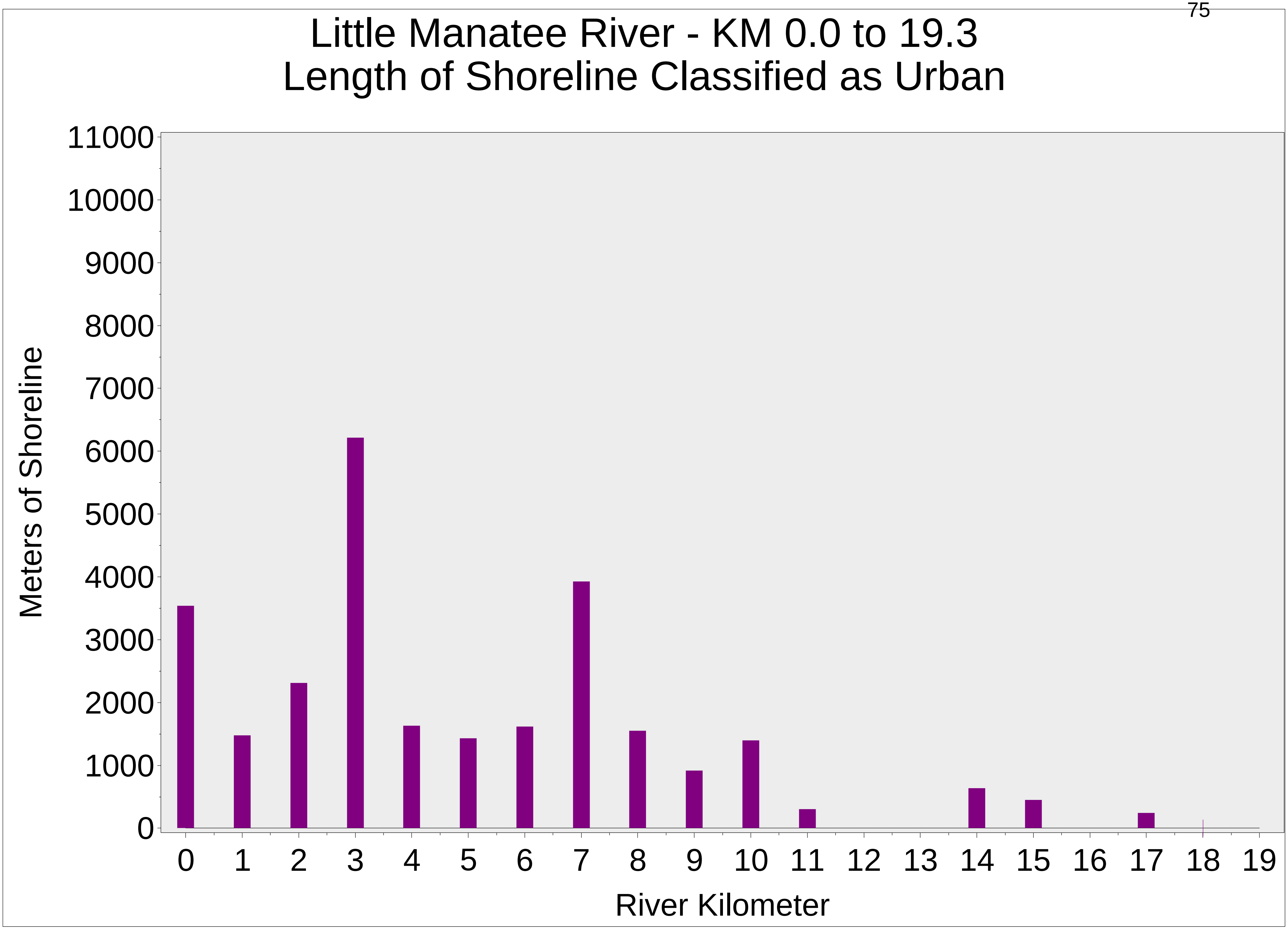


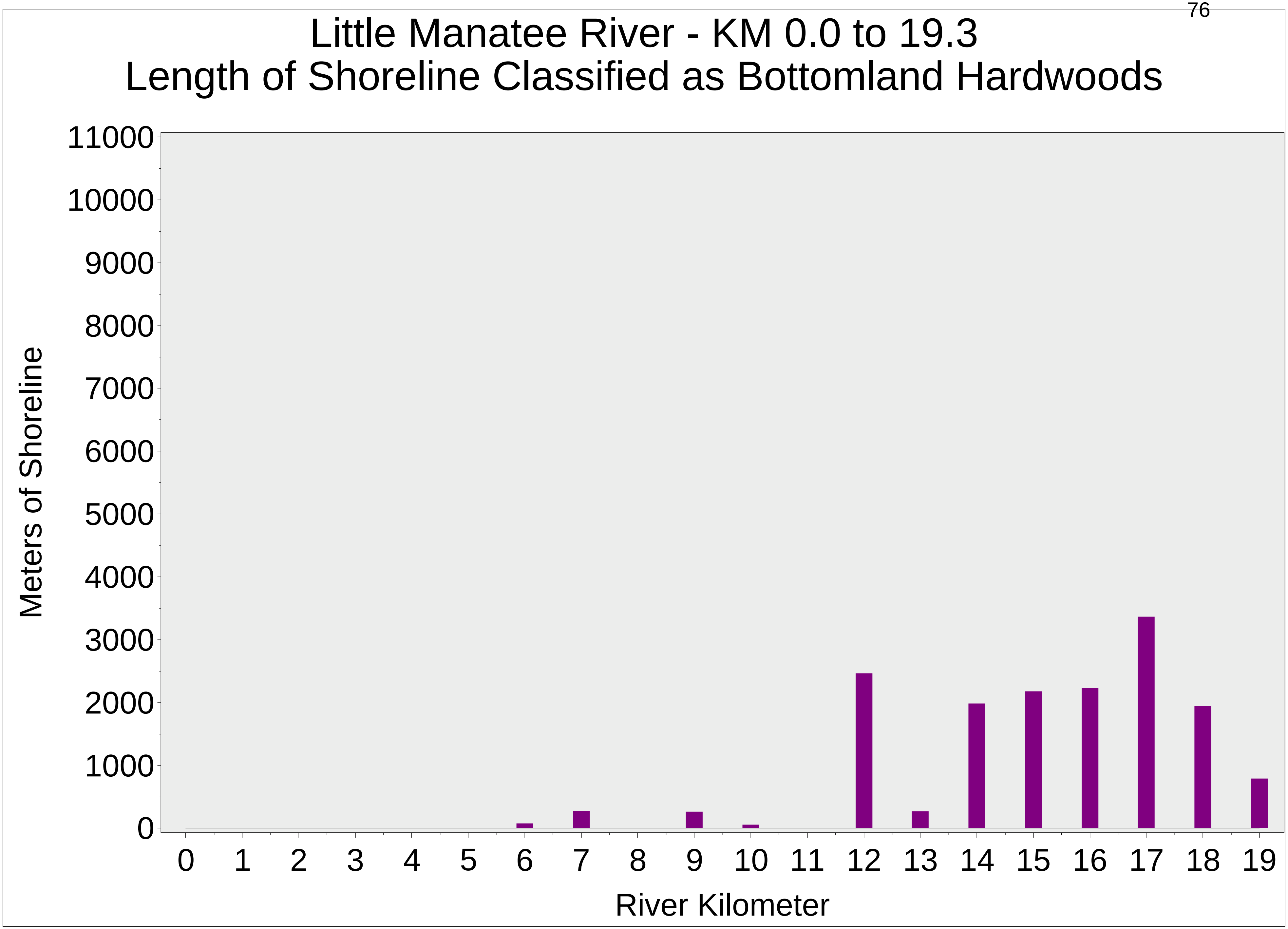
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Coastal Hammock
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

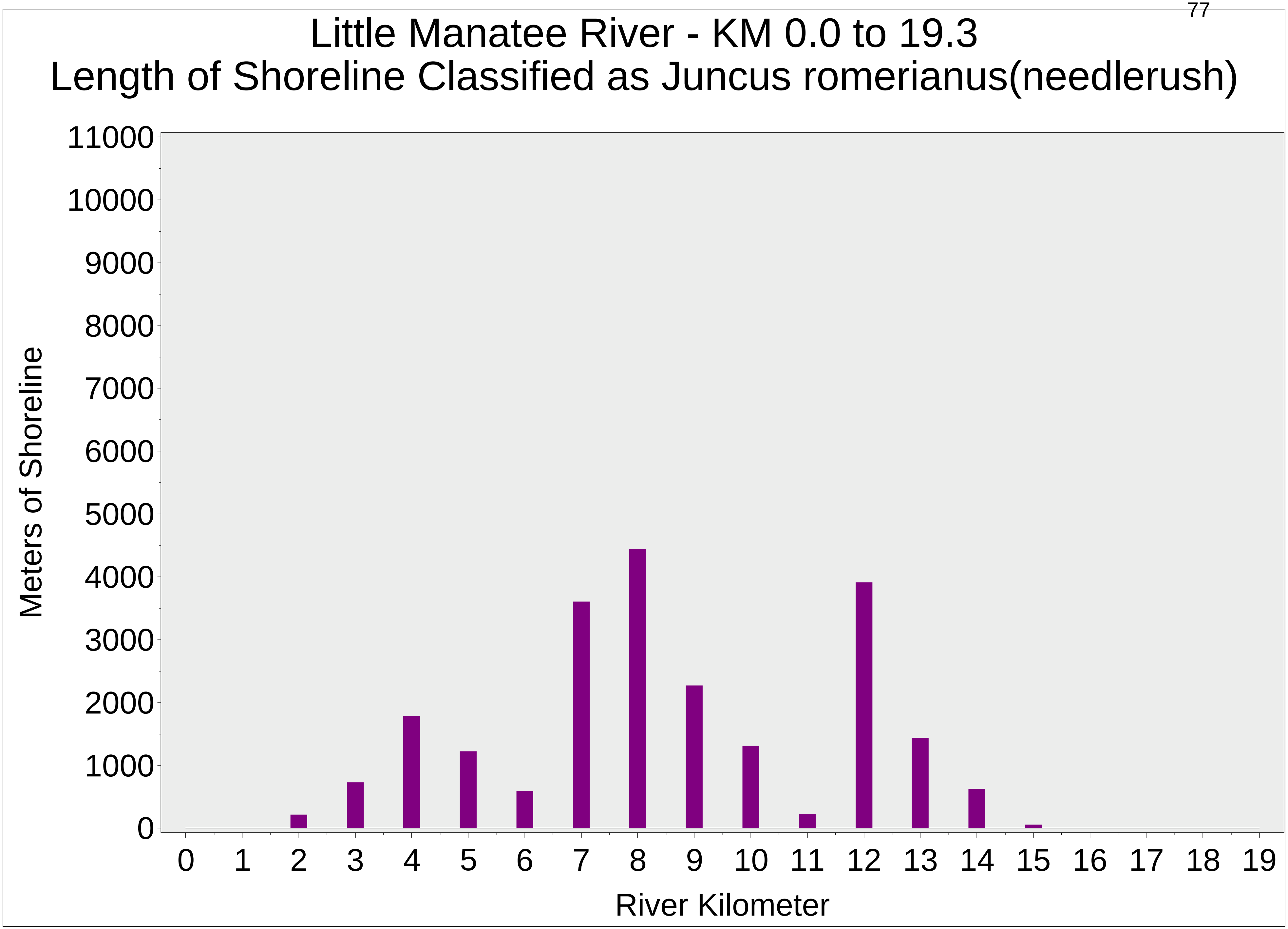

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Upland Conifers
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

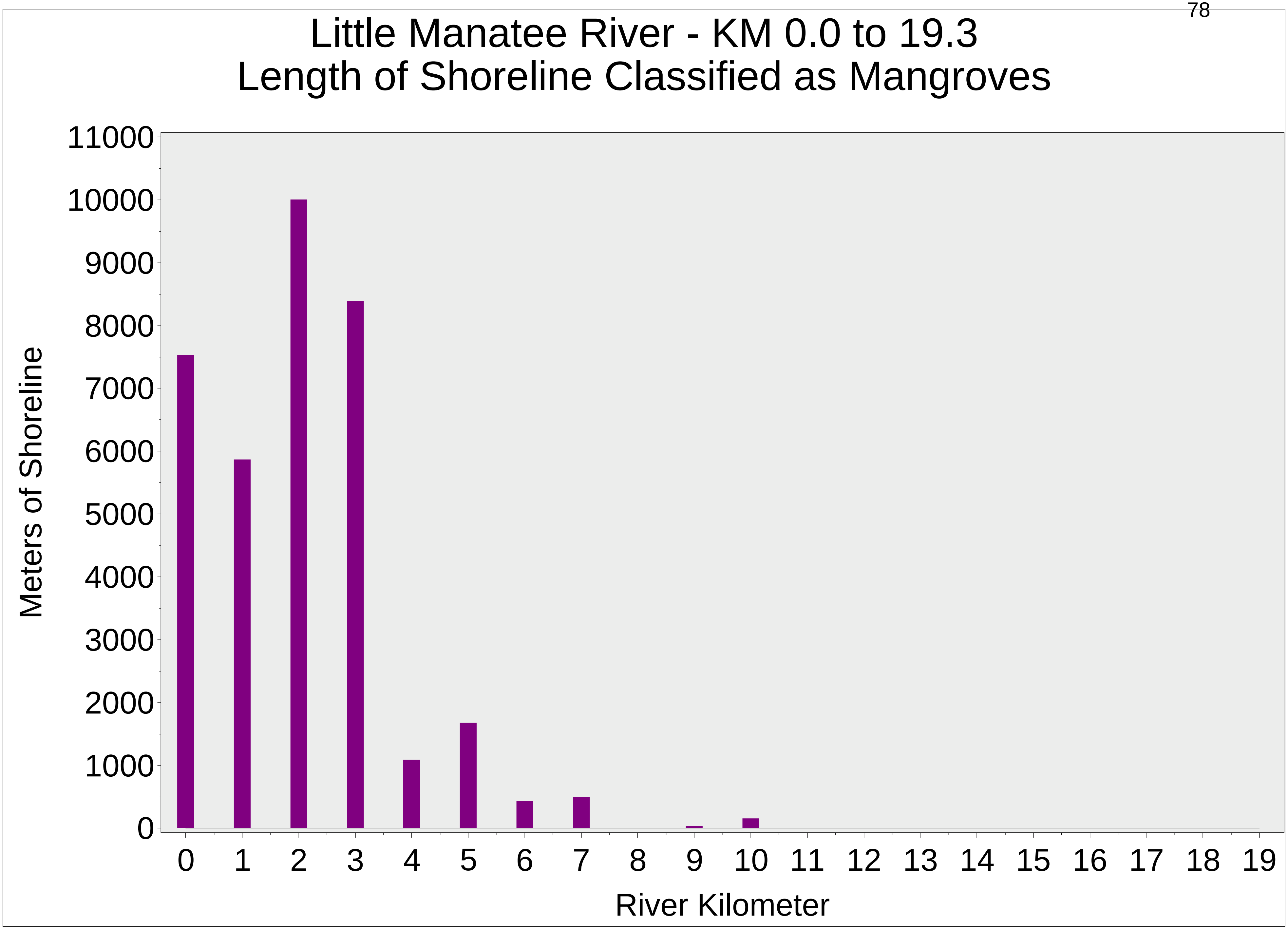


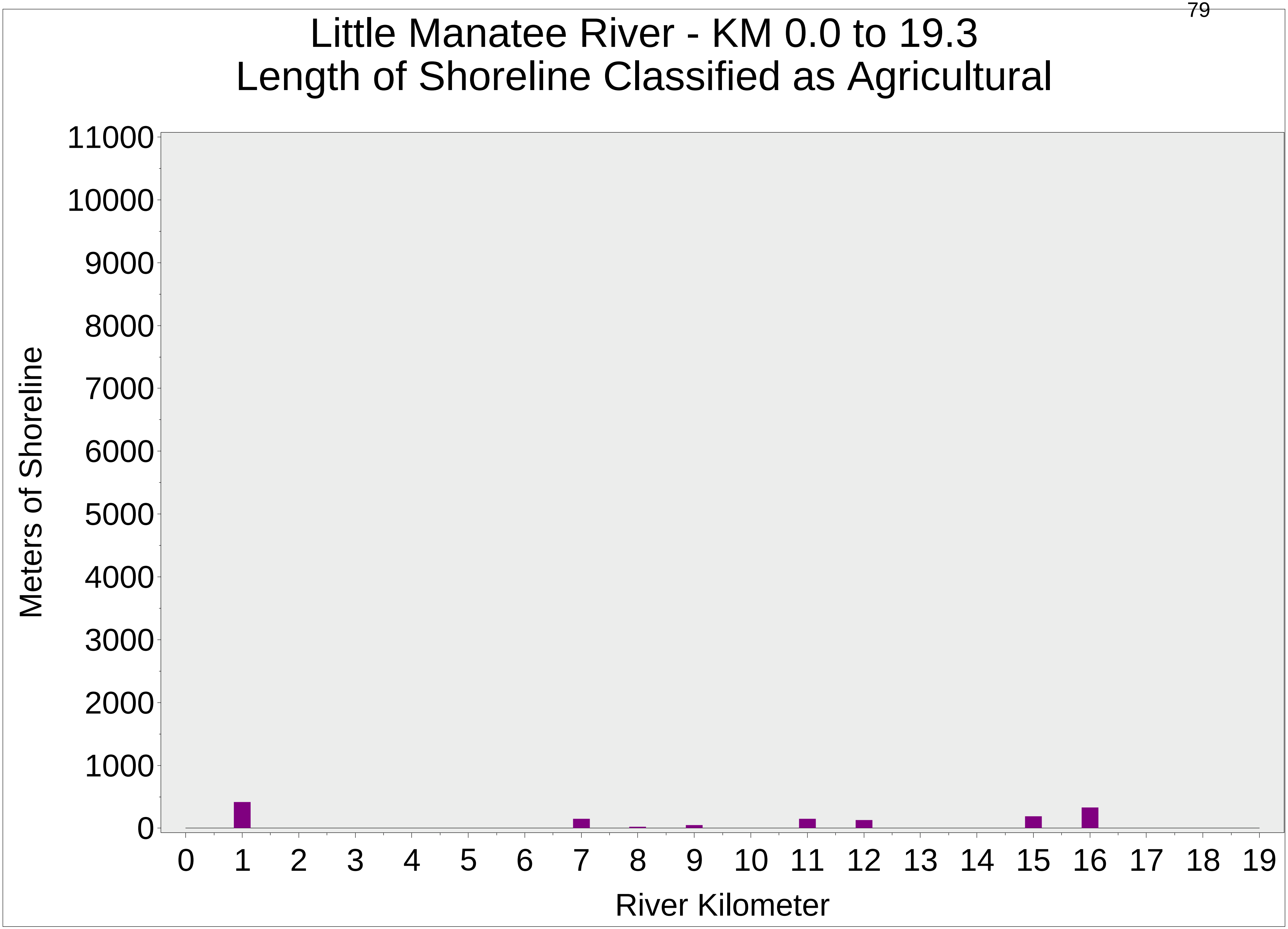
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as freshwater marsh
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

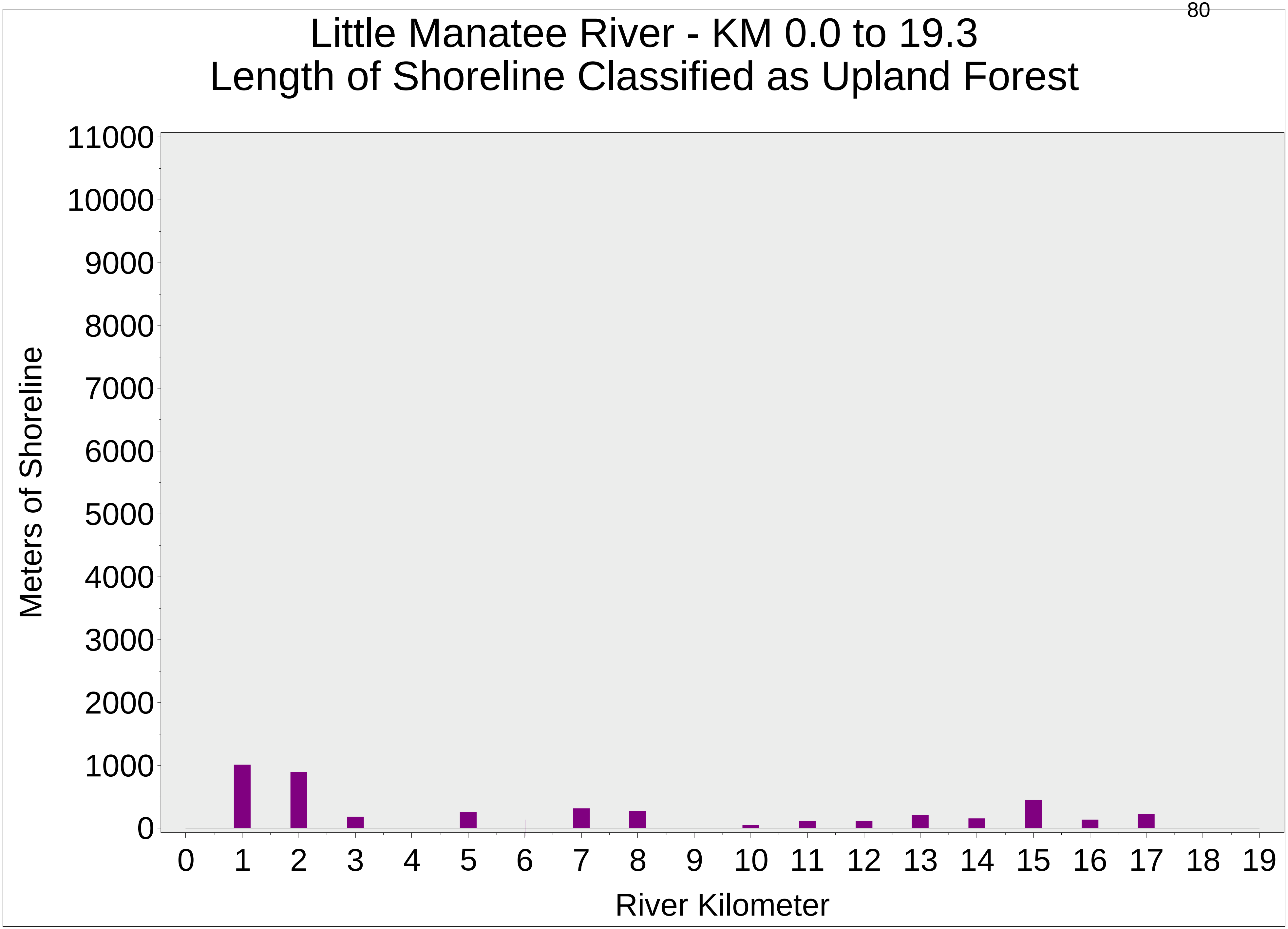

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Urban
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Bottomland Hardwoods
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
River Kilometer

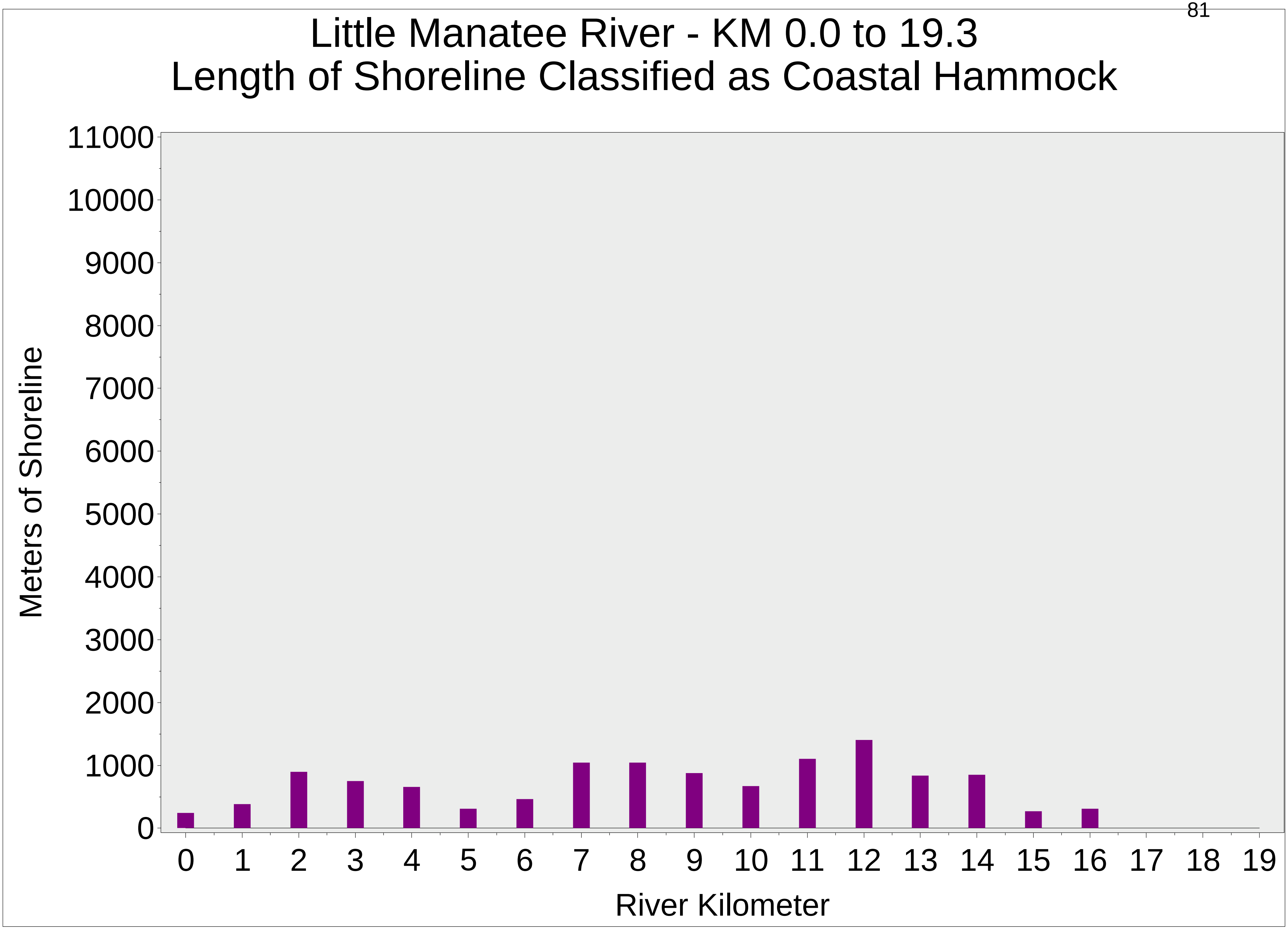

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Juncus romerianus(needlerush)
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Mangroves
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

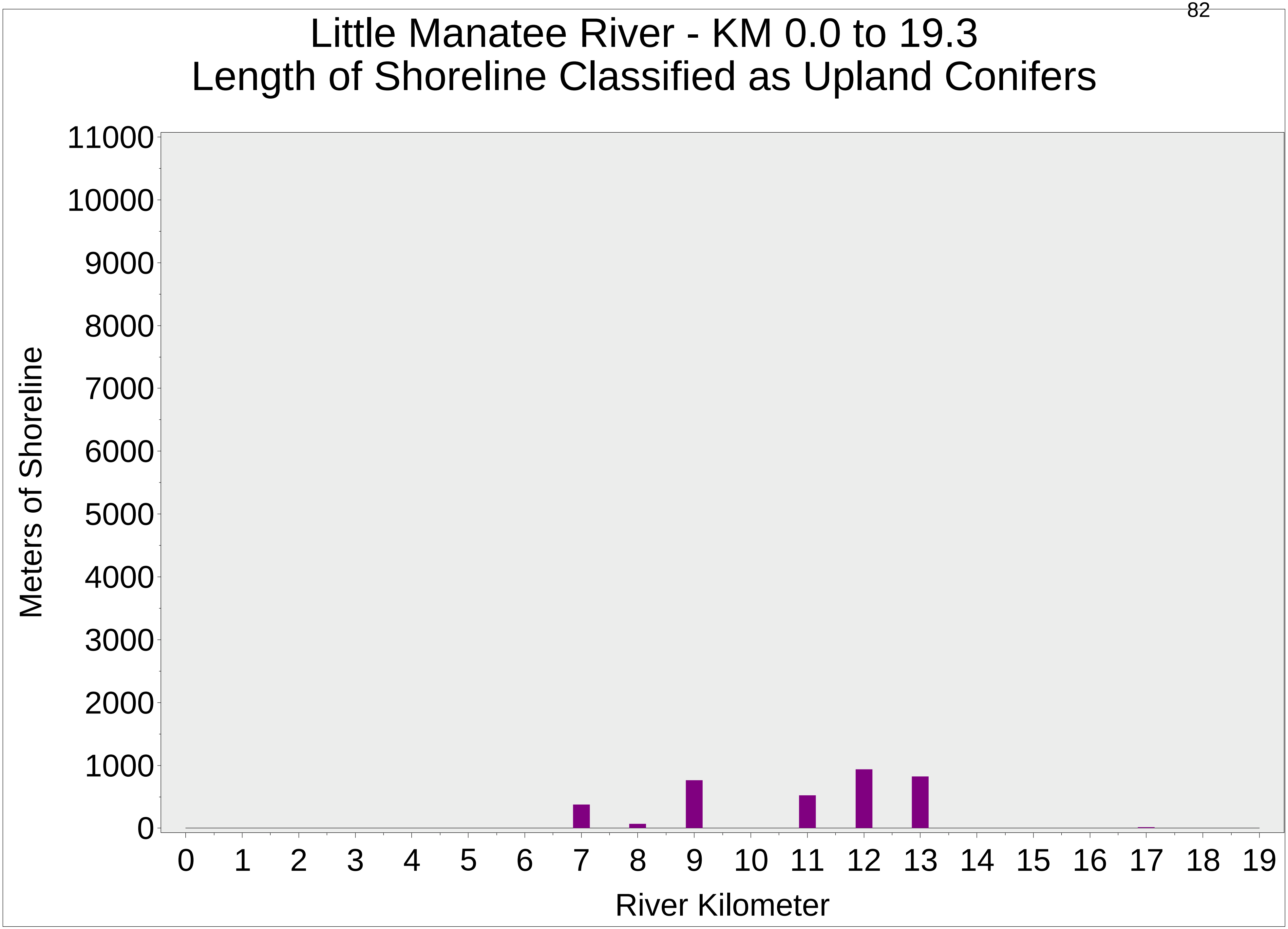

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Agricultural
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

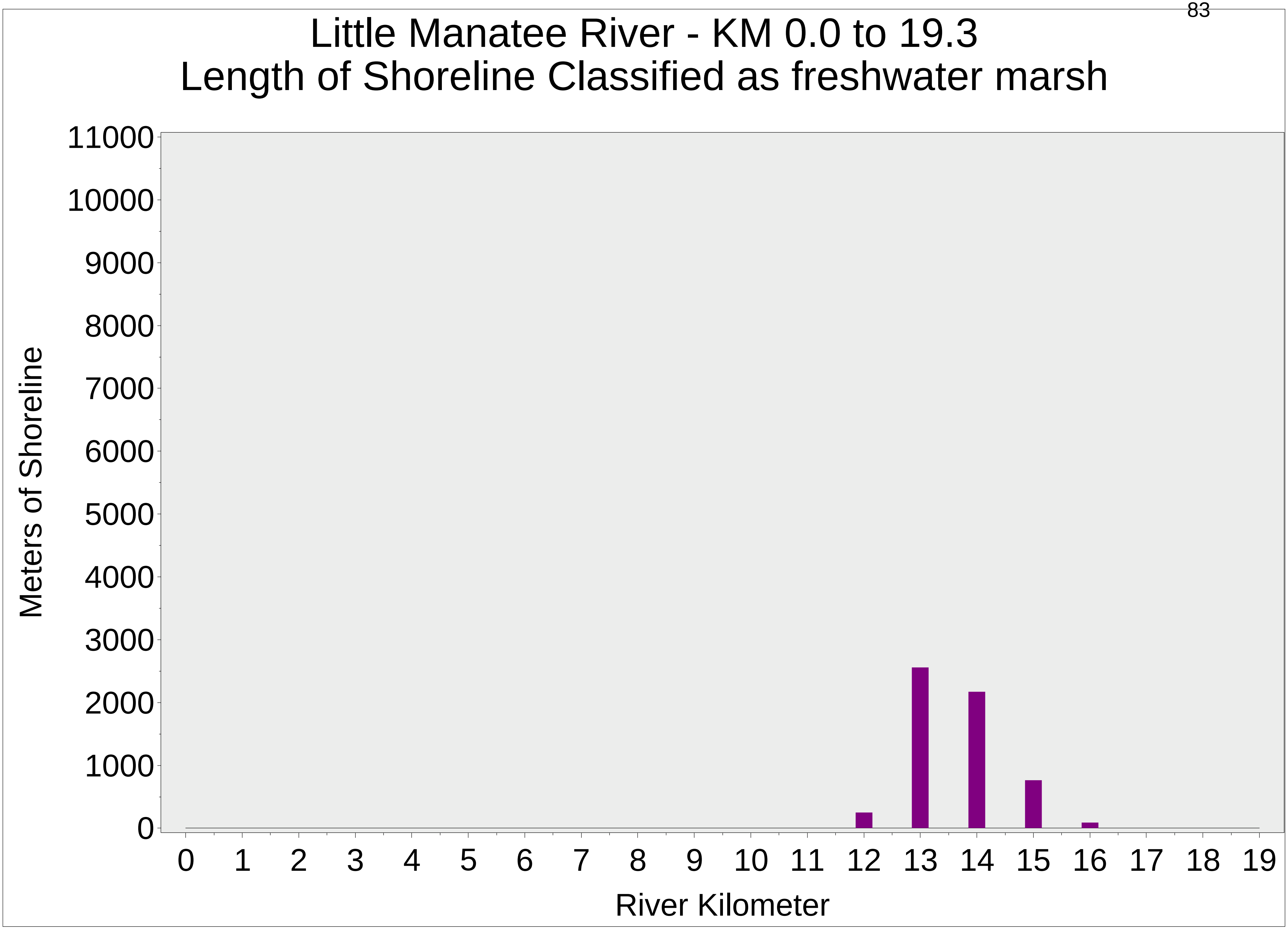


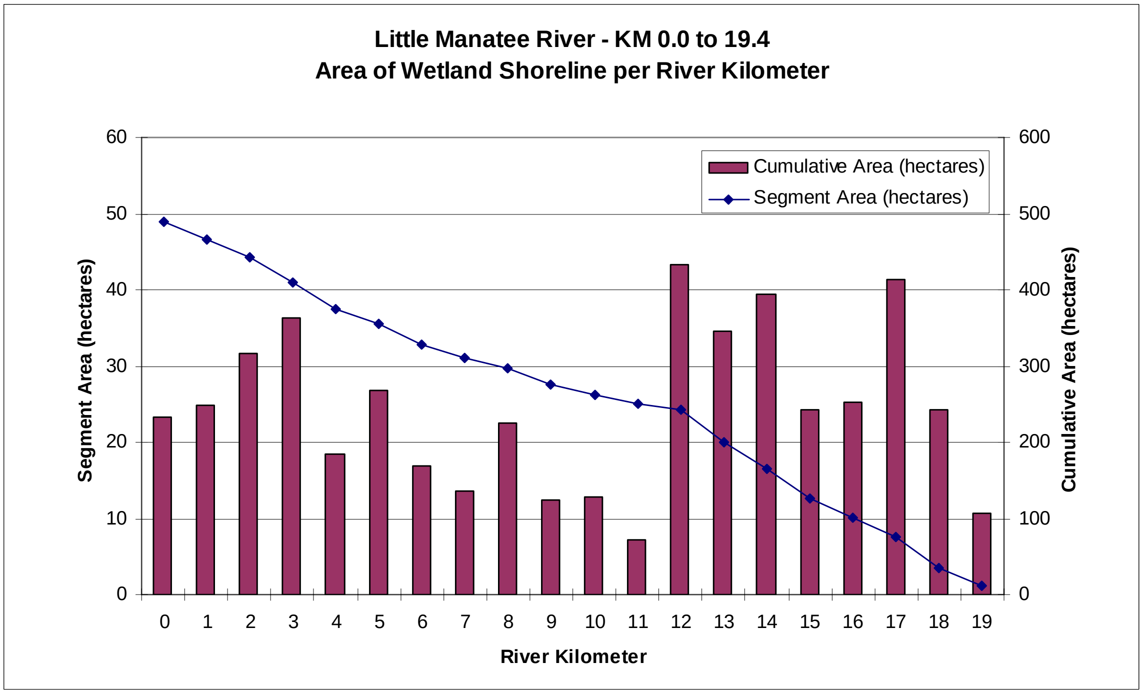
Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Upland Forest
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

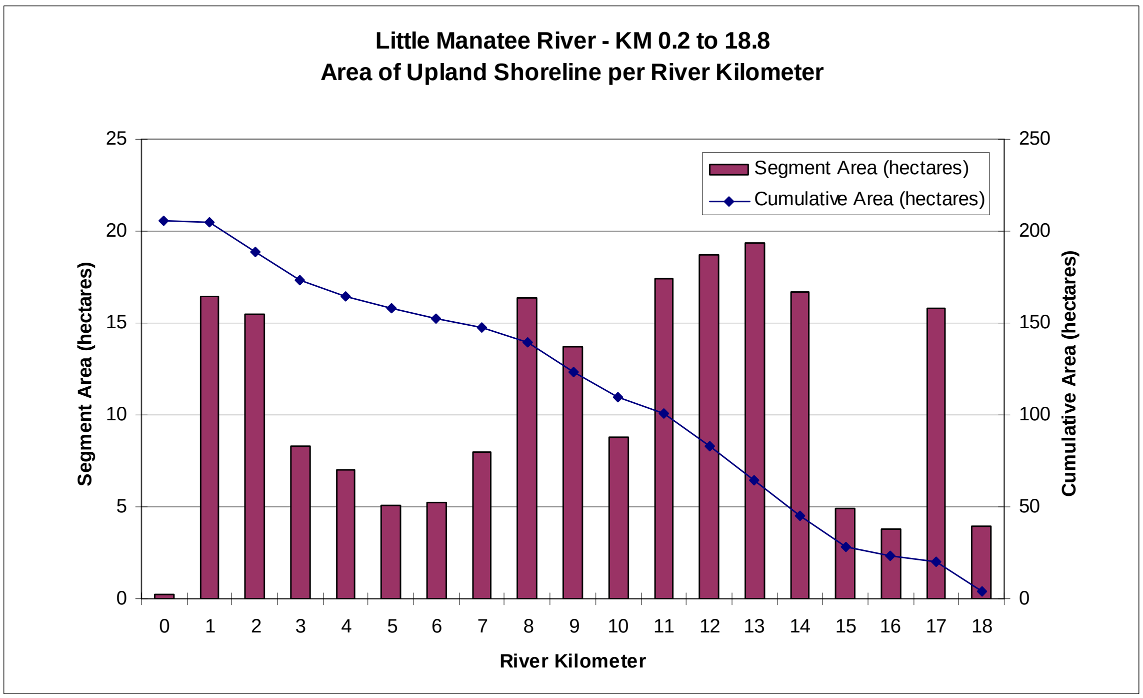


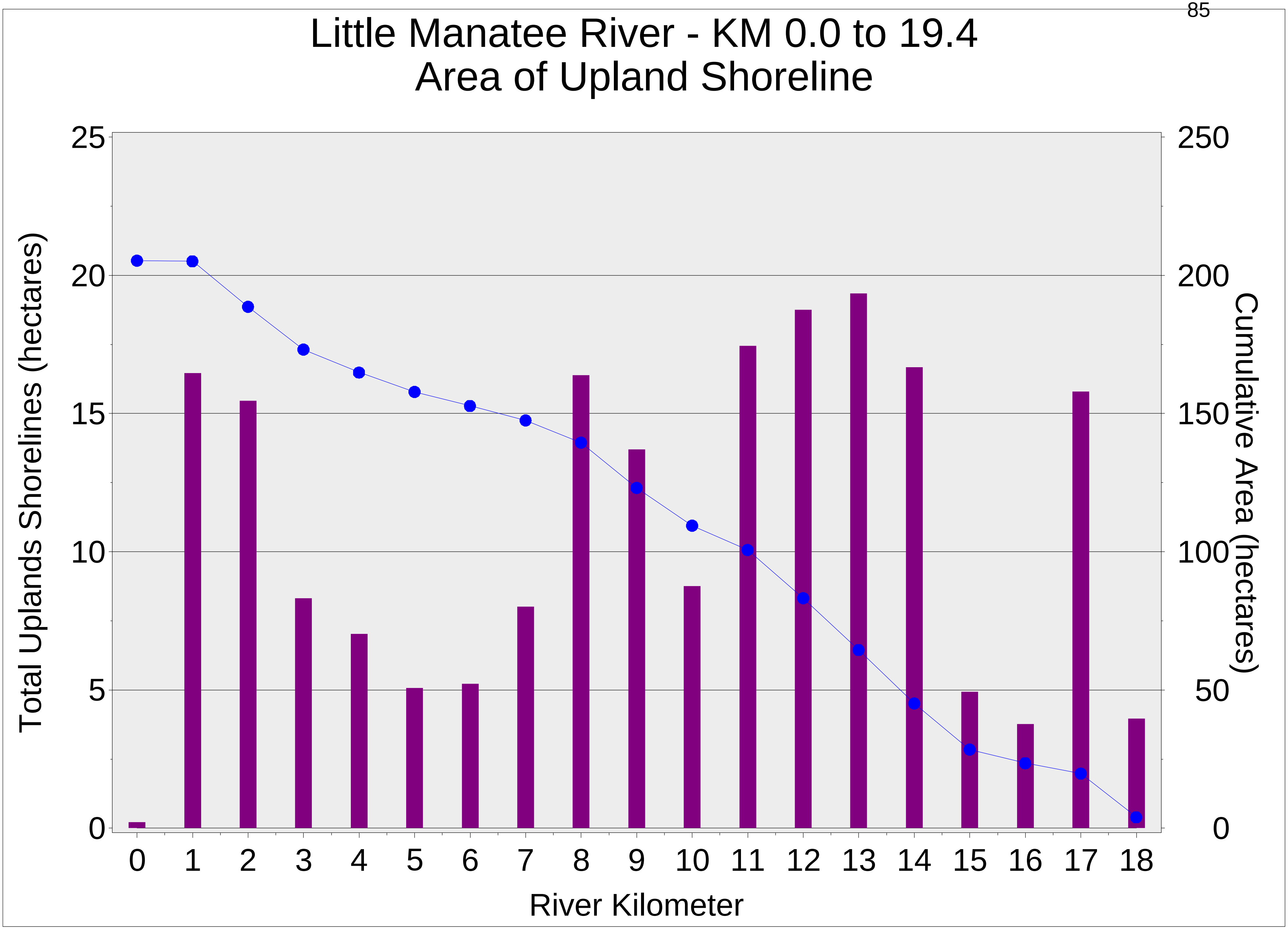
Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Coastal Hammock
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

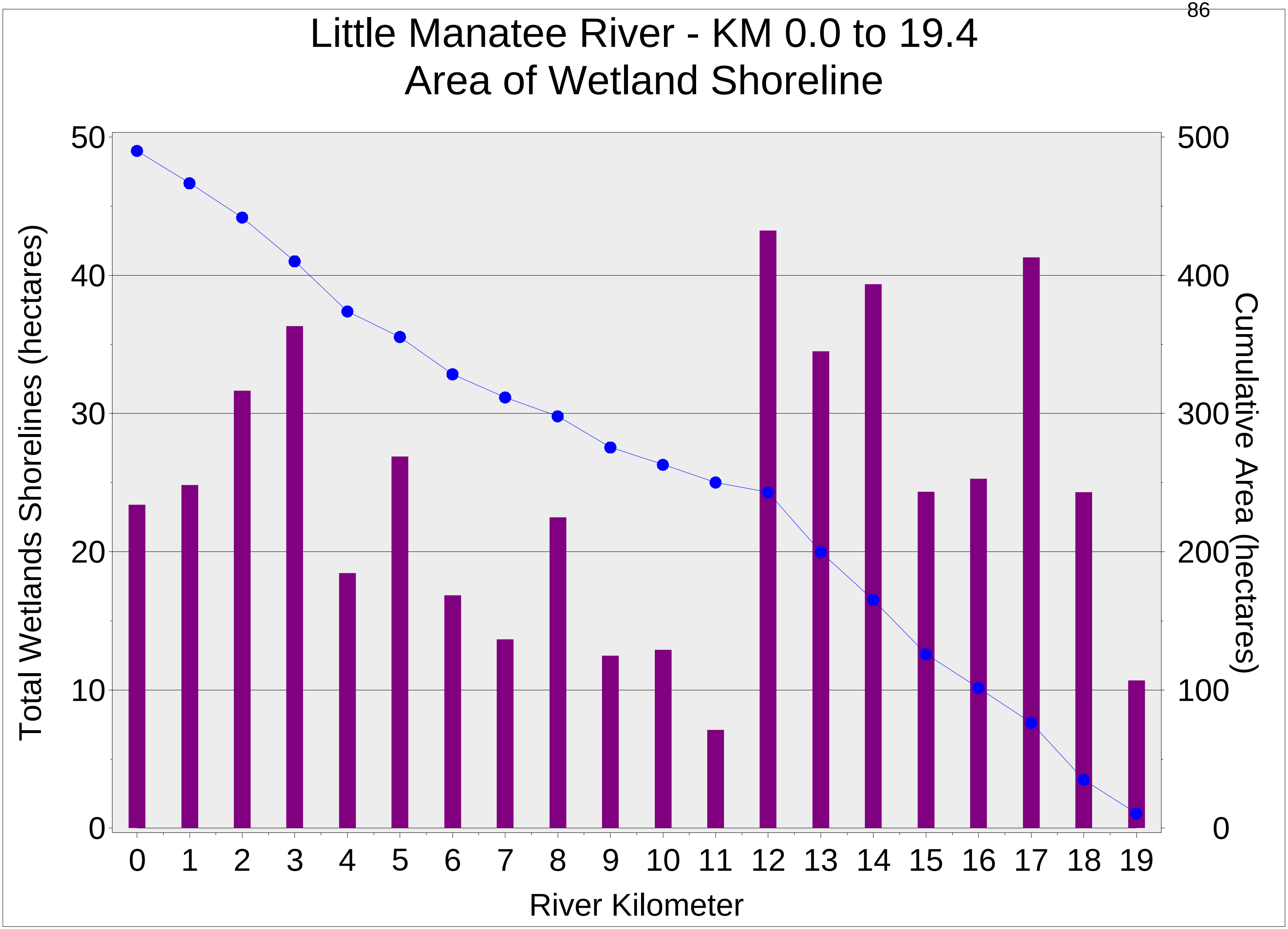

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Upland Conifers
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as freshwater marsh
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.4
Area of Wetland Shoreline per River Kilometer
Cumulative Area (hectares)
Segment Area (hectares)
Segment Area (hectares)
Cumulative Area (hectares)
River Kilometer
0
10
20
30
40
50
60
100
200
300
400
500
600
1
2
3
4
5
6
7
8
9
11
12
13
14
15
16
17
18
19

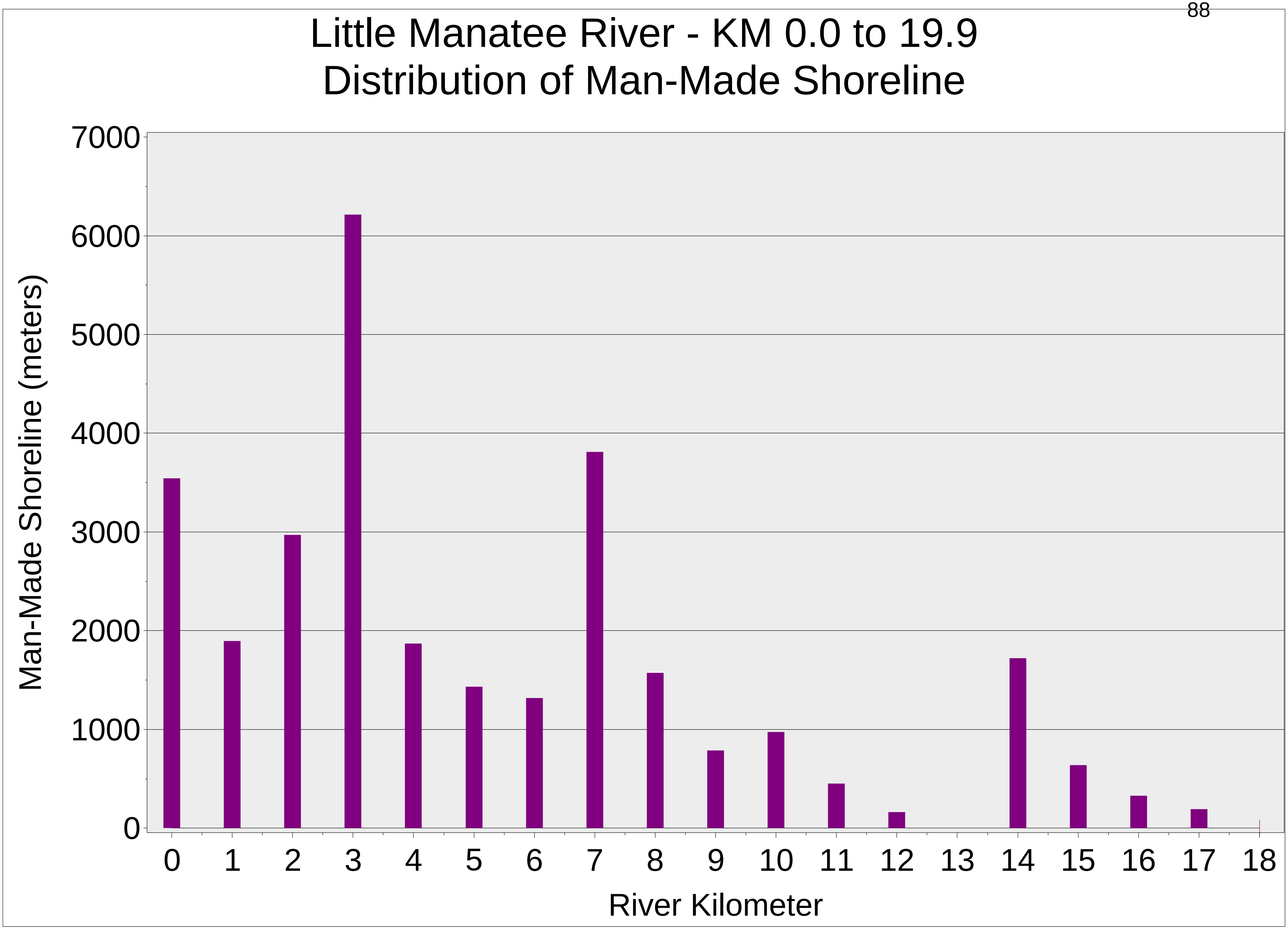

Little Manatee River - KM 0.2 to 18.8
Area of Upland Shoreline per River Kilometer
Segment Area (hectares)
Cumulative Area (hectares)
Segment Area (hectares)
Cumulative Area (hectares)
River Kilometer
0
5
10
15
20
25
50
100
150
200
250
1
2
3
4
6
7
8
9
11
12
13
14
16
17
18


Little Manatee River - KM 0.0 to 19.4
Area of Upland Shoreline
Total Uplands Shorelines (hectares)
Cumulative Area (hectares)
River Kilometer
0
5
10
15
20
25
50
100
150
200
250
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

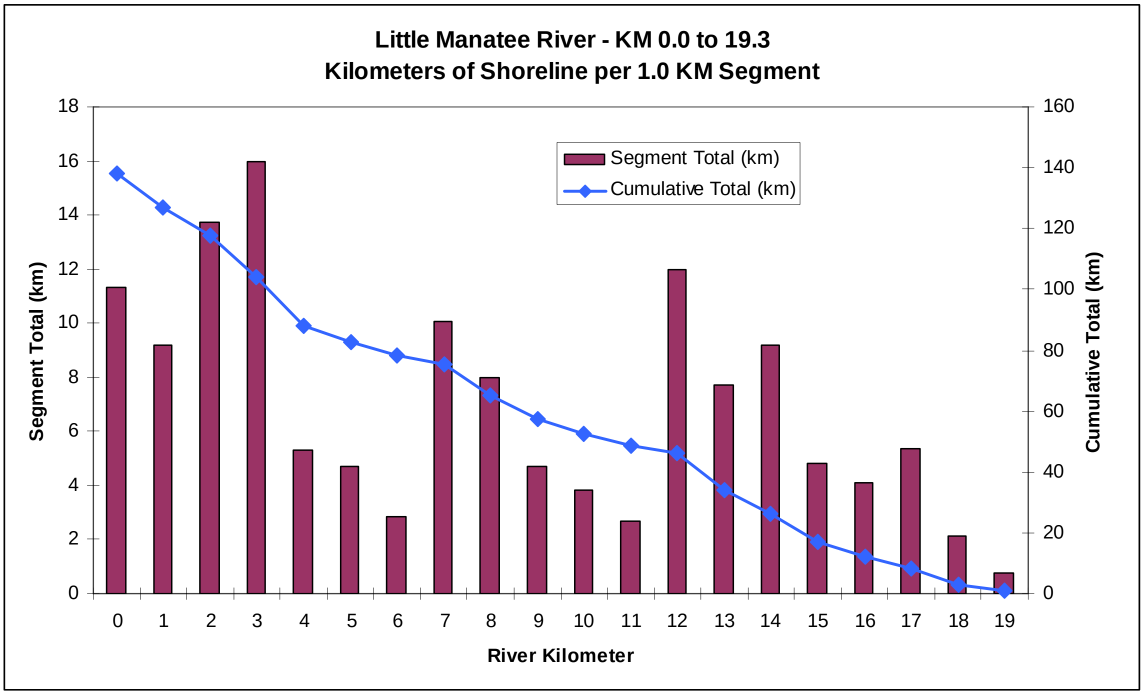

Little Manatee River - KM 0.0 to 19.4
Area of Wetland Shoreline
Total Wetlands Shorelines (hectares)
Cumulative Area (hectares)
River Kilometer
0
10
20
30
40
50
100
200
300
400
500
1
2
3
4
5
6
7
8
9
11
12
13
14
15
16
17
18
19

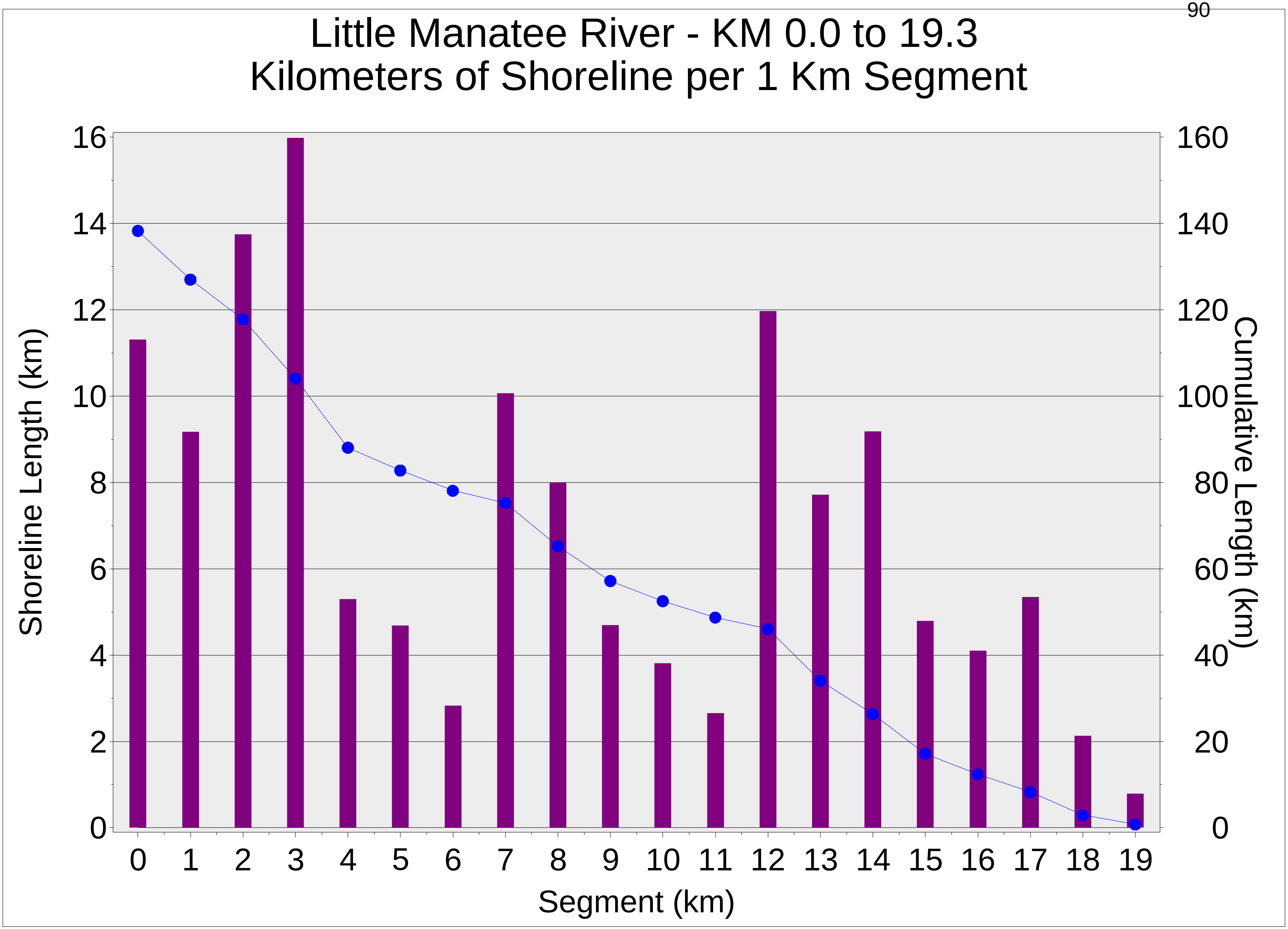
Area of Major Shoreline Plant Communities Along the Little Manatee River Shoreline

Species or Group	Area (hectares)	Percent of Total
Urban	267.63	25.6%
Bottomland Hardwoods	152.91	14.6%
Juncus romerianus(needlerush)	150.54	14.4%
Mangroves	107.64	10.3%
Agricultural	81.02	7.8%
Upland Forest	68.80	6.6%
Coastal Hammock	68.78	6.6%
Upland Conifers	47.21	4.5%
Freshwater Marsh	44.01	4.2%
Range	14.76	1.4%
Echinochloa	9.97	1.0%
Wetland Conifers	8.93	0.9%
Upland Hardwoods	5.29	0.5%
Marsh with Cladium (sawgrass)	4.56	0.4%
Typha (cattail)	3.38	0.3%
Leatherfern	2.35	0.2%
Juncus and Leatherfern	1.91	0.2%
Tidal Flat	1.65	0.2%
Wetland Marsh	0.88	0.1%
Cladium (sawgrass)	0.72	0.1%
Saltmarsh	0.48	0.0%
Sabal Palmetto	0.47	0.0%
Utilities	0.39	0.0%
Wet Prairie	0.06	0.0%



Little Manatee River - KM 0.0 to 19.9
Distribution of Man-Made Shoreline
Man-Made Shoreline (meters)
0
1000
2000
3000
4000
5000
6000
7000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Kilometers of Shoreline per 1.0 KM Segment
Segment Total (km)
Cumulative Total (km)
River Kilometer
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
0 2 4 6 8 10 12 14 16 18
0 20 40 60 80 100 120 140 160


Little Manatee River - KM 0.0 to 19.3
Kilometers of Shoreline per 1 Km Segment
Shoreline Length (km)
Cumulative Length (km)
Segment (km)
0
2
4
6
8
10
12
14
16
20
40
60
80
100
120
140
160
1
3
5
7
9
11
13
15
17
18
19

December 13, 2021

Request and questions about Little Manatee River EFF modeling

Hello Kym and Doug,

I have request for a report, selected model output, and have a few questions about the Environmental Favorability Function (EFF) modeling results presented in the minimum flows report for the Little Manatee River. If the District could address these requests when it is convenient, it would be greatly appreciated.

The references for report I am asking for is below, taken from page 186 in the minimum flows report.

Wessel, M. 2011. Defining the Fish-Flow Relationship in Support of Establishing Minimum Flows and Levels for Southwest Florida Tidal Rivers: Building on the Toolbox of Analytical Techniques. Report prepared by Janicki Environmental Inc. for the Southwest Florida Management District

I would also like to receive output from the Environmental Favorability Function modeling that was done for fish species in the lower river. In particular, I am requesting daily output for the amount of favorable habitat for the fish species listed on pages 146 to 149 of the minimum flows report, except for Sheepshead, for the baseline and the 15, 20, 25 and 30% flow reduction scenarios. If it saves time, my request could be limited to the Sailfin Molly, Naked and Clown Gobies, Eastern Mosquitofish, Rainwater Killifish, small gobies and Common Snook. I would also like to receive the flows at the USGS streamflow gage near Wimauma for these flow scenarios for the years 2015 to 2019, the results for which are presented on pages 146 to 149.

The questions I have are about the EFF analyses are listed below.

1. Figure 6-11 on page 147 in the minimum flow report shows average percent reductions in favorable habitat for 10 species. How were the average percent change values calculated for each flow reduction scenario. Were simple arithmetic averages of favorable habitat calculated from all days for the baseline scenario and each flow reduction scenario, then the average for the flow reduction scenario divided by the baseline average value, or was some other method used?

Similarly, in Tables 6-5 to 6-7, were the percent reduction in favorable habitat values calculated as averages for each flow reduction scenario as described above, within flow blocks, or was some other method used to calculate the percent reduction values?

2. The report about nekton in the river collected by the FFWCC that was prepared for the District (MacDonald et al., 2007) divided the stages of many species into size classes for certain analyses. For the species that were assessed for the EFF modeling, were all size classes combined for the modeling of flow reduction effects?

The following questions pertain to the habitat factor that is included in the logistic regression equation that is shown on page 129 of the minimum flows report with the intercept adjustment on page 130. Information on the EFF model is also presented in the report included as Appendix E the minimum flows report, which is draft minimum flows analysis submitted by Janicki Environmental (JEI) in June 2018. The questions below pertain to Appendix E. If these factors are no longer applicable or have been updated, please let me know.

3. On page 4-21, Appendix E says that for the refined model, the habitat levels were collapsed to the following categories: mangroves, emergent (marshes), structure and freshwater habitats, with tree, terrestrial grasses, and bare sand group as a single category. Are these the categories that remained in the final EFF model used to determine the minimum flows?

Also, this page shows a map of the dominant shore types assigned by FFWCC as part of their seine collections. Were the shoreline classifications assigned by FFWCC categories used as the source data to create the collapsed shore habitat types used in the EFF modeling, or was some other source used to determine the shore habitat types?

The map of page 4-21 of Appendix E shows the distribution of dominant shore types identified FFWCC as part of their sampling. It is interesting to note that the map shows 'freshwater" shore types that are located fairly far downstream, sometimes in the mesohaline reach of the river. I wonder what the FFWCC was using to classify the shore type. Were they looking at the vegetation on the upland next to the shoreline? For fish sampling, I would suggest that the shore type should be classified based on habitats and vegetation within the inter-tidal range of the river, but I don't really know what FFWCC used to classify shore types. Does the District or JEI have any information on that?

Also, the FFWCC sampling generally did not extend upstream of approximately kilometer 14. Again, what source data was used to assign habitat types, was something other that data for FFWCC data used? What was applied upstream of kilometer 14?

In general, how was favorable shore habitat determined and applied in the EFF model? I am assuming that shore type was what used to determine shore habitat. Is that correct? Was a separate analysis conducted on the frequency of occurrence of fish species in various shore habitats conducted to determine favorable shore habitats, then the quantity of those shore habitats in various river reaches applied in the EFF modeling? Or, did the EFF modeling itself derive what the favorable shore habitats were for each species? More explanation of how favorable shore habitats were determined and applied in the model would be helpful.

For example, could a species have more than one favorable shore habitat? From looking at the map on page 4-21, I would think that combined emergent marsh and freshwater would make sense.

The figure on page 4-25 for favorable habitat predictions for the striped mojarra (*Eugerre plumieiri*) using the EFDC and the LOESS model is interesting. Does it incorporate both the salinity predictions and favorable habitat factors or is it just based on salinity? On this date (December 6, 2003), it appears that salinity distribution had much to do with favorable habitat being upstream of approximately kilometer 10, as the flow at the gage on that date was 53 cfs.

I would assume on a day with higher flow, the favorable habitat would extend farther downstream. If that were the case, does the EFF analysis also incorporate data from within the bayous and Ruskin Inlet? Page 169 in MacDonald et al. (2007) shows that the striped mojarra had higher geometric mean abundance values in the bayous than in the river channel during that period of data collection (1996-2006).

Thanks for whatever information you can provide to these questions. I expect you are very busy with the holidays approaching, so whenever you can address these if fine, with after Christmas or sometime thereafter being fine.

Thanks again and Happy Holidays!

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*

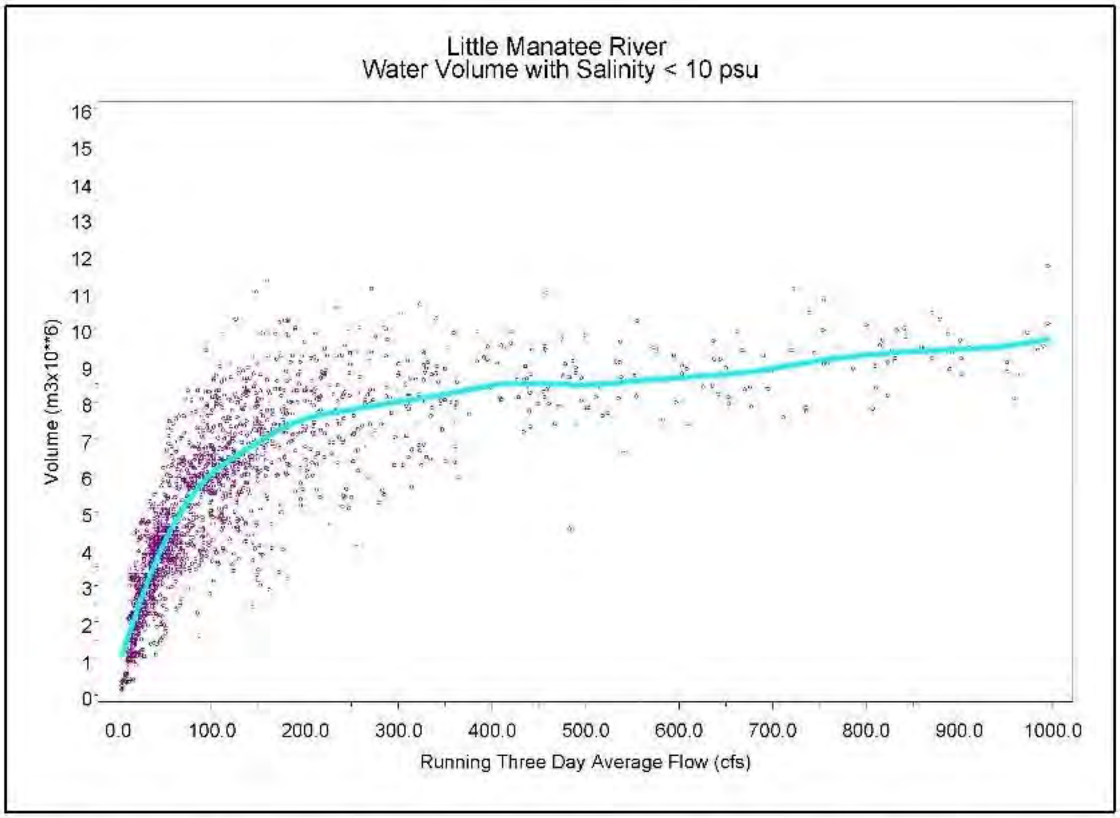
[3] *PBS&J, Inc., 5300 West Cypress Street, Suite 300, Tampa, Florida 33606*

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.

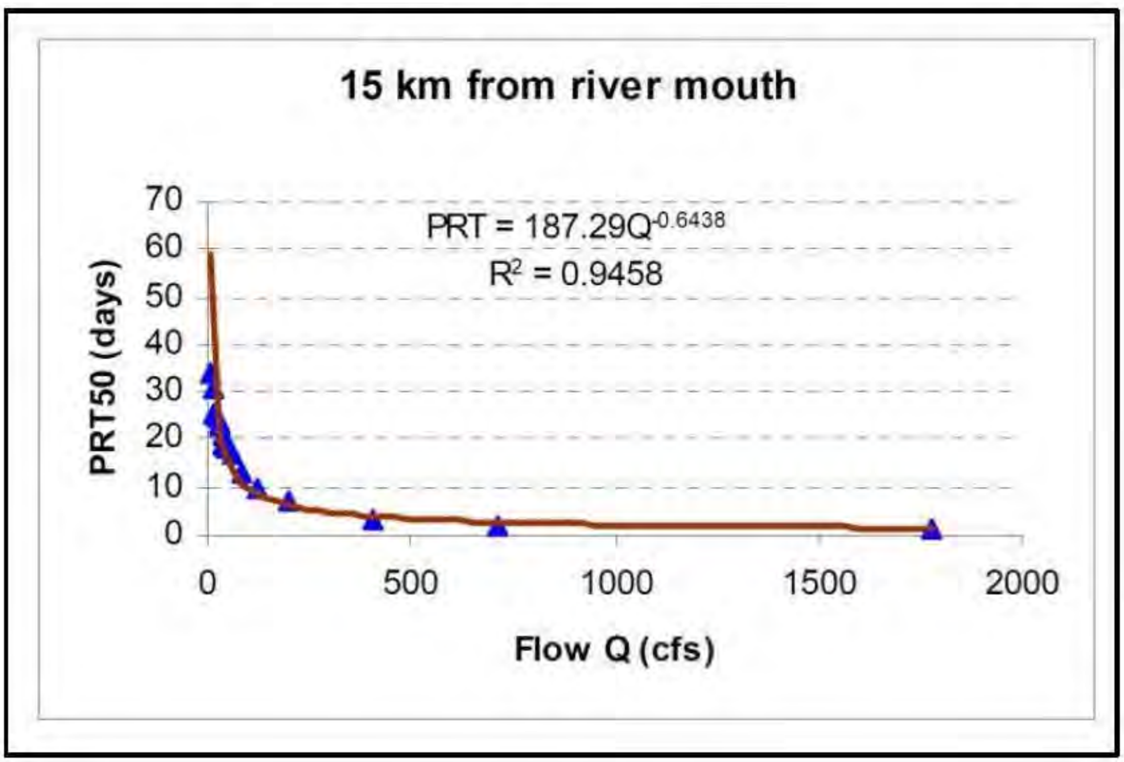
Introduction

Stream ecologists have emphasized the importance of natural flow regimes for maintaining the

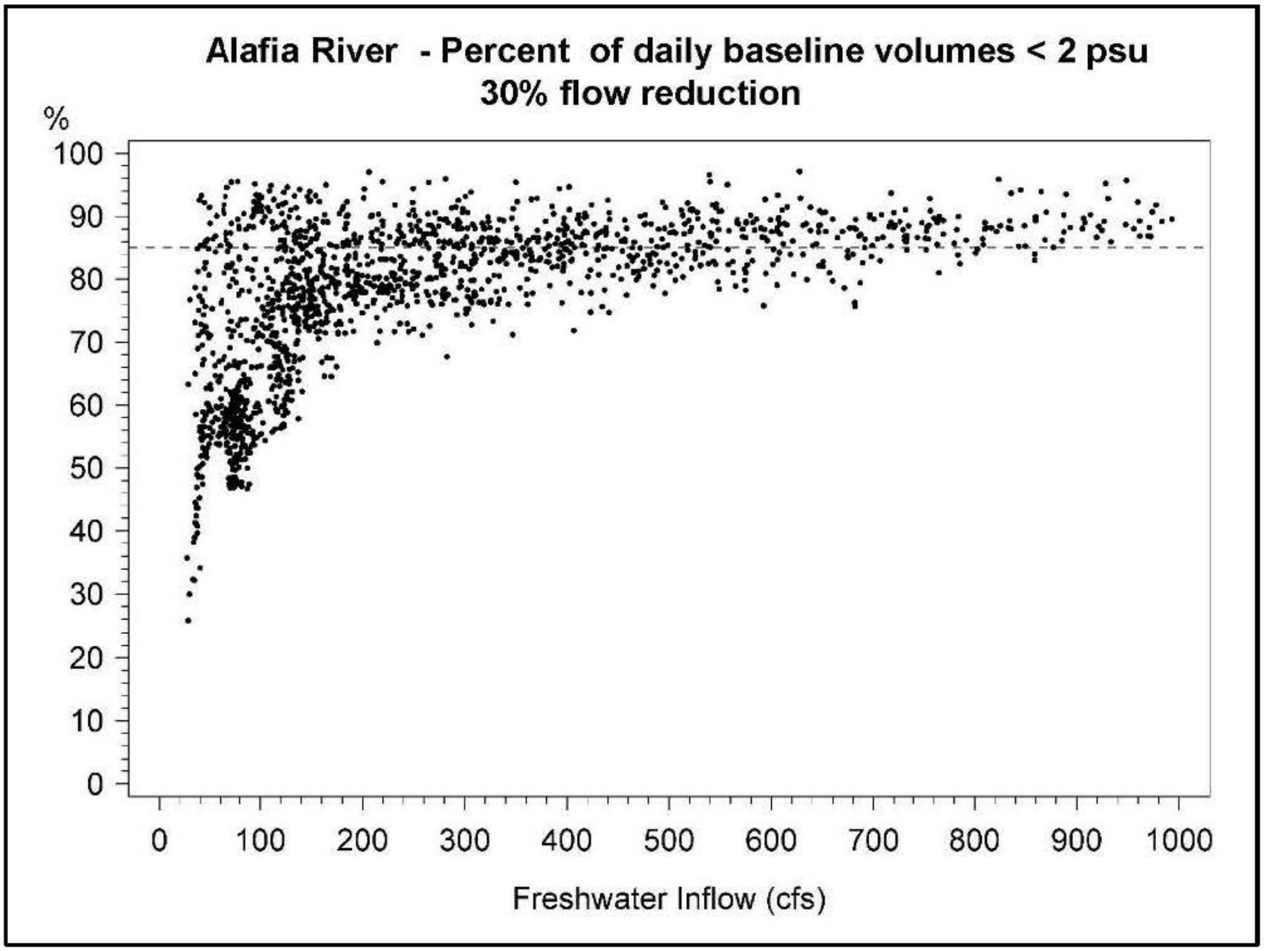
ceding freshwater inflow terms calculated over 2-mo or 3-mo intervals, indicating that the seasonality of inflow can have a significant effect on fish



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

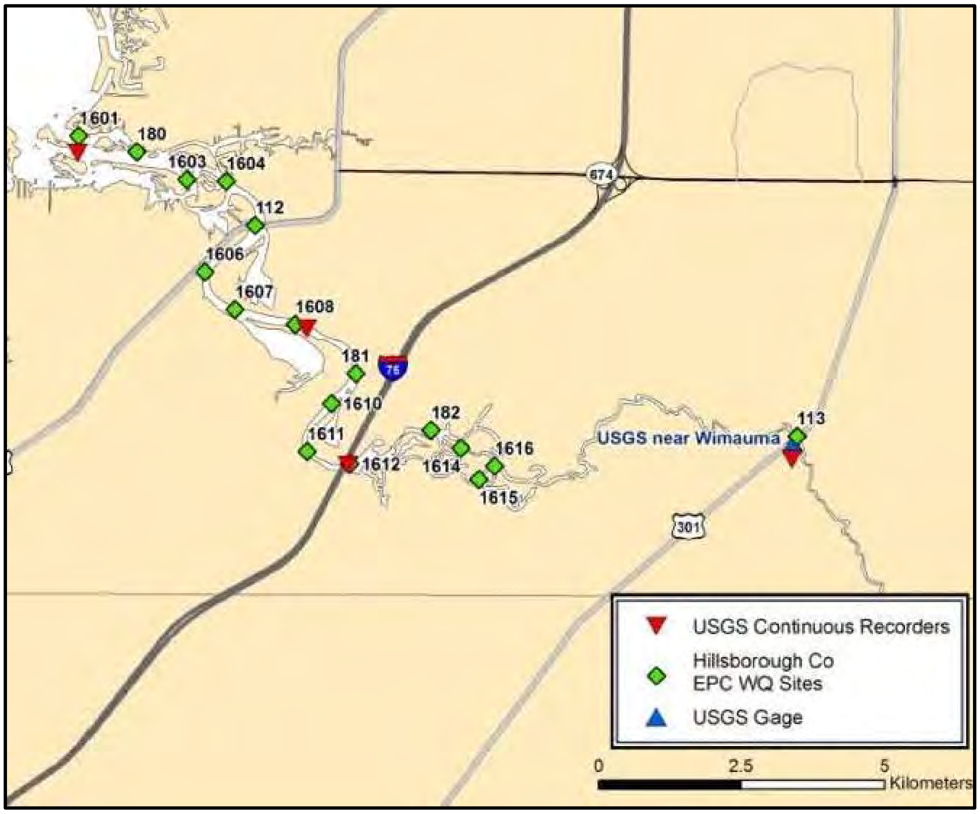


Figure A. USGS salinity recorders and EPCHC vertical profile stations in the lower river.

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

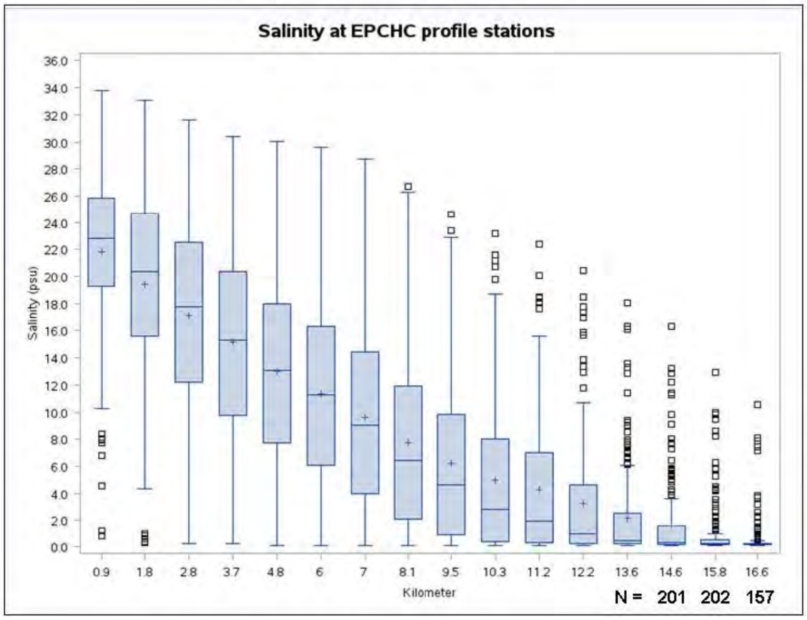


Figure C. Box plot of mean water column salinity values for vertical profiles measured in the lower river by the EPCHC from 12/14/2000 to 10/2/2006 and 01/26/2009 to 08/17/2001. N values for three upstream stations are the number of dates each station was sampled.

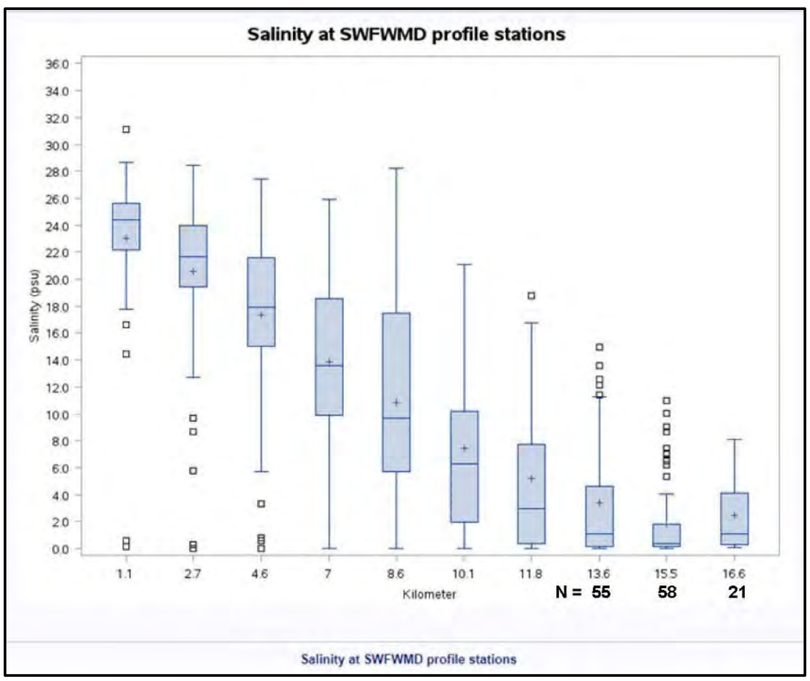


Figure D. Box plot of mean water column salinity values for vertical profiles measured in the lower river by the SWFWMD from 1985 to 1989. N values for three upstream stations are the number of dates each station was sampled.

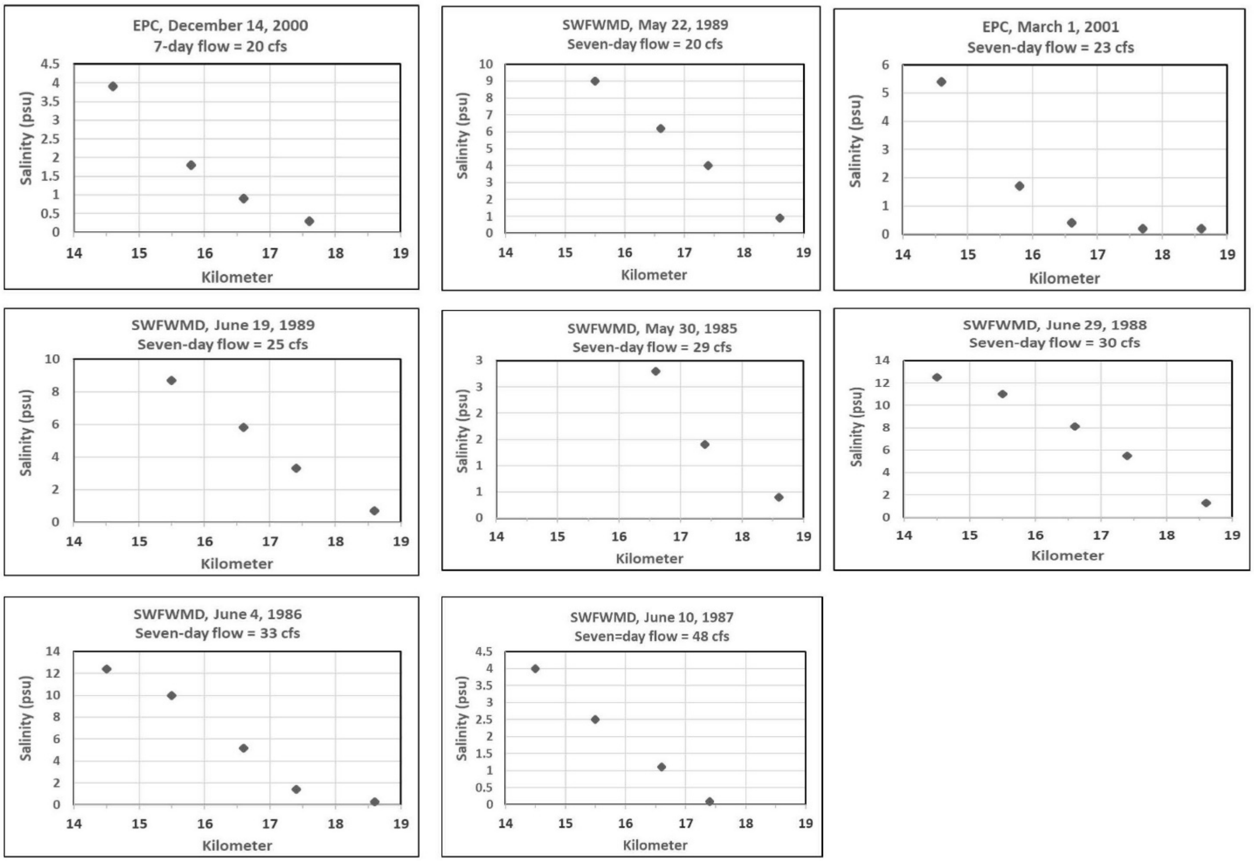


Figure E. Mean salinity values at stations in the upper reaches of the lower river on days when sampling by the EPCHC or the SWFWMD extended upstream of kilometer 16.6

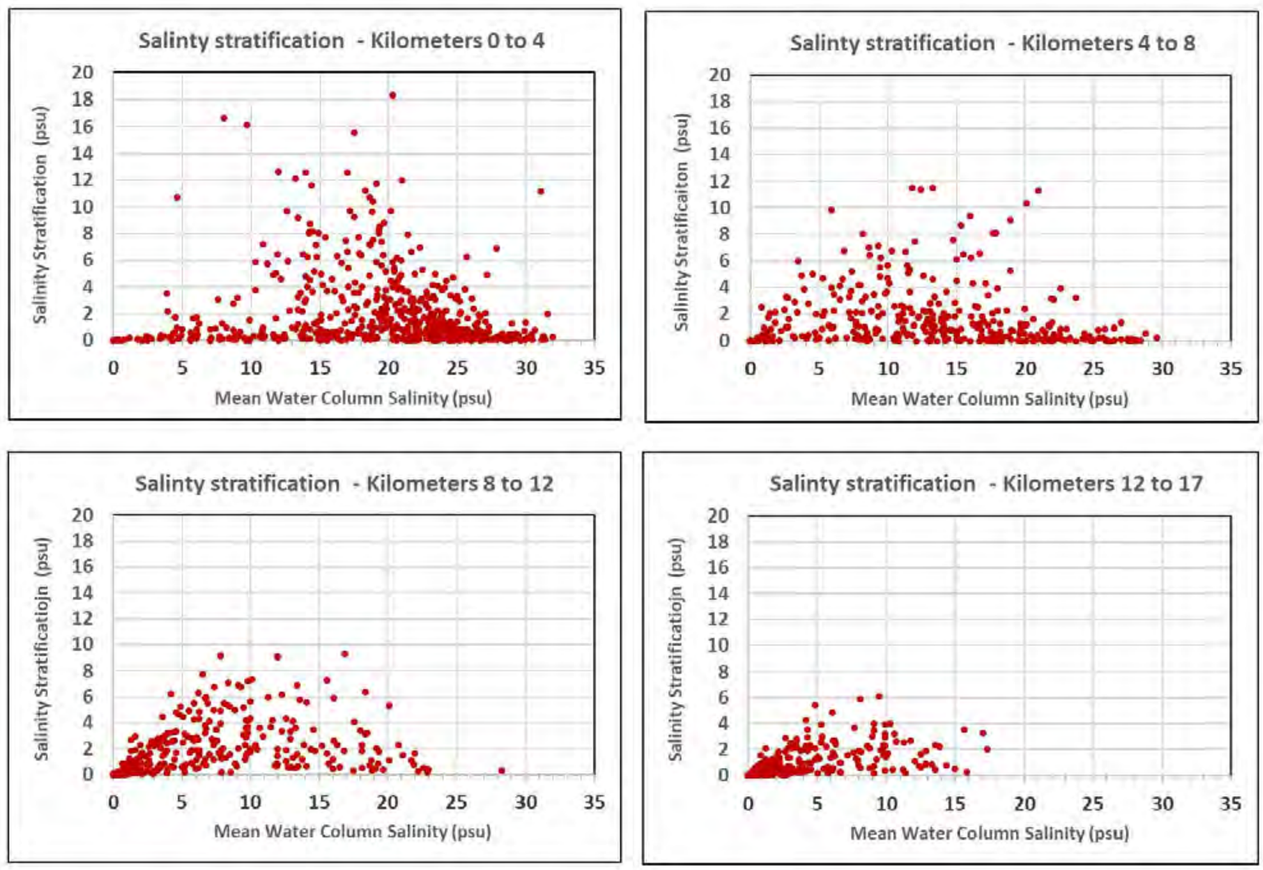


Figure F. Salinity stratification in four reaches of the lower river vs. mean water column salinity for stations that were two meters deep or greater. Stratification was calculated by subtracting the surface salinity value from the bottom salinity value.

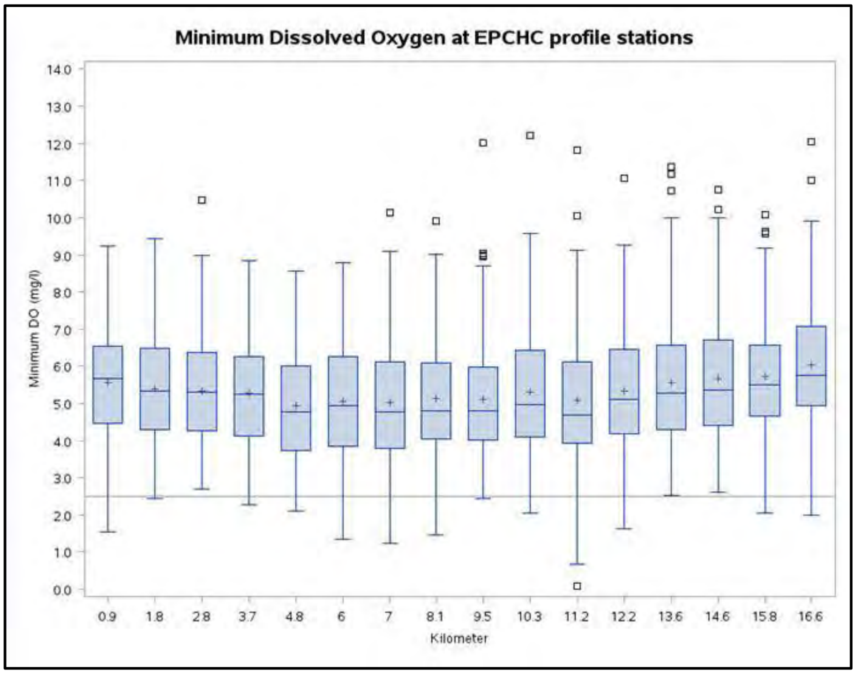


Figure G. Box plot of minimum dissolved oxygen concentrations a stations in the lower river monitored by the EPCHC. Whiskers are 1.5 times ssssssssss.

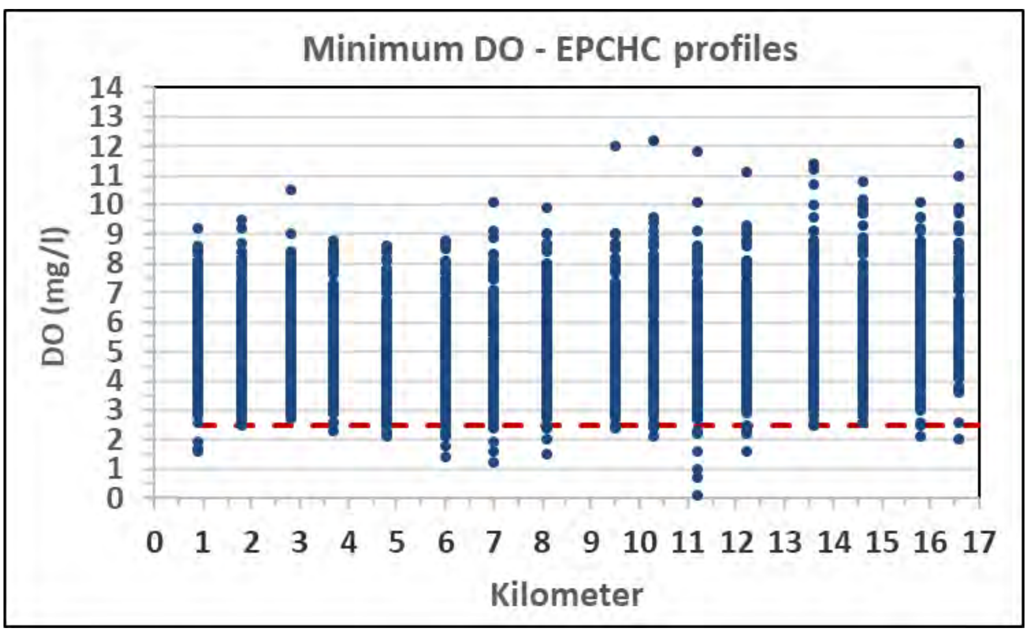


Figure G. Minimum dissolved oxygen concentrations at EPCHC vertical profile stations.

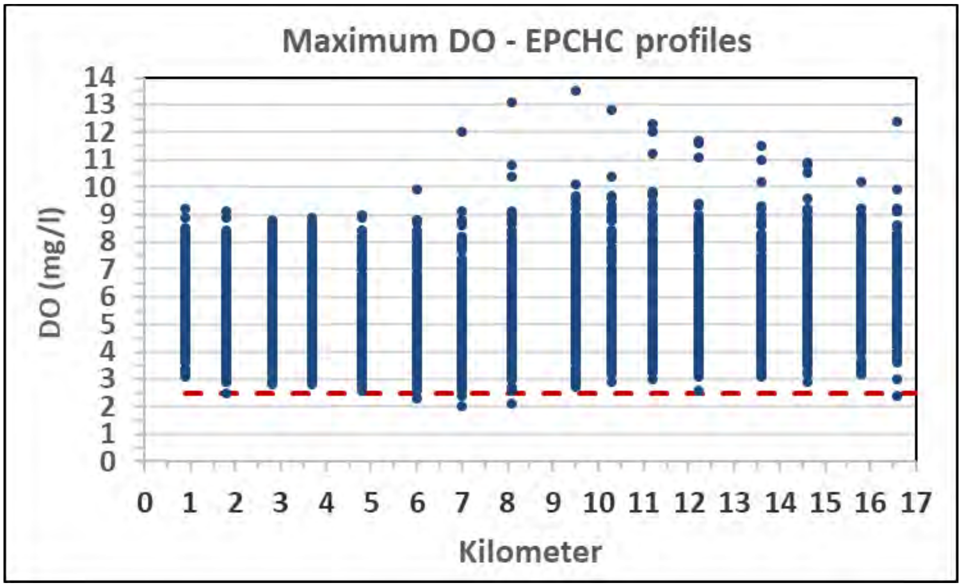


Figure H. Maximum dissolved oxygen concentrations at EPCHC vertical profile stations.

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*	2,126	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	Bleniid	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

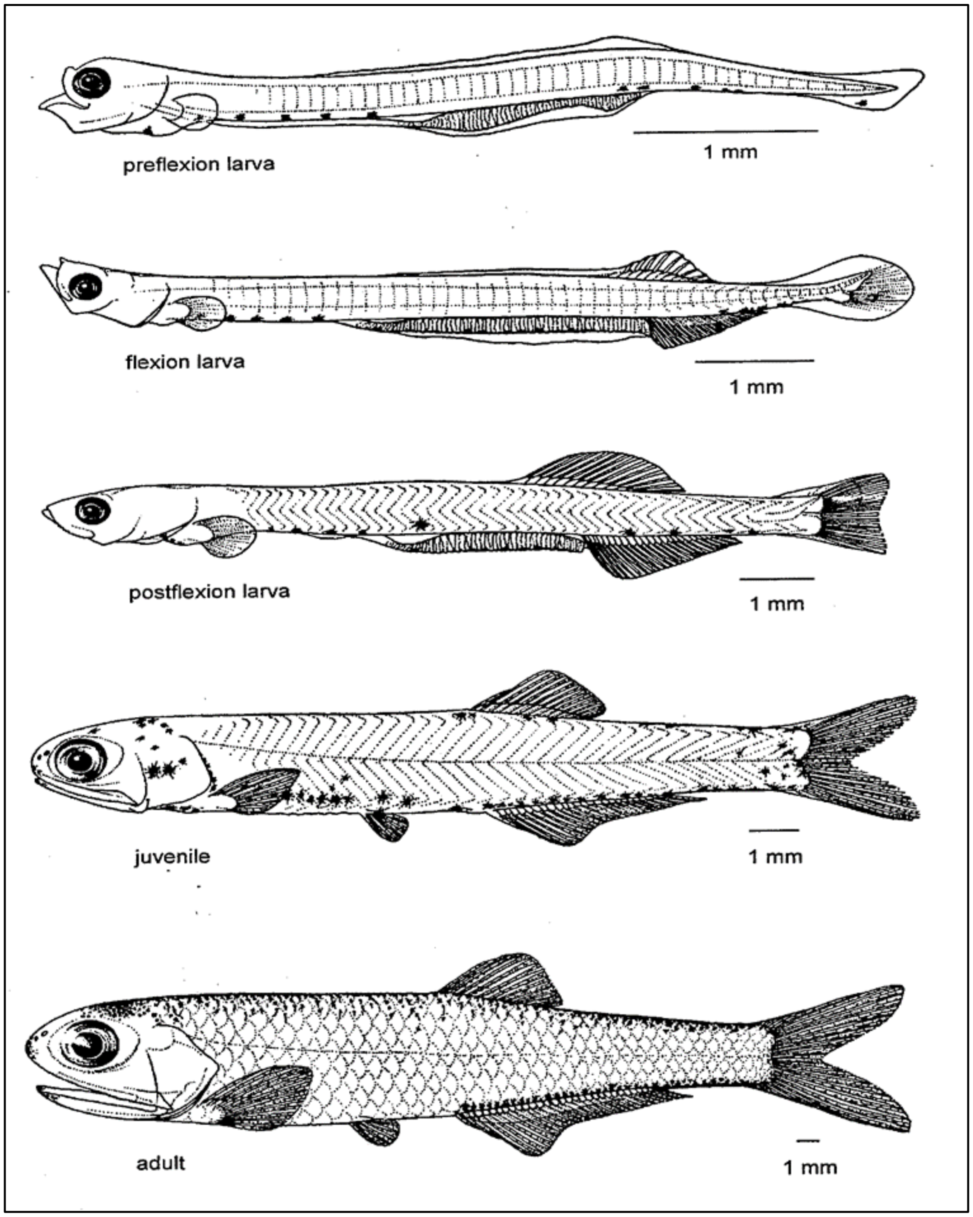


Figure I. Development stages of the bay anchovy (*Anchoa mitchilli*) collected from the Lower Little Manatee River and Tampa Bay, measuring 4.6, 7.0, 10,5, 16 and 31 mm standard length.

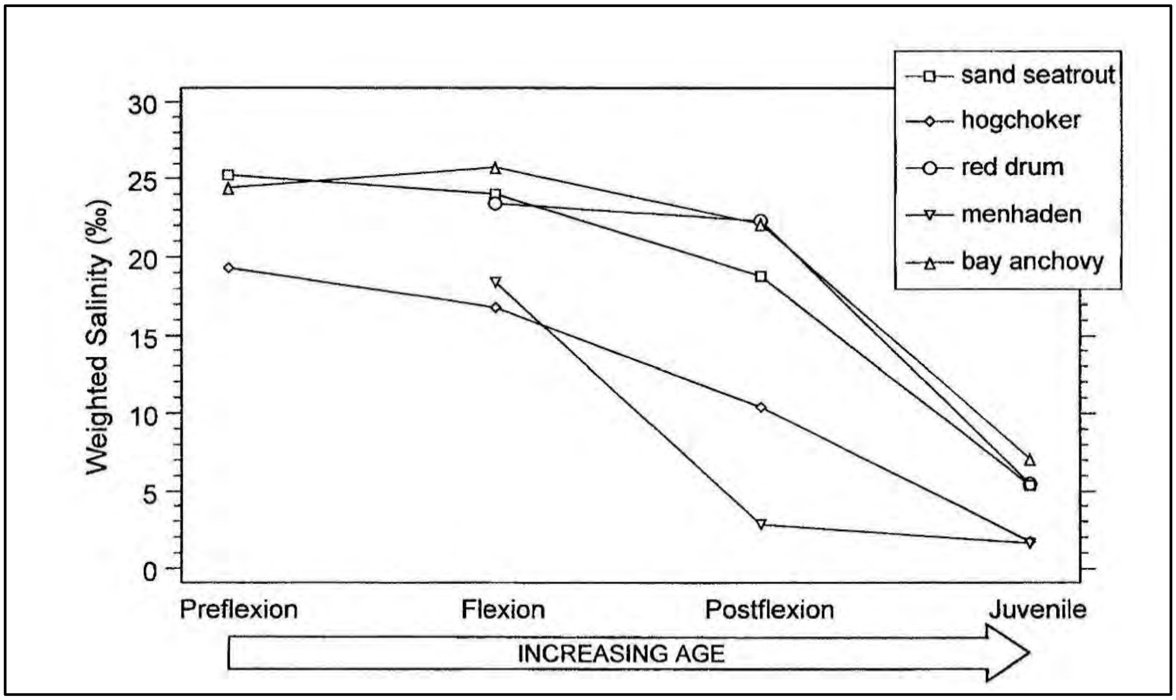
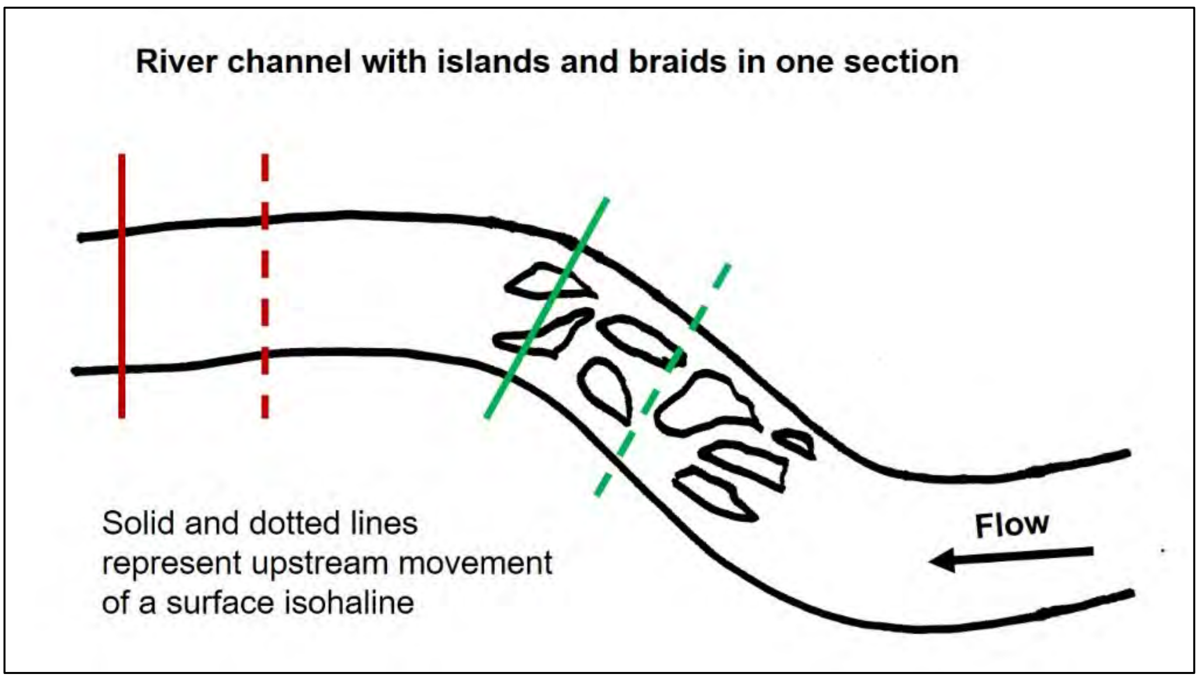


Figure J. Examples of decreasing mean salinity at capture with fish development. See Figure I for illustrations of these stages for the bay anchovy (*Anchoa mitchilli*).

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, 2022

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.

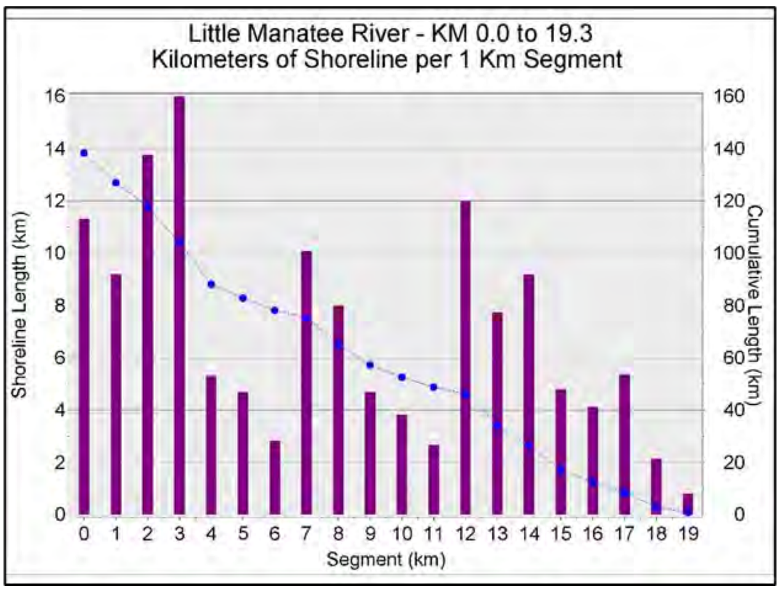
Conversely, there will be a much greater reduction in shoreline length associated with the green lines as there is a much greater quantity of shoreline length in that zone. The differences in these changes will also be reflected in percent reductions in total area and shoreline length upstream of these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

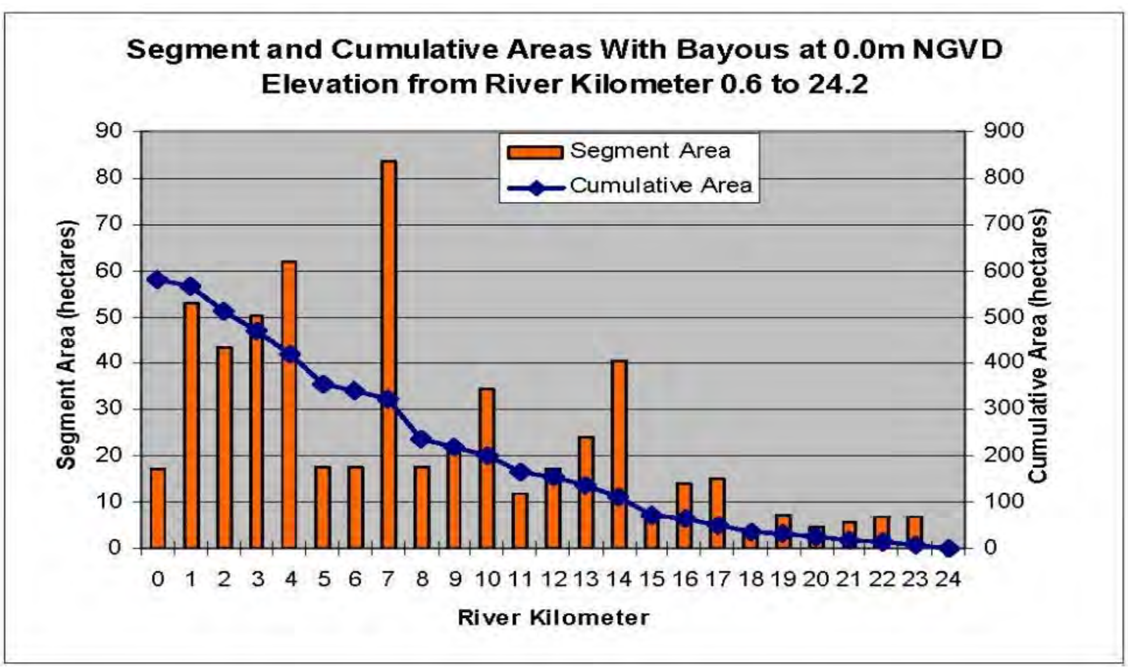


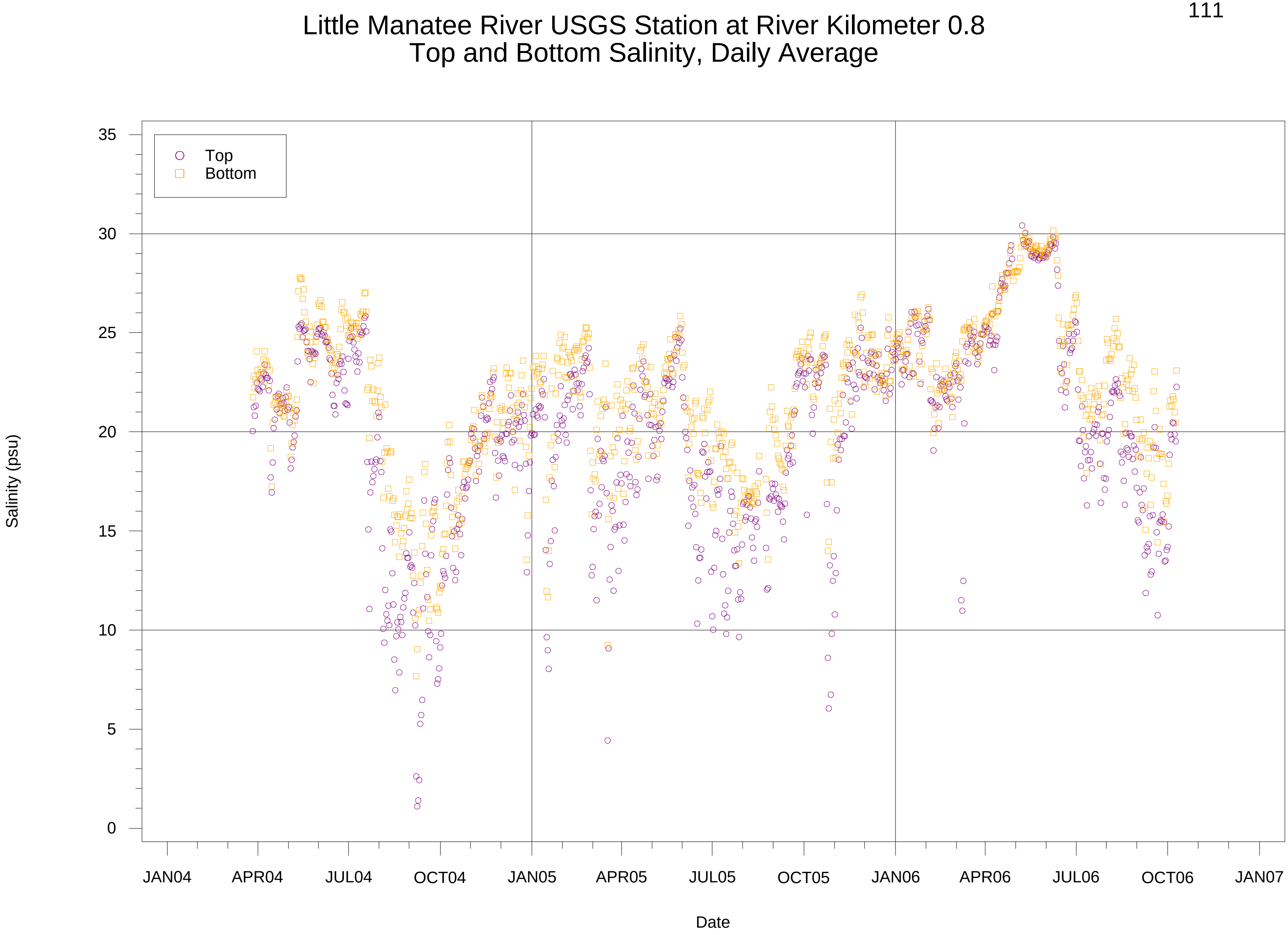
See next page for graphs from the Little Manatee

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.

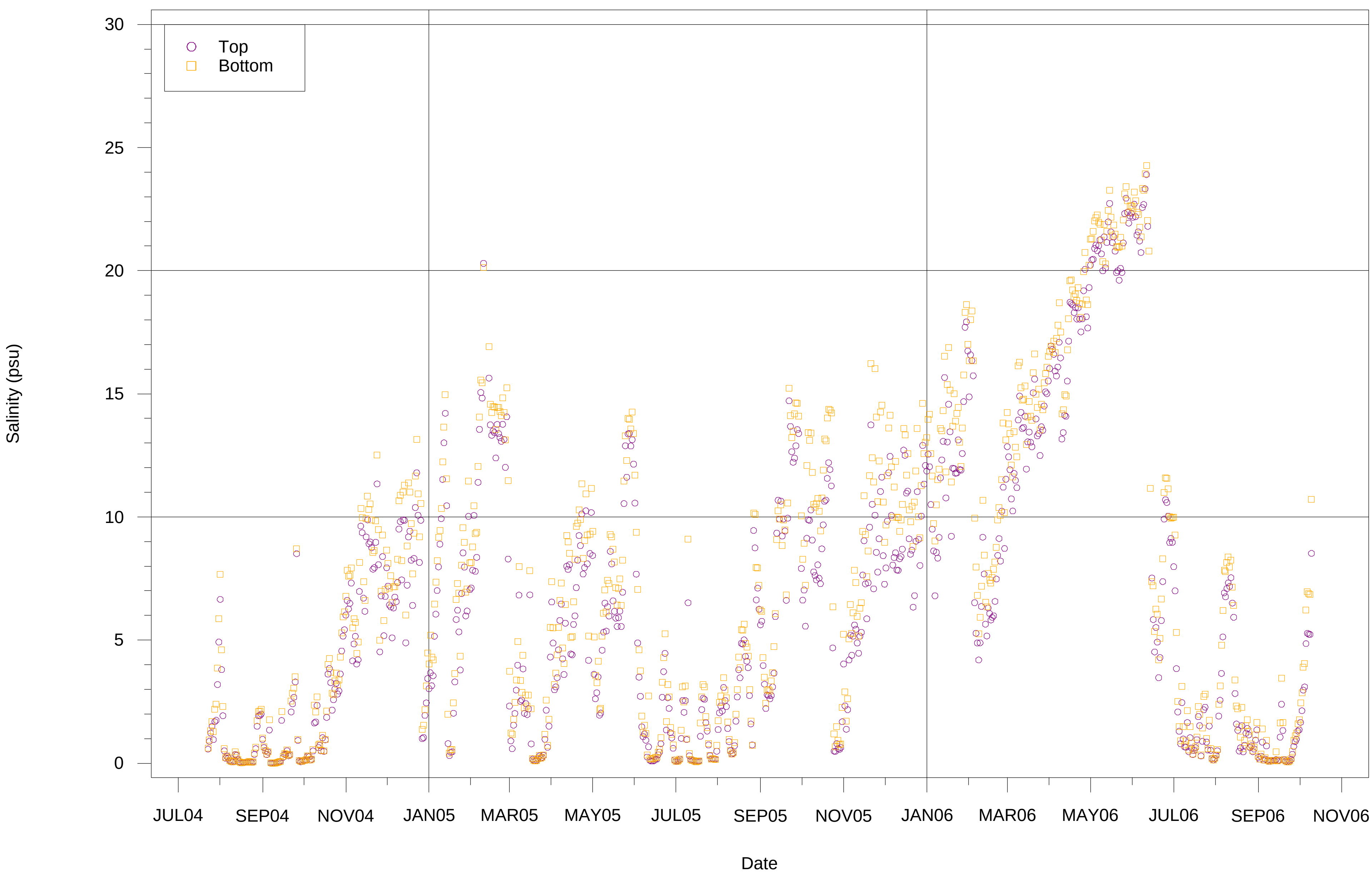




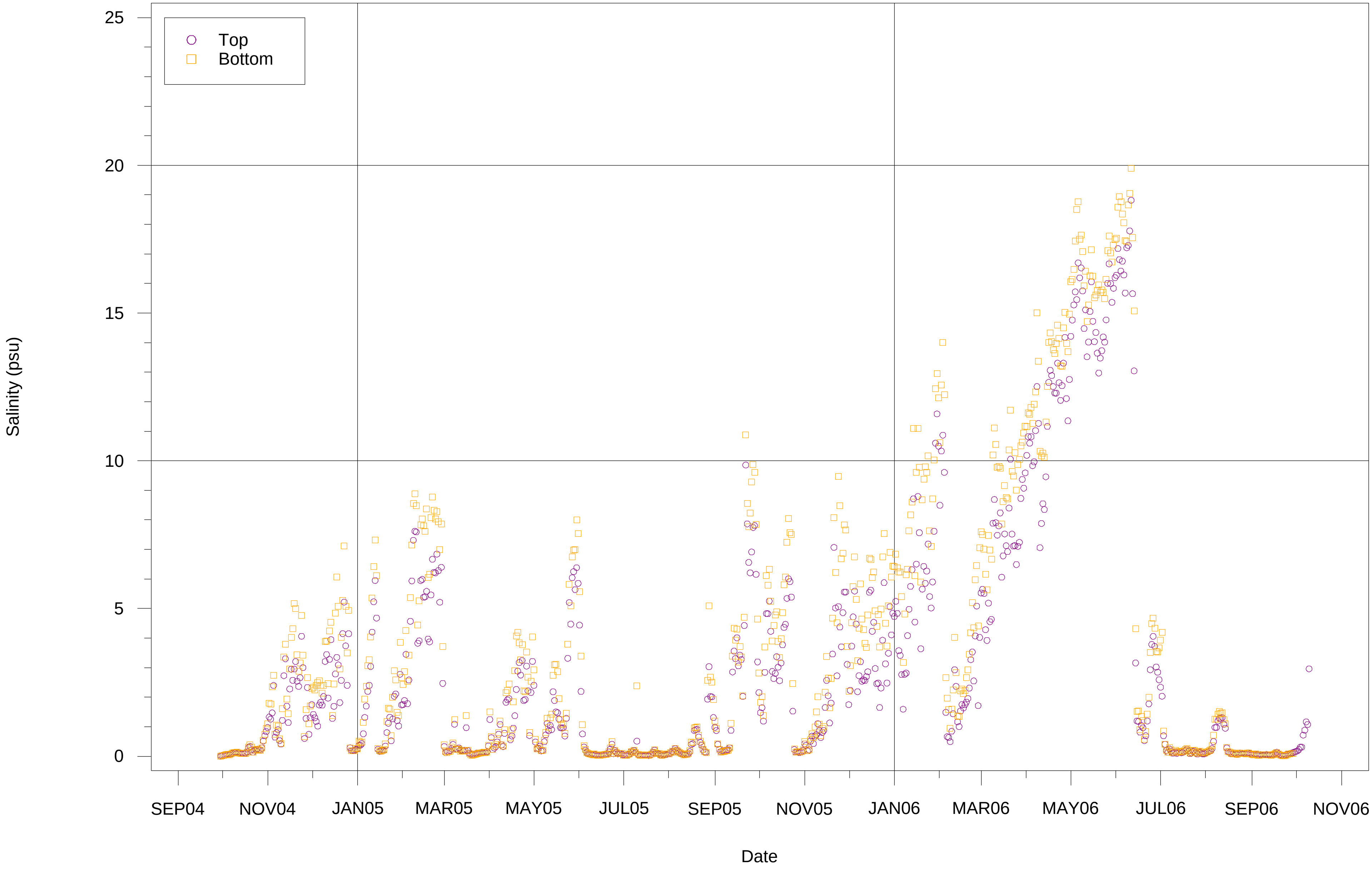


Little Manatee River USGS Station at River Kilometer 0.8
Top and Bottom Salinity, Daily Average
Top
Bottom
Salinity (psu)
35
30
25
20
15
10
5
0
JAN04
APR04
JUL04
OCT04
JAN05
APR05
JUL05
OCT05
JAN06
APR06
JUL06
OCT06
JAN07
Date

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



September 7, 2022

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.

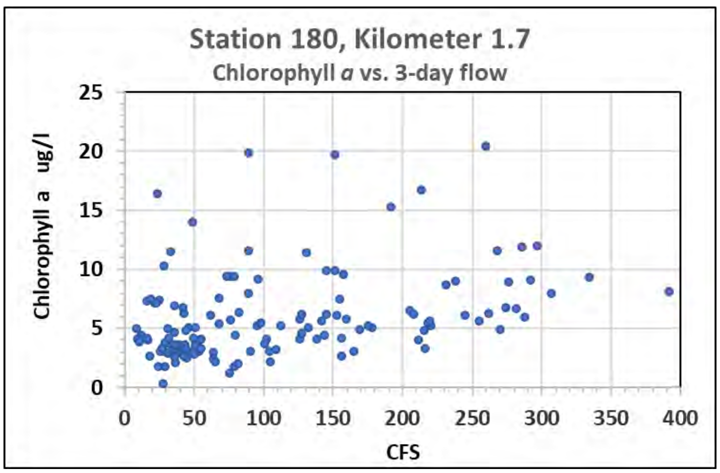
These studies have shown that the spatial distribution of chlorophyll *a* concentrations in tidal rivers is strongly affected by a number of factors, including nutrient loading, light penetration, and residence time. In turn, all of these factors are strongly affected by the rate and volume of freshwater 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.

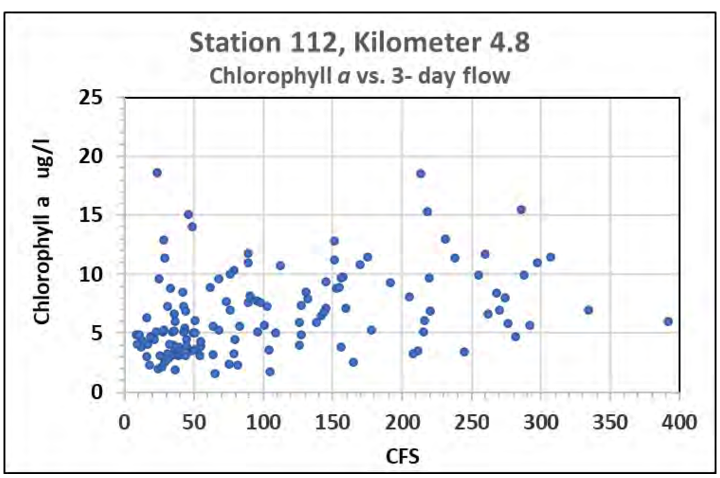
Table 2. Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers, adapted from Vargo et al. (2004).

		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.



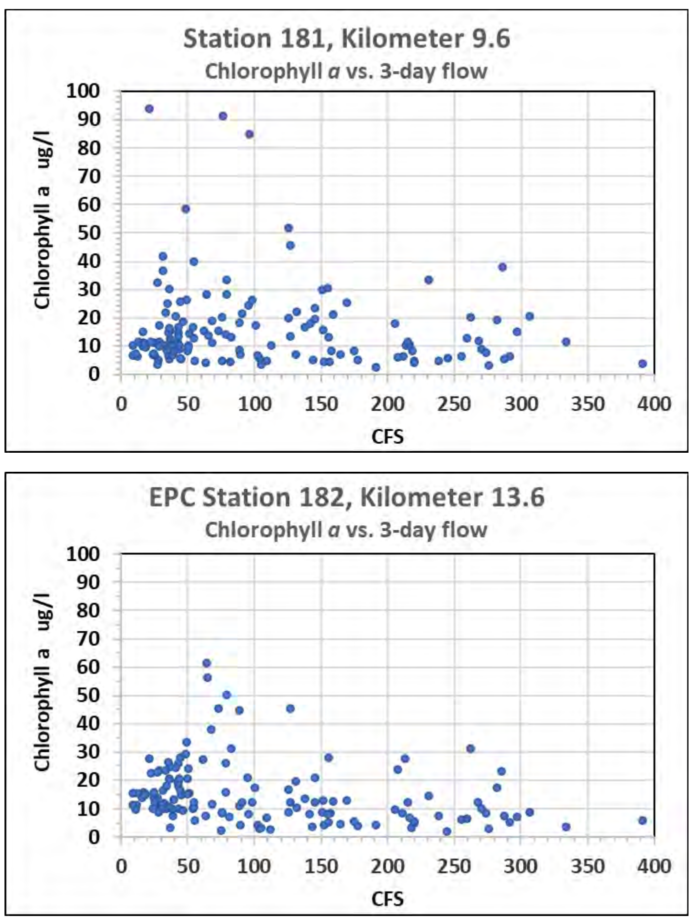


Figures 1 and 2. Chlorophyll *a* concentrations at EPCHC stations at kilometers 1.7 and 4.8 in the Lower Little Manatee River vs. the preceding three-day average flow at the US 301 gage.

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.

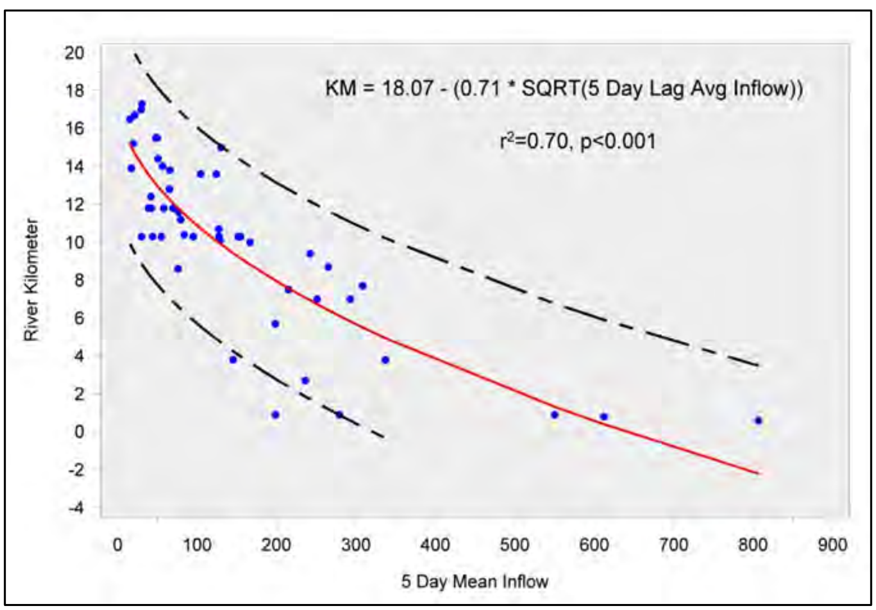


Figure 5. Scatter plot and regression of the location of maximum chlorophyll *a* concentrations measured among four moving salinity-based stations in the Lower Little Manatee River vs. the preceding five-day average inflow for each sampling date.

*** 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.

Location of maximum chlorophyll *a* concentrations in relation to freshwater inflow in the Little Manatee River

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.*

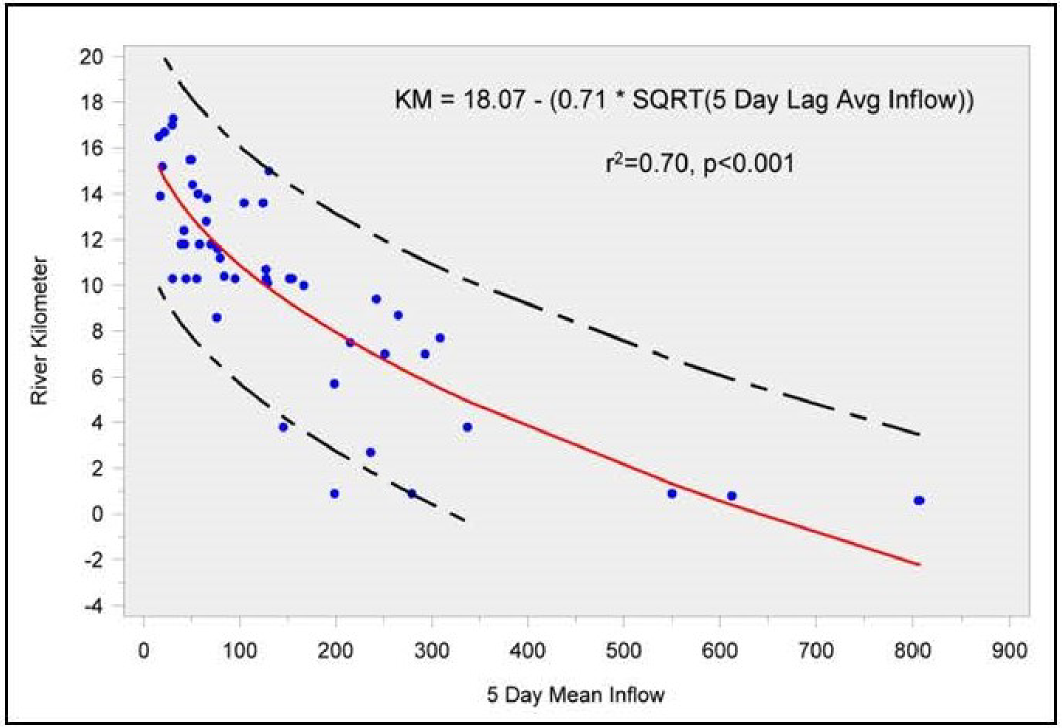


Figure 5. Scatter plot and regression of the location of maximum chlorophyll *a* concentrations measured among four moving salinity-based stations in the Lower Little Manatee River vs. the preceding five-day average inflow for each sampling date.

July 24, 2023

Plan of Study – Graphical analyses to evaluate flow blocks for minimum flows for the Lower Little Manatee River

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

As part of a public records request, the Southwest Florida Water Management District (the District) will provide to me files of predicted output values from the EFDC hydrodynamic model and EFF favorable fish habitat models for the Lower Little Manatee River. These files will be used to generate graphics to help evaluate suitable flow rates to serve as blocks to allow changes in allowable percent withdrawal rates for the lower river.

The District has estimated these files can be provided near the beginning of August, but the exact date of delivery may vary. I will begin to generate the graphics as soon as I receive the files and hope to produce a series of plots and a corresponding technical memorandum within a week or so. This memorandum may support the flow blocks of 29 and 96 cfs recommended in the revised draft minimum flows report, or instead could possibly suggest revised flow blocks for the lower river.

The graphics that will be generated are fairly simple, but are very informative and have been used to evaluate flow blocks for tidal estuarine rivers in three previous minimum flow studies conducted by the District. Examples of these types of graphics and their utility were discussed in a supplemental analyses, data presentations, and clarifications report I submitted to the District in January 2002 and also shown in two slides I presented to the minimum flows peer review panel at their meeting on July 5, 2023.

In the case of the Little Manatee River, it is critical that relationships of favorable fish habitats to freshwater inflow be evaluated, as the minimum flows for the lower river were ultimately based on reductions in fish habitats as they generally provided more conservative results that reductions in salinity zones. Also, the EFF fish habitat models include both a salinity and shoreline type component, so the predicted values may show relationships with freshwater flow that are different than simple salinity zones because shoreline types change along the length of the lower river.

Plots of baseline values - The first type of graphics will be plots of daily values for the quantities of salinity zones and favorable fish habitats vs. baseline flows. The salinity zones that will be graphically evaluated will include bottom area, volume, and shoreline lengths below salinity values of <1, <2, <5, <10 and <15 psu. Similar plots of the amount of favorable fish habitats vs. baseline flows will be generated for eight taxa of fish analyzed in the minimum flows reports.

Plots of reductions in salinity zones and fish habitat v. baseline flows for various flow reduction scenarios - The second type of plots will show percent reductions in daily values for salinity zones and favorable fish habitats for a series percent flow reduction scenarios. Based on findings from previous minimum flow studies of other tidal estuarine rivers (lower reaches of the Peace, Myakka, and Pithlachascotee Rivers), these types of graphics are very useful for evaluating flow blocks that allow increases in allowable percentage withdrawal rates.

*** *one of several with that job title at the District including another staff member in the minimum flows program at the time of my retirement***

Using output from the EFDC model, plots of daily values for percent reductions in the volume, bottom area, and shoreline lengths less than the aforementioned five salinity values vs. the corresponding rate of baseline flow will be produced for the flow reduction scenarios of 15, 20, 25 and 30 percent. Using output from the EFF models, plots of daily values for percent reductions in favorable fish habitats vs. the corresponding rate of baseline flow will be shown for eight fish taxa that were assessed in the minimum flows report for flow reductions of 15, 20, 25, 30 and 35 percent.

As a separate effort, graphics and analyses of the response of the chlorophyll *a* in the lower river to freshwater inflow may also be submitted to the District and the peer review panel if they provide useful related findings that support the evaluation of flow blocks that are based on salinity zones and favorable fish habitats. In addition, regressions of freshwater inflow with the number and center of abundance for various fish species in the ichthyoplankton and nekton catch published in previous studies of the lower river by the University of South Florida and the Florida Fish and Wildlife Conservation Commission may also be examined as they pertain to the establishment of flow blocks for the lower river.

Data presentation and analyses - It is expected that a series of graphics will be provided for some, but not all, of the plots in a technical memorandum I will prepare with emphasis on those graphics that seem most critical to the evaluation of flow blocks for the lower river. Appendices containing of the total set of graphics can be provided upon request.

As previously mentioned, the findings of this assessment may either support the 29 and 96 cfs thresholds for flow blocks for the lower river recommended in the draft minimum flows report, or instead may recommend revisions to the flow blocks. If revisions to the flow blocks are recommended, the memo will statistically analyze the percent reductions of salinity zones and favorable fish habitats within each of those flow blocks.

September 4, 2023

To: Kym Holzwart, Yonas Ghile, XinJian Chen, Gabe Herrick, Kristina Deak, Jordan Miller, Doug Leeper, Chris Zajac, Randy Smith, Jenette Seachrist

CC: Peer review panel for the minimum flows for the Litte Manatee River via the webboard

From: Sid Flannery, retired, formerly Chief Environmental Scientist with SWFWMD MFL program

Subject: Critical graphical analyses for the evaluation of flow blocks and allowable percent withdrawal rates as part of minimum flows determination for the Little Manatee River

This memorandum ties together some technical points I have made as part of the review of draft minimum flows report for the Little Manatee River. This memo discusses some graphs that were shown at meetings of the peer review panel for the minimum flows report, plus two important related graphs for the Lower Peace River were discussed but now shown at those meetings.

As application of the percent flow method had progressed over the years, important relationships have been described and documented in the estuarine reaches of rivers in the District. Based on those findings, certain analytical tools have proven to be very effective for determining flow blocks and allowable percent withdrawal rates that hopefully protect such rivers from significant harm from water supply withdrawals.

As I have previously discussed and will be put into further context below, minimum flows for the lower section of the Little Manatee River should not be recommended or adopted until some important, additional graphical analyses are performed and reviewed, as these types of analyses have been used effectively for the determination of minimum flows for other tidal rivers in the District and represent the application of some of the best available information which could help protect the Little Manatee River from significant harm that could result from water supply withdrawals.

The need to account for the high flow effect in the nonlinear response of salinity to freshwater inflow in the evaluation of flow blocks and allowable percentage withdrawal rates

As discussed in District papers and reports, the response of salinity in tidal rivers is often nonlinear with changes in salinity most sensitive at low flows. That is one justification for the percent of flow method, as it reduces the quantity of withdrawals from rivers during sensitive low flow periods. However, it is interesting that this nonlinearity applies even when the effects of simulated water withdrawals are limited to a percentage of flow, which is acknowledged on page 122 of the most recent draft minimum flows report for Little Manatee.

A clear demonstration of this is in Figure 1 for the Lower Alafia River on the following page, which was reviewed but not presented in the minimum flows report for that river. It is clear that a 30 percent withdrawal rate results in a greater percentage reduction in the volume of water less than 2 psu salinity at low flows and less percentage reductions for that salinity zone at high flows.

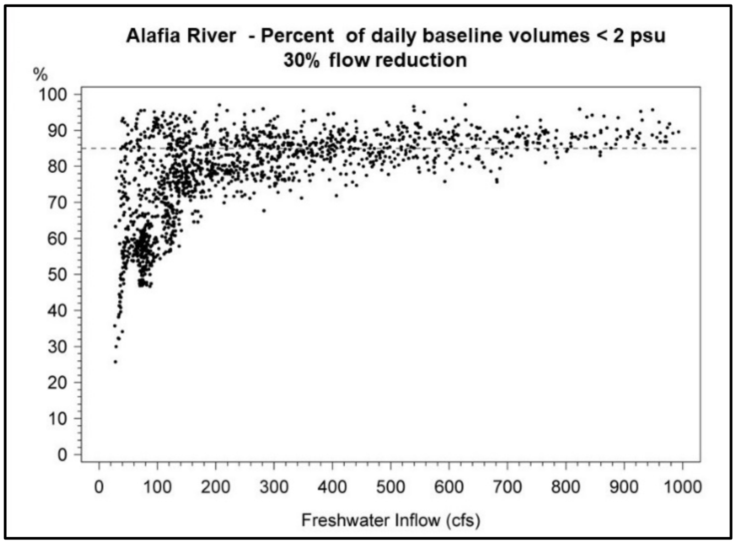


Figure 1. Percent of daily water volumes less than 2 psu salinity for a 30 percent withdrawal rate relative to the daily volumes for baseline conditions vs. the corresponding rate of baseline flow

These types of plots are very useful for evaluating flow blocks for tidal rivers and were used for that purpose and shown in minimum flows reports for the Lower Peace, Lower Myakka, and the Pithlachascotee Rivers. As shown by Figure 1, they were also examined for the Lower Alafia River, but not included in that report.

To support the flow blocks for the Lower Little Manatee River, the District presented only one graph in the minimum flows report, that being a plot of water volumes less than < 2 psu salinity vs. baseline flows. The report says that other graphics were examined, but did not describe the general content of those graphics. I strongly recommend that graphics of percent reductions in salinity zones for various flow reduction scenarios such as Figure 1 above be performed for the Little Manatee River and made available for review and possibly included in an Appendix to the report.

The nonlinear relationship of reduction in salinity zones to flow also has important implications for the determination of allowable percent withdrawal rates within flow blocks. Although not shown in Figure 1, the volumes of water < 2 psu will generally increase with flow and reach high values at higher flows. As flows increase, the volumes of water < 2 psu for both the baseline and a flow reduction scenario will increase, but the percent difference in these values generally decrease.

For example, If the percent reduction in the volume of a salinity zone is calculated from the difference in the average volume values for the baseline and the flow reduction scenario, the large volumes during high flows that have relative small differences between scenarios can overwhelm and mask the results for many days at lower flows in which the volumes are lower, but the relative differences between scenarios are greater.

It is therefore very important to define the method that is used to calculate the net percent reduction in salinity zones used to determine the allowable percent flow reduction for each flow block. I may have missed it, but it appears the method to determine the net percent reductions in salinity zones listed and shown in figures and tables in the draft minimum flows report is not identified in the report. In other District minimum flows reports, the same consultant generated cumulative distribution curves for salinity zones for baseline flows and various flow reduction scenarios and computed net percent reductions in salinity zones using the normalized area under the curve (NAUC) method. A good summary of this method is presented in the minimum flows report for the Lower Myakka River.

I have not personally applied the statistical program for the NAUC method, but is seems like it would produce results for percentage reductions in salinity zones similar to what the difference in the average values for salinity zones between the scenarios would yield. If so, the effects of large volumes of salinity zones that have small relative differences between flow scenarios during high flows could overwhelm and mask the effects of many days at low flows when the volumes are small, but the relative percent differences are greater.

A very informative analysis in that regard was performed for the minimum flows report for the Lower Peace River published in 2010. At that time, the District applied the calendar based approach to minimum flows for the lower river, with blocks corresponding to what are typically periods during the year that have low (Block 1), medium (Block 2), or high flows (Block 3). Along with a low flow cutoff of 130 cfs, the allowable flow reductions were 16% of flow for calendar based Block 1, 29% for Block 2, and 38% for Block 3.

Concerns were raised that low flows can periodically occur in any these blocks, particularly during Block 2 which ran from late October to mid-April. To account for the occurrence of low flows, a flow threshold of 625 cfs was applied to ensure that flows reach a suitably high rate before the higher withdrawal percentages could be applied in the calendar based medium and high flow Blocks 2 and 3.

Two graphs from the 2010 minimum flows report for the Lower Peace are reprinted here, as they represent very informative types of graphics that are useful for evaluating flow blocks in tidal rivers. Figure 2 is application of a 29 percent flow reduction in the calendar Block 2, along with a 130 cfs low flow cutoff and a 400 cfs withdrawal limit that was applied in that minimum flow determination and subsequent rule. Figure 2 does not include the 625 cfs flow threshold, and shows that within Block 2 the percent of water volume < 2 psu salinity relative to baseline varies considerably as a function of flow for the 29% withdrawal rate.

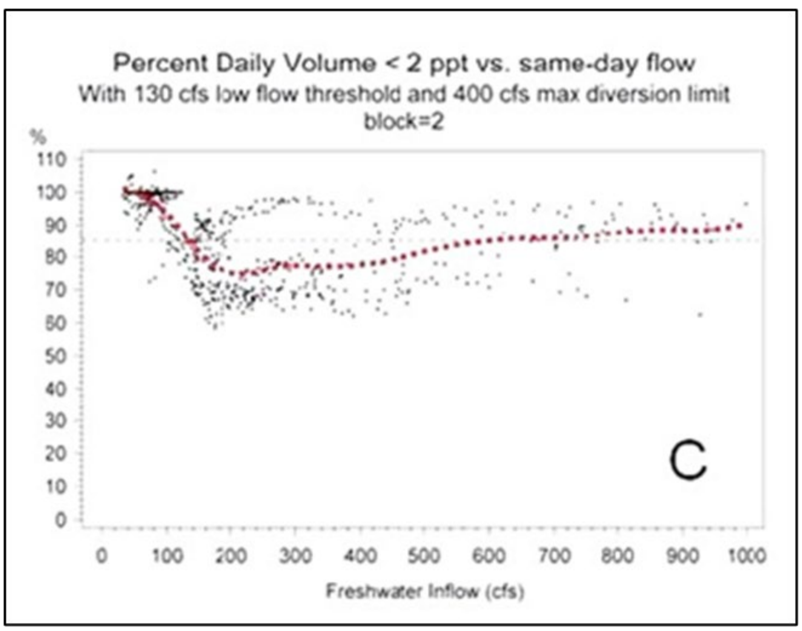


Figure 2. Percent of daily volumes of water < 2 psu salinity relative to baseline conditions for a 29% percent flow reduction vs. the rate of baseline flow within calendar based Block 2, with a reference line at 85% of volume and a LOWESS smoothed line fitted to the data. Reprinted from 2010 minimum flows report for Lower Peace River.

The allowable 29% flow reduction for the calendar Block 2 was determined using the NAUC method for all the days in that block. It is apparent in Figure 2 that daily reductions considerably greater than the District's 15% target (85% of baseline condition) for water volumes < 2 psu were frequent at flow rates between 150 and 600 cfs, with a greater frequency of smaller percentage reductions at higher flows.

The median flow for Block 2 during the 20 years prior to this 2010 report was 327 cfs, so reductions in the volume of water < 2 psu considerably greater than 15% would have occurred much of the time. This indicates the high flow effect described on pages 2 and 3 can mask large percent reductions in salinity zones at lower flows depending on how the allowable percent flow reductions are determined, in this case using the NAUC method, which may have been used for the Little Manatee, but again it appears the method to calculate net percent reductions in salinity zones is not identified in the draft report.

Based on information in Figure 2, the District applied a flow threshold of 625 cfs below which the allowable withdrawal percentages for Blocks 2 and 3 could not be applied, as the withdrawals must remain at the 16% rate for Block 1 until baseline flows exceed at rate of 625 cfs. The daily values of percent of water volume < 2 psu salinity relative to baseline conditions that employed the 625 cfs flow threshold is shown in Figure 3. It is apparent that this flow threshold did much to reduce the daily percentage reductions of that salinity zone at flows between 150 and 600 cfs, so the 625 cfs threshold was incorporated in minimum flow rule adopted for the Lower Peace River at that time.

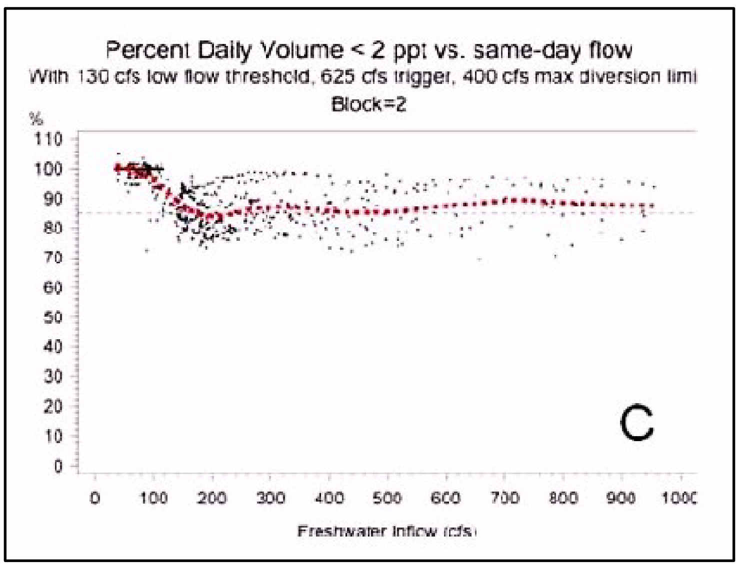


Figure 3. Percentages of the daily volumes of water < 2 psu salinity relative to baseline conditions for a 16% percent flow reduction below a flow rate of 625 cfs and a 29% flow reduction above a flow rate of 625 cfs vs. the rate of baseline flow within Block 2, with a reference line at 85% of volume and a LOWESS smoothed line fitted to the data.   Reprinted from 2010 minimum flows report for Lower Peace River.

These graphs of percent reductions in salinity zones vs. flow for a various flow reductions scenarios can be very useful for determining flow blocks that change the allowable percentage withdrawal rates and the percentage withdrawal rates within those blocks. As previously described, such graphics were previously used to evaluate flow blocks for minimum flows for three rivers in the District. However, if such graphics were generated for the Little Manatee River, they were not shown in the recent draft report for the river. Accordingly, In addition to plots of salinity zones vs. baseline flows (one of which was shown in the report), graphics of the percentage reductions in salinity zones for various flow reduction scenarios should be

prepared and reviewed for the Little Manatee River, including the recommended minimum flows with the corresponding flow blocks of 29 and 96 cfs.

As part of my comments to the peer review panel during the first set of meetings in the fall of 2021, I recommended such graphic analyses be performed and described the approach taken for the Lower Peace River, though graphics were not shown for that river. Also, in subsequent communications with the District, I inquired about receiving files derived from output from the EFDC and EFF models for the river so I could do such analyses. However, when I learned that both models were being revised, I said I would wait until the new models were finalized. I then concluded that I would wait and see that the District recommended for flow blocks in the revised minimum flows report, which was made available in late June of 2023.

Based on the very limited results presented in that report, two days after the review panel meeting on July 12, 2023, I placed a request to the District for files of values of the area, volume and shoreline lengths less than certain salinity values (e.g., < 2 psu) for a series of flow reduction scenarios generated by the EFDC model. As described in the next section, values were also requested for the amounts favorable fish habitat produced by the EFF model. This was handled as a public records request, which I happily paid $402 to have processed.

As my request was being processed, I apprised the peer review panel of the expected timelines for delivery of the files from the District, which changed over time, and posted to the minimum flows Webboard my plan of study. However, possibly due to misunderstanding of what I was asking for, on August 24th I received an external hard drive that contained files I cannot use due to either their format or size. These are very large files, which appear to be the basic output from both the EFDC and EFF models with values for many cells, layers, or segments.

I will continue to pursue getting the type of files I was interested in from the District and want to perform the graphical analyses I was intending, which I initially expected to have completed well before now. These files should not be complex in structure and I have to believe the consultant has such files, as they have generated graphical and statistical results that indicate that smaller files that resulted from post-processing the model output data exist. Frankly, I would think the staff for the consultant could generate the simple types of graphics I am describing in a day or two.

Regardless of who generates these graphics, I think they are critical to evaluating flow blocks and allowable percentage flow reductions that protect the Little Manatee River from significant harm, a topic I will summarize in the final section of this memorandum.

Related analyses of favorable fish habitat from the EFF models for the lower river

The management of freshwater inflows is important because of major ways that inflows affect the physical, chemical, and ecological characteristics of estuaries, including the production of many fish and invertebrate species that comprise economically important sport and commercial fisheries in Florida. Accordingly, the District has sponsored outstanding studies of fish and invertebrate use of tidal rivers and also funded detailed analyses of data for fishes and selected invertebrates in tidal river estuaries in the District collected by the Florida Fish and Wildlife Conservation Commission (FFWCC).

As described in the draft minimum flows report, the data for the Little Manatee River are particularly extensive, with data available for analysis extending from 1996 to 2020 when the draft report was prepared. The consultant has done a very good job developing Environmental Favorability Function (EFF) models for a number of fish species in the Lower Little Manatee River based on the data collected by the FFWCC. What is interesting about the EFF models is that they include a salinity component and a shoreline component, based on the preferences for different shoreline types exhibited by various fish species in the tidal section of the Little Manatee River.

It is important to note the EFF modeling results for reductions in the favorable habitat for a number of fish species gave more conservative (lower) results for allowable percentage flow reductions than did analyses of reductions in salinity zones. So, as described in the draft minimum flows report, the final recommended minimum flows were based on reductions in fish habitat for a number of indicator species.

In that regard, it seems logical that the evaluation of flow blocks to best protect fish populations in the lower river should consider relationships of fish habitat to flows and examine flow ranges in which favorable fish habitats change from being more sensitive to less sensitive to the effects of flow reductions. However, from the minimum flows report, it appears the District only examined changes in salinity zones to determine flow blocks for the lower river, with one graphic shown in the report.

It is my conclusion that analyses of the relationships of favorable fish habitat to flow should be examined to determine flow blocks that will prevent significant harm to fish populations in the Little Manatee River. These analyses would be similar in approach to the graphical analyses I recommended for salinity zones, that for various species, examine the amount of favorable habitat as a function of baseline flows and also the how reductions in favorable habitat varies as a function of flow for various flow reduction scenarios.

Because it includes a shoreline component, relationships of fish habitats to flow may show inflexions and breakpoints that are different than those for relationships of salinity zones to flow. A brief summary of findings from FFWCC studies presented in the minimum flows report indicate that tributaries and backwaters with marshes along the river provide optimal habitat for snook and other species. In that regard, it is important to recognize that these physical features and various shoreline types are not evenly distributed along the river channel.

In that regard, I sent to District staff graphs for physical features, vegetation communities, and shoreline types along the river as a function of river kilometer that are available in files I left at the District. I also showed an graph of shoreline lengths per kilometer to the review panel that shows the effect of the braided zone in the river that is referred to in the minimum flows report. I am disappointed the District has chosen not to include such graphics in the report, the types of which are shown in minimum flows reports for other rivers, but I can live with that.

What is critical, though, is that along with salinity, the effects of shoreline features on the favorable fish habitats that are incorporated in the EFF models be accounted for in the determination of flow blocks for the lower river. Basically, if a minimum flows are ultimately based on favorable fish habitat, those relationships should be used to evaluate appropriate flow blocks for the lower river, as they may show different results than analyses that are based solely on salinity.

Similar to the situation for output from the EFDC model, on July 14, 2023, I requested files derived from the EFF models for the Little Manatee, but when I received those files on August 24th I realized I could not use them due to their size, as they might be the basic model output.

Again, I hope to interact with the District to receive files I can use, but as stated for the EFDC model output, I think the consultants for the District could generate the graphics for the EFF modeling results described in my plan of study in very short order. Regardless, they need to be completed by someone in order to provide information that would be critical for determining minimum flows that protect the Little Manatee River from significant harm.

Summary

As previously described, I believe it is very important that additional graphical analyses are needed to evaluate flow blocks for the Little Manatee River. This would include very informative graphical analyses of the relationships of salinity zones to flow that have been used to determine flow blocks for the other tidal rivers in the District. Also, since the minimum flows were ultimately based on favorable fish habitat, similar analyses should be performed on the response of favorable fish habitats to flow to evaluate flow blocks for the lower river. If the flow blocks are revised, it could affect the allowable percent flow reductions within the blocks, but that should be easy to evaluate.

I realize the District wants to adopt minimum flows for the Little Manatee River in 2023, but the analyses I am recommending should not take long to perform and that schedule can likely still be met if revisions are made to the report. However, getting these minimum flows right is the key consideration, even if it delays the adoption of minimum flows for the Little Manatee River into the very early part of 2014, which I don't think will be necessary.

Accordingly, I suggest peer review process for the minimum flows report for the Little Manatee River be extended so that these important additional analyses can be performed. The Litte Manatee River is truly one of the most ecologically important and valued tidal river estuaries in the District. It is also a river that has benefited from very extensive data collection and analyses over the years and was one of the foundational rivers on which the percent of flow method was initially based. In that regard it is important, as stated in Florida Statues, that the best information available be used to determine minimum flows for this outstanding river to protect it from significant harm.

I loaded to the minimum flows web board a plan of study for a quick graphical analysis I will perform to evaluate flow blocks for minimum flows for the lower Little Manatee River. Based on a request I submitted on July 14th, the District will provide to me output for the area, volume and shoreline lengths of various salinity zones and favorable fish habitats predicted by the EFDC and EFF models, respectively, for the lower river. It is expected the model output values will be provided by the District near August 2nd and I should be able to produce a technical memorandum with related key graphics about a week later. Using techniques previously employed by the District to evaluate flow blocks for minimum flows for three other estuarine rivers, these graphics should provide useful information concerning suitable flow blocks for the lower section of the Little Manatee. I hope the review panel can consider these results in their evaluation flow blocks for the lower river.
I also loaded to the web board a slide of a regression of the location of maximum chlorophyll *a* concentrations vs. flow in the Little Manatee to supplement comments made by Dr. Ernst Peebles of USF regarding chlorophyll *a* in the lower river at the peer review meeting on July 12th. As mentioned in the plan of study, relationships of chlorophyll *a* to flow might be used to supplement findings from the EFDC and EFF modeling to evaluate flow blocks for the lower river, along with regressions of freshwater inflow with the number and center of abundance for various ichthyoplankton and nekton species published in previous studies of the lower river.
Sid Flannery

From: Escribano, Yesenia
To: Kym Holzwart
Subject: RE: Little Manatee MFL Watershed
Date: Friday, June 30, 2023 1:57:41 PM
Attachments: image001.png
image002.png

You don't often get email from yesenia.escribano@fdacs.gov. Learn why this is important

[EXTERNAL SENDER] Use caution before opening.

Yes, a shapefile would be great and after the holiday works for me.

Thank you so much for the quick reply Kym.

Sincerely,

Yesenia Escribano

From: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Sent: Friday, June 30, 2023 1:15 PM
To: Escribano, Yesenia <Yesenia.Escribano@fdacs.gov>
Subject: [External] RE: Little Manatee MFL Watershed

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

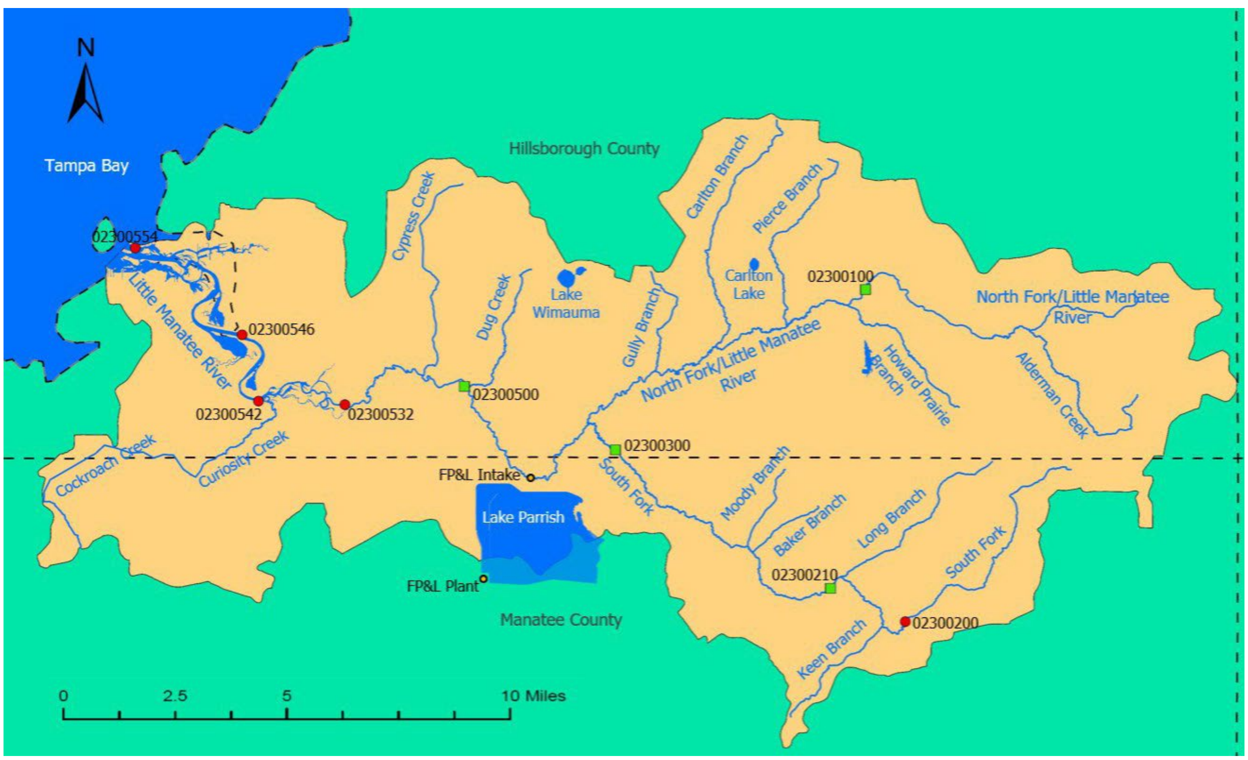
Good Afternoon,

Below is a figure from the report that shows the watershed. Note that the latest version of the Little Manatee Recommended Minimum Flows report should be available from our website sometime today, and there are a number of figures in that report that show the watershed. If you need the GIS layer or a shape file, I could probably get that for you after the 4th of July holiday.

Best regards,

Kym

Kym Rouse Holzwart, M.S.
Certified Senior Ecologist
Lead Ecologist
Environmental Flows and Levels Section
Natural Systems & Restoration Bureau
Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604
352-269-5946
kym.holzwart@swfwmd.state.fl.us



From: Escribano, Yesenia <Yesenia.Escribano@fdacs.gov>
Sent: Friday, June 30, 2023 11:44 AM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Subject: Little Manatee MFL Watershed

You don't often get email from yesenia.escribano@fdacs.gov. Learn why this is important

[EXTERNAL SENDER] Use caution before opening.

Good Afternoon Kym,

At your earliest convenience, could you please share with me (if available) or direct me to where I can find, the watershed boundary of the little manatee watershed being used to evaluate the MFLs?

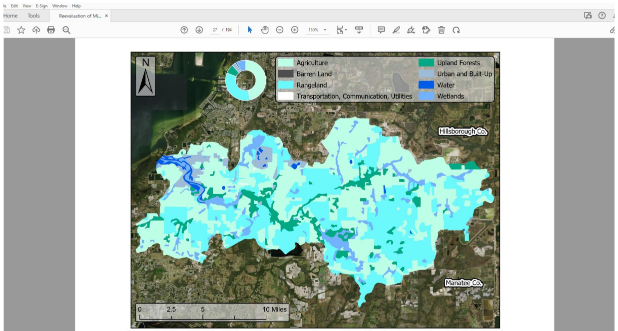


Figure 2-5. The 1974 Florida Land Use, Cover and Forms Classification System (Level I) of the Little Manatee River watershed (Anderson et al. 1976).

Yesenia Escribano
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Florida Department of Agriculture and Consumer Services (FDACS)

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"There is never enough science, if there is no political will"

www.FreshFromFlorida.com/Divisions-Offices/Agricultural-Water-Policy

October 30, 2023

Editorial review of the draft minimum flows report for the Little Manatee River dated August 2023, submitted by Sid Flannery

Note – Suggestions concerning on the application of these proposed edits to the draft report were contained in an email sent to District staff on October 31, 2023

Cover - Rotate slightly the photo of the mouth of the river so that the horizon is not slanted – see adjusted photograph below. BTW- I took this photo from a helicopter in 1989.

P ii to iii – Table of contents – Some indentations are needed after the section numbers for consistent format in the Table of Contents

P 2 – last sentence in second paragraph - Change "The estuarine portion………" to "The tidal, largely estuarine portion……..". This might seem trivial, but in a few places the report correctly mentions there is a short tidal freshwater zone below US 301, so this small edit on page 2 is helpful. It is relevant to many findings presented in the report, particularly the descriptions of the channel, vegetation communities along the river, and the findings for the fish sampling by Dutterer (2006).

This clarification still supports the use of US 301 to delineate the upper and lower portions of the river. However, it is misleading to suggest that estuarine conditions occur up to US 301, which can be avoided with some very minor edits.

P 2 – third paragraph - The City of Palmetto and the community of Terra Ceia are not in the Little Manatee River watershed. Also, "Sun City" should be changes to "Sun City Center".

P 2 – bottom of page - Change "available" to "favorable" as this more accurately describes the findings of the Environmental Favorability Function (EFF) fish habitat modeling.

P 3 - third paragraph, line 6 - Again change "available" to "favorable".

P 5 – third paragraph, second sentence – Delete "….(e.g., the freshwater portion extends downstream of the US 301 bridge, Peebles and Flannery 1992)…". That report did not say that, and this might be an accidental miswording. It is simple enough in this sentence to just say "……the Upper Little Manatee River starts at the headwaters near Ft. Lonesome and ………gage is located (Figure 1-1)."

Later in the report it is described that minor tidal water level fluctuations can extend up to US 301 and there is more technical description of the delineation of the upper and lower river. Thus, a simple description of the delineation of the upper and lower river is sufficient on page 5.

P 5 - last paragraph -- Similar misquote of Peebles and Flannery (1992) , which can be deleted as above. Instead, the report could read "For purposes of minimum flows development, the lower or tidal, largely estuarine portion of the Little Manatee River begins at the US 301 bridge………"

P 6 - last paragraph or top of page 7 – Somewhere the report should mention the new Appendices that were added to the report. I believe there are at least two: (1) a new Appendix that includes the other plots used to evaluate the flow blocks for the lower river; and (2) the sensitivity analyses of the EFDC model. It necessary, the margins on page 6 or 7 could be expanded to keep the pagination the same, or alternately Figure 1-1 on page 6 could be reduced, or cropped down from the top, to allow for another line or two about these two Appendices on page 7 without affecting the pagination.

P 11 – third paragraph, last sentence. This point may seem picky, but I think taking out one word can fix it. I have never been a proponent of calendar-based seasonal blocks without some flow-based thresholds, as flows can be uncharacteristically low in seasonal blocks 2 and 3 for prolonged periods of time. As written, this sentence mentions seasonal blocks (possibly implying calendar based) in the same sentence as Flannery et al. (2002). The abstract for that paper says "Ongoing efforts are oriented refining percentage among seasons and flow ranges to account for shifts in responsiveness of estuarine resources…."

As such, a general application for seasonal and/or flow-based blocks can easily be referenced in the last sentence of paragraph 3 by replacing "This seasonal, building block approach………" with "A building block approach………" The District has established that a building block approach can be applied to both seasonal blocks and flow-based blocks, which is explained in paragraph 5 on this page. Thus, a generic reference to building block approach at the end of paragraph 3 works fine and does not erroneously attribute the calendar-based seasonal block approach to the 2002 journal article. BTW – using flow-based blocks effectively implements lower withdrawal rates in the ecologically sensitive spring dry season.

P 13 – second or third paragraph – As it was the foundational paper for the percent of flow method ("percent-of- flow approach" is in the title of the paper) the Flannery et al. (2002) reference would be appropriate at either one of two spots in paragraphs 2 or 3. Optimally, it could be added to the end of the second paragraph as the abstract of the paper expresses this same concept.

Alternately, It could be added after Lower Peace River in the first sentence of the third paragraph as "Lower Peace River (Flannery et al. 2002) and has………" as that paper described how the percent-of-flow approach has been applied to the Lower Peace, Little Manatee, and Alafia Rivers.

P 13 – last paragraph first sentence Has the percent of flow approach (or method) actually been implemented for "numerous" permitted surface withdrawals? I would like to think so and would be great if that is the case, but I know of only three at this time which are mentioned in the sentence. The percent of flow method has been applied to rules for numerous rivers, but actually implementing them in water use permits to date has been much less, but that could increase as it gets applied on other water courses in the District. If there only a few permits where the percent of flow method has been applied, simply taking out the word "numerous" in the first sentence could remedy this situation, unless there are other water use permits I don't know about.

Page 15 – third paragraph, last sentence. The City of Palmetto and the community of Terra Ceia are not in the Little Manatee River watershed. Also, change "Sun City" to "Sun City Center."

Page 17. Figure 2-3. There are three other USGS gages where flow was measured as part of the DEP funded watershed study conducted by the District, which were important for demonstrating the excess flow the river was receiving in the late 1980s. The names, numbers, and period of record for (as month/year) flow at those gages are below. Note that flows were measured at the Cypress Creek gage for eleven years, which included the watershed study.

Cypress Creek nr. Wimauma, (0200530), 10/1980 to 9/1991
Dug Creek nr. Wimauma, (0200430), 10/1987 to 1/1989
Carlton Branch nr. Wimauma, (10/87 to 1/1989)

The location of these gages could be added to Figure 2-3 and mentioned in the figure caption. Lat-long information for these sites can be obtained from the USGS website, or their locations can graphically approximated from the dots at the bottom of sub-basins 6, 7, and 8 from the Flannery et al. (1999) article as shown on the next page.

If additional room is needed on page 17, Figure 2-3 could be cropped at the top without losing any critical information or the top margin of that page reduced to make more space for text.

P17 – first paragraph – no correction needed as the third sentence in this paragraph does a good extrapolation of the extent of the tidal freshwater zone of the river as described by Peebles and Flannery (1992). As discussed elsewhere in this review, this is a very important ecological zone of the river which needs to be recognized.

P 17 – first paragraph, fourth sentence - It would be helpful to point out in this sentence that the tidal water level fluctuations at US 301 are small, with added words shown here in italics as in "upstream of the US 301 bridge crossing (Fernandez 1985*), but tidal water level fluctuations at US 301 are small.* In that same regard, page 86 in the District report accurately says "with minor fluctuations extending upstream towards the US Highway 301 Bridge Crossing."

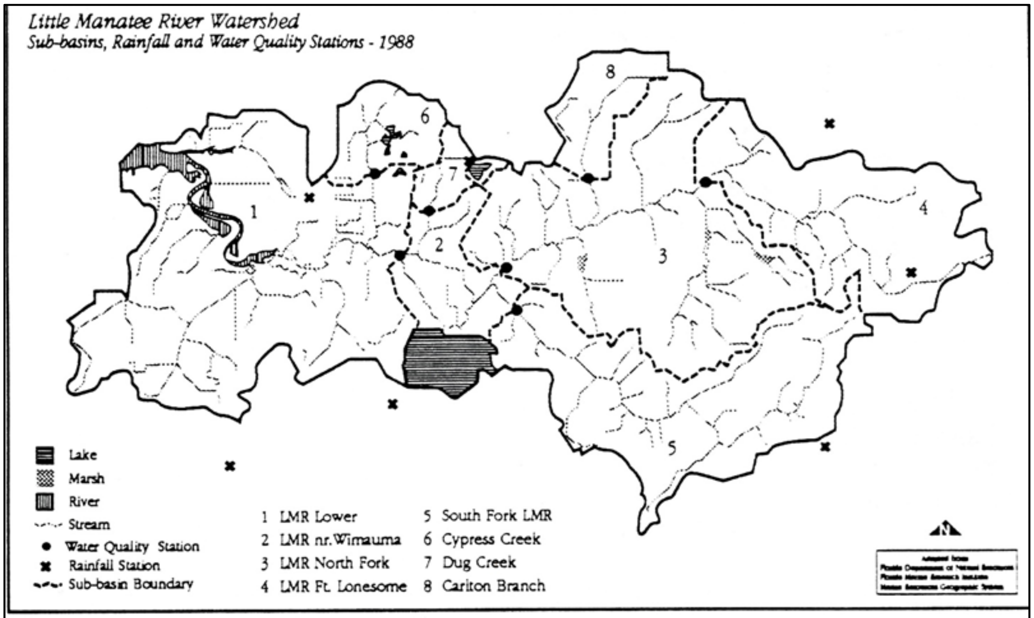

Figure 2. Subbasins, rainfall and water quality stations monitored during the first year of study.

Page 40 – first paragraph, first sentence. To clarify the use of the term "Historically", this sentence should describe the excess agricultural flows became pronounced in the mid-1970s, which was described in the Flannery et al. (1999) paper and on page 124 in the baseline flow section of the District report. The last part of the first sentence could be expanded to read "due to spring and vegetable farming, the effects of which became apparent in the flow records for the river in the mid-1970s (Flannery et al. 1991, JEI (2018b) in Appendix E)."

On a related note, the next sentence says "These practices were attributed to historical flow-field irrigation practices". Our 1991 paper did not go into that level of detail, so it might be better to just say "These practices were due *to* historical flow-field irrigation practices".

Page 42 - first sentence. The statement that "these flows decreased to zero after 2000" is not correct. As described on page 125 in the report, it could say "….beginning in 1978, but with excess flows trending toward zero after 2000 because of decreases ……………………………."

Page 42 – second paragraph - I don't believe the USGS has measured flow at the Little Manatee River at Ruskin and Little Manatee River at Shell Point near Ruskin gages, but I could be wrong. They did do some tidal discharge measurements in the lower Peace and Myakka Rivers years ago, and currently measure tidal discharge at Rowlett Park gage in the Lower Hillsborough River. District staff should check with the USGS or the consultant if there are any historical flow measurements at the two gages in the Little Manatee River mentioned above, but I doubt it. If they have not, these gages should not be mentioned in this paragraph.

This same paragraph, which references Figure 2-3, should mention the three additional gages I described for page 17, especially Cypress Creek which has 11 years of record. If extra space is needed for this wording, Figure 2-27 on this page could be reduced to a smaller size.

P65 - third paragraph Reference to this paper should also mention increased nutrient enrichment as that was a key finding of the study, which was mentioned in the title of the paper, and the sentence correctly mention increasing trends in nitrate-nitrite. The sentence could read "………..Little Manatee river indicated increasing *nutrient enrichment* and mineralization of the system………"

Page 71 There is room on page 71 to briefly mention and cite the previous studies of phytoplankton, chlorophyll *a* concentrations, and nutrients in the Little Manatee River. This will not change the conclusions of the report, but will alert readers to other valuable information for this river. Two short paragraphs are suggested below which could follow paragraph 1 and before the paragraph about dissolved oxygen that is currently paragraph 2. If additional space is needed, the top margin of this page could be reduced a bit.

"The findings of a two-year study of chlorophyll *a* concentrations, phytoplankton populations, and nutrient relationships in Lower Little Manatee River are presented in two reports by Vargo (1989; 1991) These studies found that long-term growth and biomass of phytoplankton populations in the lower river were nitrogen limited based on bioassays of natural phytoplankton populations.

The findings from the first year of the Little Manatee study were compared to data collected in the Lower Peace River and Lower Alafia Rivers, which used a similar sampling design that employed moving salinity-based stations. The Little Manatee was different that the other two rivers in that peak chlorophyll a concentrations typically occurred at the lowest salinity zone (0.5 psu), whereas the highest chlorophyll *a* concentrations typically occurred at 6 and 12 psu zones in the Lower Peace Lower Alafia Rivers (Vargo et al. 2004)."

The references for these studies are as below.

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Vargo, G.A. 1991. Phytoplankton studies in the Little Manatee River and Tampa Bay: Species Composition, Size Fractionated Chlorophyll, Primary Production, and Nitrogen Enrichment Studies. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

Page 83 – third paragraph, last sentence. Biological Oxygen Demand should be referred to as Biochemical Oxygen Demand

P84 - second sentence, last sentence Since the upper river is described in the section below this paragraph, this sentence should say "…………the benthic macroinvertebrate community of the Lower

Little Manatee River is described in Section 4.4.2, and the lower river fish and nekton community is summarized in Section 4.3.2 using data from the FWC's long-term ...."

Note that the use of "fish and nekton" is this sentence is not technically correct, as nekton includes both fish and larger free-swimming invertebrates. It is okay on this page, but as will be described for Page 104, better clarification should be presented there.

Pages 85 and 86 – The description of the Little Manatee River being estuarine up to US Highway 301 is the most misstated in this section of the report, but it can be fixed fairly easily.

It is true that the river is tidally affected up to US 301, but a described earlier in the report, a tidal freshwater zone extends about 5 to 7 kilometers below US 301, which stays fresh throughout the year. This was discussed by: (1) Peebles and Flannery (1992); (2) the supplemental analysis document I submitted to the District; and last but not least, (3) the first draft report for the lower river prepared by Janicki Environmental (JEI 2018b in Appendix E).

Also, the current draft minimum flows report briefly discusses the masters thesis by Dutterer (2006), which was oriented to a freshwater fish species (spotted sunfish) that is found in the tidal freshwater part of the river, with those stations shown in Figure 4-8 in the District report. The minimum flows report states describes that study found obligate freshwater fish in this part of the plus some estuarine fish that can penetrate into freshwater (e.g., snook).

The tidal freshwater section also has distinctly different morphological characteristics which is described in the second on page 86 which states "...... to a point where the channels converge and constrict near RKm 17, progressing to the US Highway bridge as a singular, narrow winding river channel (Figure 4-2)". Precisely, this is largely why this section of the river stays fresh.

The tidal freshwater part of the river is also clearly apparent Figure 4-2 on page 87, which shows major vegetation communities along the river channel with stream and lake swamps identified for this section of the river.

In that regard, the caption for Figure 4-2 should say "distribution of major vegetation communities along the Lower Little Manatee River". It currently says major shoreline types, but the coverages extend back from the river, vegetation communities are identified, and shoreline types (e.g., seawall) are not shown. The discussion of major shoreline types is discussed in Section 5.4.6 of the report and shown in Figure 5-18, so it is better to describe vegetation types for figure 4-2 and shoreline types for Figure 5-18.

As a result, I think it is important to adjust the language on pages 85 and 86. The first paragraph in Section 4.1.2 should say "The tidal portion of the Little Manatee River is long (15 miles or 24 km), narrow........ and sinuous". As second sentence could read "Estuarine water (greater than 0.5 psu salinity) can extend up to near Rkm 17 in dry periods, with a tidal freshwater zone extending approximately 5 to 7 kilometers upstream to the US 301 bridge." The next sentence could say "The *tidal, largely* estuarine conditions that extends 15 miles from Tampa Bauy .... can be appropriately divided into *four* main sections based on ...."

I can't emphasize enough how there are four, not three, sections to the river between Tampa Bay and the 301 bridge. This was discussed in detail by Peebles and Flannery (1992,) who described three zones in their study area and a fourth upstream above kilometer 16 where the river largely returns to one channel and freshwater aquatic vegetation becomes more common (the kilometer system has been revised slightly since that paper was published). This is a very important part of the lower river which needs to be identified. Again, since it is tidally affected, identification of this zone does not contradict the delineation of the upper and lower sections of river at US 301. This correction to the sections of the river can easily be fixed on page 86. Substitute these two paragraphs, the first of which tracks the original text, for the second paragraph on page 86.

"The third section of the Lower Little Manatee River extends upstream from the Interstate 75 bridge, where the river begins a series of braided but well defined channels snaking across the landscape to a point near Rkm 17, where the channel converge to single, narrow winding channel that extends further upstream. Vegetation in this braided section of the river is characterized by brackish oligohaline marshes that contain some scattered black needlerush mixed with stands of freshwater plants that are tolerant of low salinity, such as cattails *(Typha* sp.), giant leather fern (*Acrostichum danaeifolium*), and sawgrass (*Cladium jamaicense*) and interspersed mixed wetland forest. Tidal water level fluctuations are pronounced up to where the braided channels constrict, with minor fluctuations extending upstream towards the US Highway 301 bridge crossing."

"An inventory of plant species found in this and other sections of the Lower Little Manatee River was presented by Clewell et al. (2002), who sampled plant species composition at 78 sites adjacent to the lower river channel between RKms 4.6 and 17.2. That report also contains maps of the areal coverage of major vegetation communities along the lower river prepared by the Florida Marine Research Institute (1997), based on detailed interpretation of aerial photography from 1990 accompanied by subsequent ground truthing and plant identification at the river."

Note – As described in previous correspondence, I don't see where the vegetation in this part of the river was discussed by Hood et al. (2011 in Appendix A). The reference to Figure 4-2 in this report in the first paragraph on page 86 is erroneous, so all references to this report on page 86 should be removed. Alternately, the references to Clewell et al (2002) and FMRI (1997) should be cited, as these District funded studies included detailed information for the Lower Little Manatee that should be referenced. The FMRI study maps show coverage of the plant species communities (cattail, sawgrass) that are mentioned by the District on pages 86 and 133.

In that same regard, it is much more accurate and informative to describe the marshes above I-75 as oligohaline or brackish marshes that occur in low salinity areas. Such marshes and the aforementioned plant species that are common in them are identified on page 86 and again on page 133 of the District report where the study by Clewell et al. (2002) is discussed. The term saltmarshes typically applies to marshes in somewhat higher salinity zones, which are typically dominated by black needlerush in our part of the state, which the report accurately describes for the section of the river between US 41 and Interstate 75 on page 85. However, the term saltmarsh is improperly used in the second paragraph on page 86, so my suggested text uses brackish oligohaline marshes instead.

The map of vegetative communities on page 87 that uses the FLUCCS codes shows the same saltmarsh coverage for the marshes both downstream and upstream of I-75. This is very misleading as these are different types of marshes. That map should stay in the report, but the text of the report should be more clear regarding the different composition of these marshes, which upstream of I-75 it does. Also, as suggested in my edits, it should also quickly reference the FMRI (1997) study, as it was a detailed effort that showed informative maps of this section of the river. The reference for the FMRI study is below.

Florida Marine Research Institute. 1997. Development of GIS-based vegetation maps for the tidal reaches of five gulf coastal rivers. Report prepared by the Florida Department of Environmental Protection for the Southwest Florida Water Management District, Brooksville, FL.

The tidal freshwater part of the river that occurs in the previously defined single channel can quickly characterized on page 86 by breaking the second paragraph into three short paragraphs. As discussed on the previous page, start the first of these paragraphs with "The third section of the Lower Little Manatee extends upstream from the I-75 bridge…". Again, as previously described, follow this paragraph with a short paragraph concerning the Clewell et al. (2002) and FRMI (1997) studies.

Then start a new paragraph as below, which much better captures the true character of the river upstream of RKm 17 and agrees with the maps shown in Figure 4-22 on page 87.

"The fourth, most upstream segment of the Lower Little Manatee River extends upstream from near Rkm 17, where the river becomes confined to a single channel. Estuarine water (> 0.5 psu salinity) rarely penetrates above this point, resulting in tidal freshwater zone that extends upstream to the US 301 bridge crossing. Shoreline vegetation communities along this most upstream section of the lower river are largely stream and lake swamps with some upland forests on bluffs that occur along the river (Figure 4-2). Some freshwater aquatic plants such as spatterdock (*Nuphar luteum)* and water pennywort (*Hydrocotyle umbellata)* also are common in the channel in this section of the river."

This last sentence in this suggested paragraph is valuable, but could be dropped if a lack of space on page 86 is an issue. However, to save space, Figure 4-1 could be cropped at the top with no loss of important information. Also, the margins on pages 85 and 86 could be adjusted to accommodate more text. A photograph of this section of the river is below.

Page 88 – third paragraph, fourth sentence - This sentence should be edited to say "Selected information from these studies of benthic macroinvertebrates in the lower river is summarized in Section 4.2.2" as the information directly below that paragraph is for the upper freshwater part of the river.

Page 104. Nekton refers to free-swimming organisms not carried by currents that include fishes and larger free-swimming invertebrates such as blue crab and pink shrimp. Accordingly, the term nekton is typically used by FWC and others to refer to all of these organisms. As such, the use Fish and Nekton in the heading for Section 4-3 and is technically incorrect, but is more problematic in the second sentence under heading 4.3 that reads "The fish (and nekton, e.g., crabs, shrimp) community of the Lower Little Manatee River" which implies that the nekton is comprised only of invertebrates.

I realize the District wants to emphasize fish, and many readers won't immediately know what nekton means, but this terminology issue could be quickly clarified. The title for Section 4.3 could read "Fish and other Nekton". The second sentence could read "The fish and larger free-swimming invertebrates (e.g., crabs, shrimp) that comprise the nekton community of the Lower Little Manatee River is well characterized as a result ………………"

Page 109 – first paragraph - No change needed, but want again to point out the discussion of the study by Dutterer (2006) on this page supports the identification of the upper portion of the Lower Little Manatee River as a distinct tidal freshwater zone as previously discussed for pages 85 and 86.

Pages 114 and 115 – Table 4-8 is a case where the margins of page 114 could be adjusted to get the entire table on one page.

Page 119 - Again modify page margins to get all of Table 4-10 on one page. As with some other tables, the fonts or spacing in the headings for Table 4-10 could be adjusted to not have words broken between lines of text (e.g., Capture, Abundance)

Page 123 or 124 - Somewhere on either of these two pages the new Appendix that contains the other plots the District examined to develop the flow blocks for the lower river should be referenced in the text of the report.

Pages 156 end of first paragraph just above Table 5-6. – The report should also reference the new Appendix that contains the sensitivity analysis of the EFDC model the District conducted to address the peer review comments, as I believe the District has prepared a new Appendix that presents those results.

Page 158 – first sentence The initials for EFF shous be defined here as "The Estuarine Favorability Function (EFF) analysis……….." It is defined only once in the report on page 134, but that was 24 pages back and it needs to be repeated on page 158 for clarity.

Page 161 last sentence - I have looked that EPC data for station 113 and it is very likely the three data points that show "oligohaline to low-mesohaline salinities" at this stations are highly questionable. Among the 564 observations I have for that station, there are three with salinity values of 5.1, 13.3, and 14.7 psu recorded in September or October of 1980 and March of 1998 (35 to 43 years ago!).

This station is fresh water and these more likely are erroneous data entries, for if these three resulted from storm tides, they would have flooded half of downtown Tampa. Possibly there could have been sort of point source release, but that is equally implausible.

It is okay to acknowledge the presence of these three high values, but it should be more qualified rather than indicating the oligohaline or low mesohaline salinity can occur at this station. Alternate language in the last sentence could read "…at the US Highway 301 bridge. There were three data points that showed oligo- to low-mesohaline salinities occurred at this station in 1980 and 1988, but these could be erroneous data." BTW- this was discussed in more detail in the first draft report for the lower River (JEI 2018b, in Appendix E)

Page 180 -third paragraph One of the most important clarifications needed in the report is the analytical method by which net percent changes in both salinity zones and favorable fish habitats were calculated within a flow block for each flow reduction scenario. As described in previous correspondence, JEI used the Normalized Area Under the Curve (NAUC) method to calculate net percent changes in predicted model values within blocks in other District minimum flows reports (e.g., see description in Lower Myakka report).

There are different ways to calculate net percent differences in predicted model values within a flow block for a specific flow reduction scenario, so whatever method they used needs to be mentioned in this section, which should not take more than one or two sentences. If space is needed, the top margin of page 180 could be adjusted to keep the pagination the same.

Page 183 – first sentence The changes in percent reduction in salinity zone habitats between two flow scenarios in five percent increments may not be a liner relationship. In other words, the percent change in a salinity zone between a 10 and 11 percent flow reduction may not be the same as the percent reduction between 14 and 15 percent flow reduction. Thus, the word "exact" in the first sentence should be dropped so the sentence reads "……………..can be interpolated to *calculate* the percentage of flow reduction from baseline conditions that would result in the 15 percent reduction of salinity habitats………."

Page 185 - No changes needed here, but in keeping with the comment for pages 2 and 3, as described on page 185, the EFF modeling analysis predicts changes favorable habitats, not available habitats

Page 186 - The presentation of percent changes in favorable habitats predicted by EFF models in Tables 6-6 through 6-8 were for flow reduction scenarios in five percent increments. However, the results presented in Table 6-9 are for values that were interpolated from the results in Table 6-6 to 6-8. As such, the interpolation step needs to be mentioned in the discussion of the values presented in Table 6-9.

From:	Sid Flannery
To:	Kym Holzwart; Yonas Ghile; Doug Leeper; Kristina Deak; Jordan D. Miller; Xinjian Chen; Gabe I. Herrick; Chris Zajac; Randy Smith
Cc:	Mike Wessel; pribble@janickienvironmental.com
Subject:	Editoral review of the draft Little Manatee River minimum flows report
Date:	Tuesday, October 31, 2023 11:46:26 AM
Attachments:	Editoral Review of Little Manatee River MFL report from Sid Flannery.docx

Hello Kym and District staff,

Attached is a WORD file which provides an editorial review of the draft minimum flows report for the Little Manatee River dated August 2023. This review addresses some terms and text used in the report, but not the analytical methods or results presented in the report, although clarification for one method is suggested.

I hope all the co-authors of the report can carefully consider and communicate regarding the edits I describe in the attached review. In some cases, it involves simply changing one or a few words to clarify the presentation of findings in the report. However, for two topics described below, I have provided some text that should be added to the report to better describe the characteristics of the river.

I think that all the edits I have proposed can be accomplished without any changes to the pagination of the report. In some cases, it might be necessary to adjust the margins on a single page to accommodate some additional text, or in two cases, it looks like a figure on a specific page could be cropped if necessary to make space for text without any loss of important information. These adjustments can be considered on a page by page basis as my edits are considered.

Minimum flows reports are important reference documents that describe the physical, hydrologic and ecological characteristics of each river. In that regard, I think there are two areas where some additional information should be briefly presented to better describe the characteristics of the Little Manatee. I think this information can be presented with a small amount of text without changing the pagination of the report.

Fortunately, on page 71 where chlorophyll *a* relationships in the lower river are described, there is half a page of space where additional text can be added to reference important studies by USF of phytoplankton populations in the river that were funded by the District. As shown by Figure 3-13 in the report, the highest chlorophyll *a* concentrations typically occur in the middle and upper part of the lower river estuary, and these studies by USF provide useful information in that regard.

Also, one characteristic of the river that needs revision in the text is the division of the river into four, not three, ecological zones, which can be handled succinctly on pages 85 and 86, where this is discussed. At present, the report lumps the braided oligohaline zone between I-75 and kilometer 17 and the tidal freshwater zone upstream of kilometer 17 into one zone, although they are fundamentally different physically and ecologically. I recommend the section of river between I-75 and US 301 be divided into two seperate zones, which is well supported by information presented in the report concerning the river's morphology, tides, salinity, vegetation, and fish communities. I have provided text which should fit on pages 85 and 86 which addresses this issue, and also cites an important study by the Florida Marine Research Institute (1997) funded by the District that supports the description of wetland communities presented in the minimum flows report.

Finally, as I have previously discussed, there is a need to describe the method by which the net percent changes in salinity zones and fish habitats within flow blocks for different flow reduction scenarios were calculated. As described in the attached review, this could be briefly presented in Chapter 6 with no effect on the pagination of the report.

I hope the District will carefully consider these edits which will clarify and improve the report. They should not take long to address and will allow the report to be finalized within the schedule for adoption in 2023.

Thanks as always,
Sid

StationNumber	SampleTime	AreaName	TotalDepth	SampleDep	AirTemp
113	8/9/1978 12:30	Little Manatee River	2.1	1.1	30
113	10/3/1979 12:10	Little Manatee River	1.2	0.6	29
113	10/30/1975 11:00	Little Manatee River	4	2	27
113	9/21/1977 12:25	Little Manatee River	2.7	1.4	31
113	2/22/1978 11:30	Little Manatee River	2.1	0.3	8
113	8/11/1982 12:30	Little Manatee River	2	1	30
113	8/26/1981 10:00	Little Manatee River	2.1	1.1	30
113	8/13/1980 10:00	Little Manatee River	0.9	0.5	26
113	3/2/1983 13:30	Little Manatee River	3	1.5	24
113	9/28/1994 10:40	Little Manatee River	4.6	0.3	25.5
113	7/14/1982 12:30	Little Manatee River	1.8	0.9	35
113	8/18/2004 10:16	Little Manatee River	4.1	0.5	29.5
113	6/16/1999 10:17	Little Manatee River	2.1	1.1	30
113	9/23/1981 10:10	Little Manatee River	2.1	1.1	28
113	2/18/1998 10:20	Little Manatee River	3.7	1.8	24
113	7/17/1974 12:35	Little Manatee River	1.8	0.9	32
113	9/15/2009 9:47	Little Manatee River	4.2	0.5	27.9
113	12/20/1977 10:55	Little Manatee River	2.1	1.1	17
113	6/14/1978 11:50	Little Manatee River	2.1	1.1	33
113	1/25/1978 11:20	Little Manatee River	2.1	1.1	24
113	6/9/1976 12:45	Little Manatee River	2.1	1.1	30
113	1/31/1980 10:20	Little Manatee River	0.6	0.3	19
113	9/5/1979 12:15	Little Manatee River	0.6	0.3	32
113	9/6/1978 12:45	Little Manatee River	1.5	0.8	30
113	7/22/2013 10:07	Little Manatee River	2.5	0.5	31.2
113	8/27/1986 12:00	Little Manatee River	2.4	1.2	30
113	8/15/1984 12:50	Little Manatee River	1.2	0.6	34
113	7/14/1976 11:15	Little Manatee River	1.5	0.8	27
113	8/27/2013 9:10	Little Manatee River	3.3	0.5	26.2
113	11/23/2015 9:52	Little Manatee River	2.5	0.5	14.6
113	8/6/1975 12:55	Little Manatee River	2.1	1.1	36
113	10/1/1975 13:20	Little Manatee River	2.1	1.1	30
113	8/27/2008 10:43	Little Manatee River	2.7	0.5	31.3
113	9/27/1989 12:05	Little Manatee River	3	0.3	30
113	8/14/1974 13:15	Little Manatee River	3	1.5	32
113	9/14/1983 12:40	Little Manatee River	1.8	0.9	24
113	12/3/1975 13:35	Little Manatee River	2.1	1.1	22
113	8/29/2018 9:32	Little Manatee River	2.2	0.5	
113	7/26/1988 13:16	Little Manatee River	1.5	0.3	30
113	8/28/2012 9:34	Little Manatee River	2.4	0.5	28.4
113	1/25/1984 12:30	Little Manatee River	0.9	0.5	28
113	3/30/1983 12:40	Little Manatee River	2.7	1.4	24
113	9/11/1974 12:30	Little Manatee River	1.8	0.9	32
113	9/20/2000 10:07	Little Manatee River	3.4	1.7	30
113	9/29/2015 11:23	Little Manatee River	2.7	0.5	25.8
113	7/16/1980 10:20	Little Manatee River	0.8	0.4	28

113	2/27/1980 10:45	Little Manatee River	0.6	0.3	11
113	6/15/2005 9:32	Little Manatee River	3.3	0.5	29.5
113	8/11/1976 12:05	Little Manatee River	2.1	1.1	38
113	1/24/1979 13:10	Little Manatee River	2.4	1.2	18
113	8/25/2015 10:20	Little Manatee River	2	0.5	32
113	6/18/1980 10:50	Little Manatee River	0.6	0.3	31
113	8/15/2007 9:57	Little Manatee River	0.5	0.3	31
113	8/13/2003 10:16	Little Manatee River	3	0.5	29.5
113	9/22/2014 9:01	Little Manatee River	2.7	0.5	24.8
113	9/20/2006 10:36	Little Manatee River	3.2	0.5	26
113	8/17/1983 13:35	Little Manatee River	2.1	1.1	
113	7/29/1987 13:20	Little Manatee River	1.5	0.8	34
113	7/20/1983 13:23	Little Manatee River	1.2	0.6	34
113	6/22/1983 12:25	Little Manatee River	0.6	0.3	32
113	10/13/1976 11:45	Little Manatee River	2.1	1.1	21
113	9/15/1976 11:05	Little Manatee River	2.1	1.1	28
113	12/11/2002 10:30	Little Manatee River	3.2	1.6	21
113	7/26/1995 10:15	Little Manatee River	2.3	0.3	26.5
113	5/17/1979 12:15	Little Manatee River	2.1	1.1	26
113	7/18/1984 12:30	Little Manatee River	0.6	0.3	32
113	10/13/1982 12:30	Little Manatee River	0.9	0.5	30
113	7/9/1975 12:45	Little Manatee River	2.1	1.1	29
113	8/24/1988 12:45	Little Manatee River	2	0.3	33
113	8/8/1979 12:00	Little Manatee River	0.6	0.3	34
113	1/21/1976 13:25	Little Manatee River	2.4	1.2	20
113	7/31/1991 12:20	Little Manatee River	1.8	0.3	24
113	10/4/1978 12:40	Little Manatee River	1.8	0.9	24
113	8/22/2001 10:32	Little Manatee River	1.2	0.6	31.2
113	11/19/1997 10:36	Little Manatee River	1.8	0.9	20
113	3/2/1977 11:55	Little Manatee River	1.8	0.9	17
113	7/25/2001 10:27	Little Manatee River	2.9	1.4	31
113	8/23/1995 10:10	Little Manatee River	1.8	0.3	28
113	10/20/1993 12:10	Little Manatee River	1.7	0.3	32
113	2/22/1984 12:55	Little Manatee River	2.1	1.1	26
113	11/15/1978 12:20	Little Manatee River	1.4	0.7	27
113	7/26/1989 12:50	Little Manatee River	1.7	0.3	33
113	7/28/2015 10:09	Little Manatee River	3.1	0.5	31
113	9/19/2001 10:14	Little Manatee River	3.7	1.8	28
113	2/22/1995 10:25	Little Manatee River	1.2	0.3	15.5
113	1/26/1983 12:30	Little Manatee River	0.8	0.4	18
113	9/15/2004 11:21	Little Manatee River	3.1	0.5	28
113	5/21/2003 9:53	Little Manatee River	1.7	0.5	28
113	7/23/1986 12:48	Little Manatee River	1.2	0.6	29
113	7/23/2018 10:10	Little Manatee River	2.3	0.5	
113	3/21/1978 12:40	Little Manatee River	1.8	0.3	25
113	4/21/1993 12:06	Little Manatee River	0.8	0.3	30
113	8/24/2021 9:52	Little Manatee River	1.6	0.5	

113	7/17/1996 9:55	Little Manatee River	0.8	0.4	29
113	9/23/2013 8:54	Little Manatee River	2.1	0.5	26.9
113	7/21/2009 9:14	Little Manatee River	2.3	0.5	27.6
113	8/26/1992 12:25	Little Manatee River	1.7	0.8	32
113	6/20/1984 12:20	Little Manatee River	0.9	0.5	35
113	7/11/1979 11:30	Little Manatee River	1.2	0.6	33
113	4/23/1980 12:30	Little Manatee River	0.8	0.4	27
113	11/18/2020 9:37	Little Manatee River	1	0.5	
113	3/28/1984 12:21	Little Manatee River	1.2	0.6	29
113	2/17/2021 10:10	Little Manatee River	1.4	0.5	
113	6/26/1991 12:35	Little Manatee River	1.2	0.3	34
113	6/19/1974 12:06	Little Manatee River	1.8	0.9	30
113	7/22/2019 10:00	Little Manatee River	1.9	0.5	
113	9/24/2012 9:17	Little Manatee River	1	0.5	25
113	7/1/1981 10:15	Little Manatee River	0.6	0.3	28
113	9/23/1992 12:40	Little Manatee River	1.7	0.8	27
113	8/27/2019 10:08	Little Manatee River	1.6	0.5	
113	2/20/1974 10:05	Little Manatee River	1.5	0.8	15
113	12/14/1994 10:15	Little Manatee River	0.6	0.3	15
113	7/12/1978 12:10	Little Manatee River	2.7	1.4	32
113	8/17/2010 8:54	Little Manatee River	0.8	0.4	28.1
113	9/19/2007 9:39	Little Manatee River	0.6	0.3	25.6
113	7/31/2012 9:20	Little Manatee River	0.6	0.3	29.7
113	1/28/1981 9:55	Little Manatee River	0.6	0.3	16
113	9/21/2020 9:18	Little Manatee River	0.8	0.4	
113	11/17/1993 12:03	Little Manatee River	0.6	0.3	31
113	9/2/1975 12:50	Little Manatee River	2.4	1.2	29
113	7/19/2016 10:21	Little Manatee River	0.8	0.4	31.8
113	4/26/2021 10:10	Little Manatee River	0.5	0.25	
113	4/17/2002 10:06	Little Manatee River	0.8	0.4	26.9
113	1/27/1988 13:01	Little Manatee River	1.2	0.3	15
113	7/26/2017 10:40	Little Manatee River	1	0.5	32.7
113	11/25/2014 9:39	Little Manatee River	1	0.5	24.4
113	3/24/1982 12:45	Little Manatee River	0.9	0.5	32
113	9/23/1999 10:34	Little Manatee River	1.7	0.8	26
113	3/16/2010 7:42	Little Manatee River	1.4	0.5	12.9
113	6/29/2016 10:24	Little Manatee River	0.8	0.4	
113	3/17/2004 10:22	Little Manatee River	2.2	0.5	21
113	5/27/1987 12:25	Little Manatee River	1.4	0.7	33
113	9/11/1985 12:30	Little Manatee River	1.5	0.8	31
113	3/17/1976 13:25	Little Manatee River	1.8	0.9	18
113	9/6/2011 9:43	Little Manatee River	0.8	0.4	25.1
113	1/19/2005 10:06	Little Manatee River	2.2	0.5	10.5
113	8/24/1994 10:40	Little Manatee River	2.1	0.3	30.5
113	7/21/2004 10:15	Little Manatee River	3.3	0.5	27
113	9/18/2002 11:19	Little Manatee River	1.1	0.5	31
113	8/28/1991 12:20	Little Manatee River	1.2	0.3	34

113	7/20/2005 10:19	Little Manatee River	3	0.5	30
113	7/16/2003 10:08	Little Manatee River	1.4	0.5	28
113	6/28/1995 10:00	Little Manatee River	0.8	0.3	28
113	8/26/2020 10:06	Little Manatee River	1	0.5	
113	6/22/2020 9:43	Little Manatee River	0.8	0.4	
113	8/21/2002 10:06	Little Manatee River	1.1	0.5	29.1
113	7/14/2010 9:05	Little Manatee River	0.6	0.3	30.7
113	3/25/1981 12:45	Little Manatee River	0.8	0.4	21
113	7/21/2014 9:30	Little Manatee River	0.9	0.45	30.2
113	4/16/2008 10:00	Little Manatee River	0.4	0.2	17.6
113	9/28/2016 10:04	Little Manatee River	1.2	0.5	30.1
113	12/21/2005 9:41	Little Manatee River	1.6	0.5	9.5
113	3/27/1974 10:15	Little Manatee River	1.5	0.8	24
113	8/26/2014 9:34	Little Manatee River	0.5	0.25	29
113	1/27/2016 10:15	Little Manatee River	1	0.5	21.4
113	10/15/1981 10:05	Little Manatee River	0.6	0.3	23
113	6/13/1979 12:45	Little Manatee River	0.9	0.5	31
113	8/21/2017 10:29	Little Manatee River	0.8	0.4	32.2
113	6/26/2013 10:56	Little Manatee River	0.8	0.4	33.6
113	3/19/2003 10:17	Little Manatee River	1.8	0.5	28
113	8/9/2011 10:03	Little Manatee River	0.6	0.3	25.6
113	7/19/2006 9:54	Little Manatee River	1.9	0.5	31.1
113	6/24/1992 12:05	Little Manatee River	2.4	1.2	24
113	9/25/2017 10:01	Little Manatee River	1.4	0.5	30.5
113	12/29/2014 9:41	Little Manatee River	0.4	0.2	22
113	10/17/2007 9:53	Little Manatee River	0.9	0.45	26.1
113	7/21/1993 11:55	Little Manatee River	0.3	0.2	34
113	5/17/1978 11:15	Little Manatee River	1.5	0.8	25
113	12/21/2020 9:33	Little Manatee River	0.5	0.25	
113	2/28/1990 12:00	Little Manatee River	1.1	0.3	23
113	6/11/1975 12:50	Little Manatee River	2.1	1.1	33
113	1/25/1989 13:07	Little Manatee River	1.1	0.3	
113	12/15/2009 9:16	Little Manatee River	0.6	0.3	22.3
113	3/24/2021 10:06	Little Manatee River	0.4	0.2	
113	12/29/2015 10:43	Little Manatee River	1	0.5	26.6
113	9/15/1982 12:25	Little Manatee River	0.9	0.5	32
113	12/18/1974 12:15	Little Manatee River	1.8	0.9	14
113	11/22/2016 10:06	Little Manatee River	0.4	0.2	17.7
113	1/24/1996 10:20	Little Manatee River	0.8	0.4	22
113	7/22/2020 10:41	Little Manatee River	0.4	0.2	
113	1/19/2000 10:00	Little Manatee River	0.6	0.3	22
113	8/1/1990 12:26	Little Manatee River	1.1	0.3	35
113	9/28/1988 12:50	Little Manatee River	0.9	0.3	30
113	2/19/2008 10:03	Little Manatee River	0.5	0.25	17.2
113	7/24/1985 11:40	Little Manatee River	0.8	0.4	
113	1/25/2021 9:29	Little Manatee River	0.5	0.25	
113	12/27/2016 9:51	Little Manatee River	0.4	0.2	24.7

113	7/23/1997 10:30	Little Manatee River	0.9	0.5	30
113	2/18/1976 13:40	Little Manatee River	2.1	1.1	27
113	11/26/2012 9:29	Little Manatee River	1.5	0.5	17.8
113	5/21/1980 12:30	Little Manatee River	0.6	0.3	31
113	2/16/2005 9:50	Little Manatee River	1.4	0.5	21
113	11/20/2002 10:29	Little Manatee River	0.9	0.5	20
113	5/15/2018 10:21	Little Manatee River	1.5	0.5	
113	9/15/1993 12:00	Little Manatee River	2.1	0.3	33
113	11/28/2018 10:27	Little Manatee River	0.5	0.25	
113	10/17/2016 9:53	Little Manatee River	0.9	0.45	25.8
113	7/19/2011 10:01	Little Manatee River	0.5	0.25	28.2
113	2/21/1996 9:55	Little Manatee River	0.9	0.5	21.5
113	10/26/1994 10:40	Little Manatee River	0.9	0.3	26
113	8/18/1993 12:35	Little Manatee River	0.5	0.3	35
113	12/19/2018 9:03	Little Manatee River	0.8	0.4	
113	11/7/2011 10:55	Little Manatee River	0.5	0.25	22.5
113	2/16/2010 8:57	Little Manatee River	0.7	0.35	9.9
113	4/25/1984 12:30	Little Manatee River	0.5	0.2	30
113	2/24/1982 12:30	Little Manatee River	0.8	0.4	27
113	1/21/1998 10:07	Little Manatee River	1.2	0.6	19
113	8/20/1997 10:45	Little Manatee River	0.9	0.5	32.5
113	6/19/1996 10:40	Little Manatee River	1.5	0.8	30.5
113	10/24/1990 12:28	Little Manatee River	0.9	0.3	31
113	6/27/1990 13:00	Little Manatee River	1.2	0.3	24
113	11/18/1987 12:52	Little Manatee River	1.8	0.3	28
113	10/21/1987 13:28	Little Manatee River	0.9	0.3	29
113	10/31/1979 11:45	Little Manatee River	0.3	0.2	29
113	12/27/2017 9:59	Little Manatee River	0.7	0.35	22.1
113	1/27/2015 9:55	Little Manatee River	0.5	0.25	13.9
113	10/18/2011 9:54	Little Manatee River	0.7	0.35	24.8
113	6/24/1987 12:40	Little Manatee River	1.2	0.5	34
113	6/21/2011 9:31	Little Manatee River	0.3	0.15	31.4
113	4/20/2010 9:09	Little Manatee River	0.6	0.3	22.3
113	12/15/1976 12:05	Little Manatee River	1.2	0.6	23
113	6/21/2021 10:36	Little Manatee River	0.6	0.3	
113	12/15/2004 10:02	Little Manatee River	1.4	0.5	6
113	6/24/2014 9:44	Little Manatee River	0.2	0.1	29.4
113	7/19/2000 11:17	Little Manatee River	1.1	0.5	35
113	2/25/1987 12:55	Little Manatee River	0.5	0.2	27
113	10/20/2015 10:35	Little Manatee River	1.2	0.5	25.5
113	6/8/2010 9:05	Little Manatee River	0.3	0.15	28.9
113	4/19/1978 12:10	Little Manatee River	1.5	0.3	24
113	7/27/2021 10:12	Little Manatee River	0.9	0.45	
113	2/21/1979 13:10	Little Manatee River	1.4	0.7	29
113	5/22/1974 13:15	Little Manatee River	2.4	1.2	28
113	12/20/2011 9:34	Little Manatee River	0.2	0.1	20.4
113	11/15/2006 9:36	Little Manatee River	0.8	0.4	21.2

113	12/15/1999 9:40	Little Manatee River	0.6	0.3	20
113	9/27/1995 10:05	Little Manatee River	1.1	0.3	30
113	6/22/1988 12:52	Little Manatee River	0.3	0.3	
113	1/27/1982 10:30	Little Manatee River	0.6	0.3	13
113	8/30/2016 9:34	Little Manatee River	0.8	0.4	28.7
113	7/25/2007 10:06	Little Manatee River	0.7	0.4	31.5
113	9/25/1996 9:45	Little Manatee River	0.3	0.2	23.5
113	1/26/1994 12:15	Little Manatee River	0.8	0.3	27
113	12/28/1988 14:00	Little Manatee River	0.5	0.3	27
113	11/17/1999 9:52	Little Manatee River	0.8	0.4	17.5
113	7/21/1999 10:18	Little Manatee River	0.9	0.5	31
113	10/28/2019 11:12	Little Manatee River	1.4	0.5	
113	2/25/2015 9:15	Little Manatee River	0.5	0.25	18.7
113	10/23/2012 9:22	Little Manatee River	1	0.5	22.7
113	2/21/2007 10:10	Little Manatee River	1.1	0.5	19.6
113	10/26/2020 9:47	Little Manatee River	0.6	0.3	
113	11/28/2017 10:26	Little Manatee River	0.7	0.35	25
113	2/25/2014 9:37	Little Manatee River	0.3	0.15	21.7
113	4/19/2011 8:14	Little Manatee River	0.9	0.45	23.2
113	9/21/2010 9:48	Little Manatee River	0.6	0.3	28.1
113	2/28/2017 9:54	Little Manatee River	0.4	0.2	24.4
113	4/16/2003 11:13	Little Manatee River	1	0.5	26
113	2/26/2013 9:23	Little Manatee River	0.7	0.35	26
113	12/17/2012 10:18	Little Manatee River	0.8	0.4	23.1
113	4/21/2004 10:47	Little Manatee River	1.2	0.5	23
113	1/20/1999 10:03	Little Manatee River	1.4	0.7	20
113	11/29/1989 12:40	Little Manatee River	1.5	0.3	23
113	3/25/2013 9:48	Little Manatee River	0.6	0.3	18.1
113	8/18/2009 10:09	Little Manatee River	1.5	0.5	31.2
113	3/19/2008 10:47	Little Manatee River	0.2	0.1	24.1
113	10/8/2003 10:06	Little Manatee River	1.9	0.5	26
113	11/28/2007 9:52	Little Manatee River	0.2	0.1	22.7
113	8/26/1998 10:04	Little Manatee River	0.6	0.3	33
113	4/17/1985 12:25	Little Manatee River	0.5	0.2	30
113	10/19/1977 10:50	Little Manatee River	1.5	0.8	18
113	6/18/2008 9:40	Little Manatee River	0.7	0.35	28.7
113	2/16/2000 9:50	Little Manatee River	0.6	0.3	20.5
113	8/21/1996 10:00	Little Manatee River	0.3	0.2	28.5
113	10/20/2004 10:46	Little Manatee River	2.1	0.5	25.5
113	2/26/1992 12:20	Little Manatee River	2.1	1.1	24
113	8/26/1987 12:03	Little Manatee River	1.2	0.3	36
113	1/25/2017 9:49	Little Manatee River	0.3	0.15	18.9
113	10/17/2001 10:06	Little Manatee River	0.9	0.5	16.5
113	11/30/1988 13:05	Little Manatee River	0.6	0.3	24
113	1/19/2010 9:08	Little Manatee River	0.9	0.45	13.6
113	11/17/2009 8:46	Little Manatee River	0.4	0.2	19.6
113	10/21/2009 9:28	Little Manatee River	0.7	0.35	22

113	8/16/2006 10:04	Little Manatee River	1.8	0.5	29.6
113	7/29/1981 10:30	Little Manatee River	1.2	0.6	34
113	5/24/2016 10:24	Little Manatee River	0.6	0.3	28.4
113	12/10/1997 10:40	Little Manatee River	0.6	0.3	26
113	4/27/1983 12:00	Little Manatee River	0.8	0.4	28
113	11/10/1976 12:25	Little Manatee River	1.5	0.8	25
113	11/26/2019 9:25	Little Manatee River	0.8	0.4	
113	3/17/2014 9:25	Little Manatee River	0.4	0.2	27.4
113	7/27/1994 10:15	Little Manatee River	2.6	0.3	32
113	5/19/2004 10:43	Little Manatee River	0.9	0.5	28
113	11/19/2003 10:42	Little Manatee River	1.3	0.5	23
113	1/28/2013 9:52	Little Manatee River	1.4	0.5	21.8
113	11/16/2005 9:52	Little Manatee River	1.6	0.5	25
113	12/15/1993 12:00	Little Manatee River	0.3	0.2	19
113	8/14/1985 12:35	Little Manatee River	1.1	0.5	32
113	11/17/1982 12:50	Little Manatee River	0.6	0.3	32
113	4/14/1976 13:15	Little Manatee River	1.8	0.9	24
113	11/16/2010 10:41	Little Manatee River	0.1	0.05	23.7
113	6/18/2003 10:14	Little Manatee River	1.8	0.5	28.5
113	5/14/1975 13:20	Little Manatee River	1.8	0.9	30
113	1/14/2004 10:53	Little Manatee River	1	0.5	17
113	2/19/1997 9:45	Little Manatee River	0.5	0.2	22.5
113	11/29/1995 13:05	Little Manatee River	0.8	0.4	27
113	12/18/1985 12:50	Little Manatee River	0.6	0.3	20
113	8/18/1999 10:12	Little Manatee River	1.4	0.7	29
113	6/22/1994 13:23	Little Manatee River	2.4	0.3	33
113	1/17/2007 9:43	Little Manatee River	0.8	0.4	18.5
113	11/4/1981 10:20	Little Manatee River	0.9	0.5	26
113	2/15/2011 9:31	Little Manatee River	0.5	0.25	14.7
113	4/18/2007 10:07	Little Manatee River	0.2	0.1	21.8
113	10/28/1992 12:05	Little Manatee River	0.6	0.3	30
113	2/15/2006 9:35	Little Manatee River	1.7	0.5	15
113	1/31/1990 13:00	Little Manatee River	0.8	0.3	23
113	8/30/1989 12:37	Little Manatee River	1.5	0.3	32
113	3/20/2018 10:27	Little Manatee River	0.3	0.15	
113	2/28/2018 10:53	Little Manatee River	0.4	0.2	
113	3/25/1987 12:55	Little Manatee River	0.6	0.3	30
113	6/23/2015 9:44	Little Manatee River	0.4	0.2	28.8
113	12/18/2013 10:16	Little Manatee River	0.4	0.2	15.7
113	9/17/2003 10:21	Little Manatee River	1.8	0.5	28
113	4/22/1992 12:00	Little Manatee River	1.4	0.7	30
113	10/26/1988 12:50	Little Manatee River	0.5	0.3	27
113	4/23/2013 9:39	Little Manatee River	0.7	0.35	22.4
113	5/17/2011 9:56	Little Manatee River	0.1	0.05	23.7
113	12/16/1992 12:30	Little Manatee River	0.3	0.2	27
113	11/7/1984 12:50	Little Manatee River	0.5	0.2	24
113	11/16/1983 12:50	Little Manatee River	0.6	0.3	22

113	9/26/2018 10:11	Little Manatee River	0.9	0.45	
113	1/30/2018 10:49	Little Manatee River	1.5	0.5	
113	1/20/2009 9:04	Little Manatee River	0.4	0.2	11.4
113	4/17/1996 10:25	Little Manatee River	0.9	0.5	20.5
113	3/14/2011 8:59	Little Manatee River	0.4	0.2	18.5
113	10/19/2005 10:13	Little Manatee River	1.6	0.5	25
113	5/27/2015 9:40	Little Manatee River	0.2	0.1	27.1
113	1/18/2006 10:32	Little Manatee River	1.8	0.5	15
113	6/27/2018 9:56	Little Manatee River	1.3	0.5	
113	12/12/2007 9:50	Little Manatee River	0.4	0.2	25.5
113	12/20/2006 10:14	Little Manatee River	0.9	0.5	22.6
113	3/20/1979 12:45	Little Manatee River	1.5	0.8	31
113	2/17/2009 8:52	Little Manatee River	0.2	0.1	11.9
113	1/28/1987 12:35	Little Manatee River	0.5	0.2	23
113	6/20/2007 9:59	Little Manatee River	1	0.5	29.5
113	10/21/1998 10:15	Little Manatee River	1.4	0.7	27.5
113	3/27/1980 13:00	Little Manatee River	0.6	0.3	29
113	8/16/2000 10:15	Little Manatee River	1.5	0.8	29
113	6/17/1998 10:20	Little Manatee River	0.3	0.2	32
113	8/29/1990 12:50	Little Manatee River	0.6	0.3	33
113	4/19/2006 10:02	Little Manatee River	1.3	0.5	26.6
113	5/12/1976 10:10	Little Manatee River	2.4	1.2	27
113	3/19/1975 12:30	Little Manatee River	1.8	0.9	23
113	10/9/1974 13:10	Little Manatee River	2.1	1.1	22
113	3/16/2005 10:02	Little Manatee River	1.6	0.5	24.5
113	3/30/2015 9:41	Little Manatee River	0.6	0.3	16.7
113	1/12/2011 9:35	Little Manatee River	0.4	0.2	8.9
113	8/17/2005 9:41	Little Manatee River	2	0.5	29
113	6/20/2001 9:50	Little Manatee River	0.2	0.1	29
113	3/22/1995 10:25	Little Manatee River	0.6	0.3	25
113	12/5/1979 12:50	Little Manatee River	0.3	0.2	24
113	3/15/2006 10:09	Little Manatee River	1.4	0.5	17.5
113	2/18/2004 10:05	Little Manatee River	1.7	0.5	12
113	12/12/2001 10:04	Little Manatee River	0.9	0.5	27.5
113	4/22/1998 9:55	Little Manatee River	0.6	0.3	22.5
113	1/15/2003 10:13	Little Manatee River	2	0.5	12
113	10/22/2013 9:35	Little Manatee River	1.6	0.5	25.2
113	11/14/2001 10:05	Little Manatee River	1.1	0.5	21.5
113	4/26/2017 10:35	Little Manatee River	0.1	0.05	26.8
113	4/29/2015 9:52	Little Manatee River	0.3	0.15	26.3
113	12/9/1981 10:45	Little Manatee River	0.9	0.5	18
113	3/27/2012 9:42	Little Manatee River	0.2	0.1	21.7
113	6/19/2002 10:33	Little Manatee River	0.6	0.3	26
113	9/24/1986 12:44	Little Manatee River	0.9	0.5	31
113	2/26/1986 12:50	Little Manatee River	0.9	0.5	19
113	11/16/1977 11:00	Little Manatee River	1.5	0.8	22
113	1/23/2012 9:38	Little Manatee River	0.3	0.15	20

113	5/18/2010 8:41	Little Manatee River	0.3	0.15	27
113	10/25/2017 9:40	Little Manatee River	0.8	0.4	18.3
113	3/23/2016 10:20	Little Manatee River	0.5	0.25	21.1
113	6/16/2004 10:16	Little Manatee River	1.7	0.5	29
113	3/17/1993 12:15	Little Manatee River	1.2	0.3	23
113	12/18/1978 12:55	Little Manatee River	1.1	0.5	24
113	10/13/1999 9:56	Little Manatee River	1.1	0.5	28.5
113	11/25/2013 9:23	Little Manatee River	1.2	0.5	22.7
113	4/23/2018 10:18	Little Manatee River	0.5	0.25	
113	7/24/2002 10:33	Little Manatee River	0.9	0.5	32
113	5/21/1997 10:40	Little Manatee River	0.8	0.4	32
113	2/20/2002 9:48	Little Manatee River	0.6	0.3	22.5
113	2/17/1999 10:12	Little Manatee River	0.8	0.4	23.5
113	11/30/1994 10:20	Little Manatee River	0.8	0.3	28
113	1/23/2019 10:15	Little Manatee River	0.6	0.3	
113	3/17/2009 8:21	Little Manatee River	0.1	0.05	21.1
113	12/13/1995 10:10	Little Manatee River	0.6	0.3	20.5
113	7/22/1998 10:02	Little Manatee River	1.1	0.5	28
113	1/22/1997 9:52	Little Manatee River	0.3	0.2	19.5
113	12/17/2008 9:54	Little Manatee River	0.4	0.2	21.8
113	10/16/2002 10:30	Little Manatee River	1.2	0.6	24.5
113	10/22/2008 10:13	Little Manatee River	0.4	0.2	23.7
113	5/21/2008 9:51	Little Manatee River	0.2	0.1	29.3
113	1/23/2008 10:14	Little Manatee River	0.8	0.4	25.1
113	5/22/1991 11:40	Little Manatee River	0.5	0.3	27
113	2/23/2016 10:29	Little Manatee River	1.3	0.5	24.9
113	1/22/2014 9:48	Little Manatee River	0.3	0.15	10.5
113	3/20/2002 10:05	Little Manatee River	0.6	0.3	26
113	11/18/1992 12:15	Little Manatee River	0.3	0.2	26
113	5/28/2014 9:32	Little Manatee River	0.2	0.1	28.4
113	10/25/1989 12:04	Little Manatee River	1.4	0.3	24
113	1/22/1975 12:55	Little Manatee River	1.5	0.8	21
113	12/30/2019 9:58	Little Manatee River	0.8	0.4	
113	6/25/2019 9:48	Little Manatee River	0.7	0.35	
113	10/25/1995 10:45	Little Manatee River	1.4	0.7	28.5
113	1/23/1974 12:20	Little Manatee River	1.8	0.9	23
113	11/18/1998 10:36	Little Manatee River	1.1	0.5	29.5
113	3/15/2000 10:20	Little Manatee River	0.6	0.3	26
113	10/16/1996 10:15	Little Manatee River	0.5	0.2	27.5
113	4/24/2012 9:17	Little Manatee River	0.2	0.1	16.7
113	7/16/2008 10:03	Little Manatee River	0.9	0.45	27.2
113	1/16/2002 10:01	Little Manatee River	1.4	0.7	15
113	12/11/1996 9:40	Little Manatee River	0.6	0.3	20
113	6/26/2017 10:40	Little Manatee River	1.3	0.5	28.6
113	5/26/2021 10:12	Little Manatee River	0.2	0.1	
113	10/15/1997 10:30	Little Manatee River	0.5	0.2	27.5
113	9/25/2019 9:32	Little Manatee River	0.4	0.2	

113	12/10/2003 9:43	Little Manatee River	1	0.5	21
113	10/23/1991 12:05	Little Manatee River	0.6	0.3	31
113	2/19/2003 10:14	Little Manatee River	1.9	0.5	21
113	12/13/2000 9:55	Little Manatee River	0.9	0.5	23
113	10/11/2000 10:10	Little Manatee River	1.2	0.6	21.5
113	1/23/1991 12:05	Little Manatee River	0.3	0.3	17
113	12/19/1990 12:05	Little Manatee River	0.3	0.3	28
113	11/28/1990 12:20	Little Manatee River	0.5	0.3	31
113	5/30/1990 12:40	Little Manatee River	0.2	0.1	31
113	12/17/1986 13:05	Little Manatee River	0.5	0.2	24
113	6/26/1985 13:15	Little Manatee River	0.5	0.2	32
113	9/21/2005 9:56	Little Manatee River	1.5	0.5	27
113	4/21/2009 9:30	Little Manatee River	0.4	0.2	22.1
113	2/25/1981 10:20	Little Manatee River	0.6	0.3	19
113	10/18/2006 10:03	Little Manatee River	1.1	0.5	27
113	4/16/1997 10:05	Little Manatee River	0.3	0.2	21.5
113	4/24/1974 13:15	Little Manatee River	1.8	0.9	28
113	2/19/1975 12:55	Little Manatee River	1.5	0.8	28
113	5/23/2017 10:31	Little Manatee River	0.2	0.1	29
113	3/27/1991 11:45	Little Manatee River	0.5	0.3	28
113	6/16/1982 12:30	Little Manatee River	1.8	0.9	32
113	4/18/2001 10:47	Little Manatee River	0.9	0.5	19
113	1/17/2001 9:55	Little Manatee River	0.9	0.5	21
113	5/4/1977 12:20	Little Manatee River	1.2	0.6	24
113	10/12/1983 12:30	Little Manatee River	0.6	0.3	31
113	2/29/2012 9:17	Little Manatee River	0.4	0.2	22.4
113	4/19/2000 9:40	Little Manatee River	0.5	0.2	22.5
113	6/18/1986 13:20	Little Manatee River	0.8	0.4	31
113	3/27/1985 12:50	Little Manatee River	0.6	0.3	29
113	9/17/2008 9:57	Little Manatee River	0.5	0.25	29.1
113	10/28/2014 9:56	Little Manatee River	1	0.5	22.1
113	11/19/2008 10:05	Little Manatee River	0.5	0.25	11.2
113	4/23/2014 10:30	Little Manatee River	0.3	0.15	22.7
113	4/16/1975 12:35	Little Manatee River	1.5	0.8	25
113	2/22/1989 12:21	Little Manatee River	0.5	0.3	
113	3/26/1986 12:45	Little Manatee River	0.9	0.5	28
113	3/20/2019 10:39	Little Manatee River	0.9	0.45	
113	3/20/1996 10:15	Little Manatee River	0.6	0.3	18.5
113	4/20/2005 9:46	Little Manatee River	1.5	0.5	20
113	5/20/2019 10:10	Little Manatee River	0.6	0.3	
113	4/23/2019 10:14	Little Manatee River	0.2	0.1	
113	9/25/1991 12:00	Little Manatee River	0.6	0.3	28
113	3/28/1990 13:00	Little Manatee River	0.6	0.3	31
113	2/26/1991 12:06	Little Manatee River	0.6	0.3	22
113	9/26/1990 12:20	Little Manatee River	0.3	0.3	33
113	6/16/2009 9:13	Little Manatee River	0.4	0.2	31
113	5/16/2007 10:34	Little Manatee River	0.3	0.2	30.2

113	6/28/1989 13:05	Little Manatee River	0.8	0.3	30
113	6/21/2000 11:13	Little Manatee River	0.6	0.3	30
113	5/15/2002 10:10	Little Manatee River	0.5	0.2	26
113	4/26/1989 12:50	Little Manatee River	0.5	0.3	31
113	3/19/1997 9:55	Little Manatee River	0.3	0.2	26.5
113	3/25/1992 12:15	Little Manatee River	0.5	0.2	28
113	4/25/2016 10:01	Little Manatee River	0.5	0.25	26.1
113	9/23/1987 12:30	Little Manatee River	1.2	0.3	31
113	2/27/1985 12:10	Little Manatee River	0.9	0.3	32
113	10/29/2018 10:22	Little Manatee River	0.6	0.3	
113	4/24/1991 11:45	Little Manatee River	0.5	0.3	31
113	12/20/1989 12:35	Little Manatee River	1.5	0.3	21
113	4/23/1986 12:35	Little Manatee River	0.6	0.3	27
113	5/18/2005 9:45	Little Manatee River	1.6	0.5	26
113	3/29/2017 9:57	Little Manatee River	0.4	0.2	23.1
113	3/21/2001 10:20	Little Manatee River	0.9	0.5	18.5
113	11/17/2004 9:58	Little Manatee River	1.8	0.5	17
113	5/24/1995 10:05	Little Manatee River	0.2	0.1	31
113	3/22/1989 12:38	Little Manatee River	0.6	0.3	31
113	2/27/2019 9:34	Little Manatee River	0.5	0.25	
113	5/16/2001 10:15	Little Manatee River	0.6	0.3	26
113	2/24/2020 9:37	Little Manatee River	1	0.5	
113	12/8/2010 9:22	Little Manatee River	0.3	0.15	8
113	11/13/1974 13:50	Little Manatee River	1.5	0.8	18
113	9/16/1998 9:54	Little Manatee River	0.8	0.4	26
113	2/21/2001 10:00	Little Manatee River	0.6	0.3	23
113	5/19/1993 11:52	Little Manatee River	0.3	0.3	25
113	4/21/1999 9:41	Little Manatee River	0.9	0.5	21.5
113	1/28/2020 10:12	Little Manatee River	0.9	0.45	
113	5/19/1999 10:26	Little Manatee River	0.8	0.4	28.5
113	4/24/1979 12:10	Little Manatee River	1.4	0.7	22
113	11/15/2000 10:35	Little Manatee River	0.9	0.5	16.5
113	12/17/1980 12:15	Little Manatee River	0.6	0.3	16
113	7/29/1992 12:00	Little Manatee River	0.9	0.5	35
113	5/20/1998 10:20	Little Manatee River	0.5	0.2	30
113	11/20/1991 11:35	Little Manatee River	0.6	0.3	28
113	9/12/1984 12:15	Little Manatee River	0.6	0.3	34
113	5/28/2013 9:52	Little Manatee River	1.2	0.5	28.9
113	2/2/1977 12:30	Little Manatee River	2.1	1.1	15
113	12/9/1998 9:54	Little Manatee River	1.1	0.5	24
113	6/21/2006 9:25	Little Manatee River	1.8	0.5	28.4
113	1/25/1995 10:50	Little Manatee River	0.8	0.3	13.5
113	1/16/1985 12:30	Little Manatee River	0.6	0.3	20
113	4/26/1995 10:12	Little Manatee River	0.6	0.3	21
113	5/27/1992 12:15	Little Manatee River	0.2	0.1	29
113	2/17/1993 12:27	Little Manatee River	1.2	0.3	26
113	3/18/1998 10:25	Little Manatee River	0.9	0.5	26

113	3/17/1999 10:42	Little Manatee River	0.9	0.5	24.5
113	12/11/1991 13:03	Little Manatee River	0.6	0.3	26
113	1/29/1986 12:36	Little Manatee River	0.9	0.5	14
113	5/15/1996 10:30	Little Manatee River	0.5	0.2	28.5
113	1/29/1992 12:00	Little Manatee River	0.6	0.3	25
113	4/22/1987 11:00	Little Manatee River	0.6	0.3	26
113	11/13/1985 12:55	Little Manatee River	0.6	0.3	29
113	6/16/1993 12:18	Little Manatee River	0.5	0.2	33
113	5/25/1983 13:00	Little Manatee River	0.8	0.4	33
113	11/20/1996 10:05	Little Manatee River	0.2	0.1	24
113	4/25/1990 12:10	Little Manatee River	0.6	0.3	28
113	3/21/2007 10:05	Little Manatee River	0.6	0.3	20.1
113	5/15/1985 12:55	Little Manatee River	0.3	0.2	34
113	5/21/1986 12:53	Little Manatee River	0.6	0.3	29
113	10/19/2010 9:23	Little Manatee River	0.6	0.3	21.3
113	5/19/2009 8:50	Little Manatee River	0.8	0.4	21
113	9/17/1997 10:10	Little Manatee River	0.9	0.5	29.5
113	4/21/1982 12:30	Little Manatee River	0.8	0.4	35
113	5/17/2006 10:01	Little Manatee River	1.6	0.5	22.8
113	5/6/1981 10:20	Little Manatee River	0.6	0.3	25
113	5/25/1994 12:57	Little Manatee River	0.3	0.3	30.5
113	5/21/2012 9:17	Little Manatee River	0.3	0.15	25.9
113	5/31/1989 13:37	Little Manatee River	0.5	0.3	31
113	6/2/1977 12:10	Little Manatee River	1.8	0.9	29
113	5/17/2000 10:00	Little Manatee River	0.6	0.3	27
113	11/5/1986 12:35	Little Manatee River	0.6	0.3	31
113	10/16/1985 12:10	Little Manatee River	0.5	0.2	28
113	6/18/1997 11:15	Little Manatee River	0.6	0.3	35
113	6/3/1981 12:40	Little Manatee River	0.6	0.3	31
113	2/23/1994 12:40	Little Manatee River	0.5	0.2	27.5
113	3/23/1994 12:25	Little Manatee River	0.3	0.2	31
113	10/15/1986 12:57	Little Manatee River	0.6	0.3	31
113	5/25/1988 13:33	Little Manatee River	1.1	0.3	27
113	5/23/1984 12:30	Little Manatee River	0.9	0.5	30
113	2/24/1988 12:45	Little Manatee River	1.2	0.3	22
113	12/16/1987 12:32	Little Manatee River	0.8	0.3	17
113	5/19/1982 12:30	Little Manatee River	0.6	0.3	33
113	12/12/1984 12:20	Little Manatee River	0.6	0.3	26
113	4/27/1988 13:00	Little Manatee River	0.5	0.3	30
113	10/10/1984 12:25	Little Manatee River	0.9	0.5	28
113	7/27/1977 10:50	Little Manatee River	2.7	1.4	27
113	8/24/1977 10:45	Little Manatee River	2.7	1.4	27
113	3/30/1977 12:15	Little Manatee River	2.1	1.1	24
113	12/14/1983 12:40	Little Manatee River	0.9	0.5	22
113	11/13/1980 10:55	Little Manatee River	0.6	0.3	23
113	9/10/1980 10:10	Little Manatee River	0.8	0.4	29
113	10/15/1980 10:30	Little Manatee River	0.6	0.3	26

113	3/16/1988 13:24	Little Manatee River	1.2	0.3	17

SecchiDept	TempWate	DO-M	Cond-M	pH-M	Sal-M	Ammonia	AmmoniaC	Kjeldahl_N
0.5	26	6.3	34	6.1	0.2	0.1		0.11
0.6	25	4.8	73	6.5	0.2	0.04		0.05
0.3	23	5.7	88	5.2	0.2	<0.09	K	0.21
0.5	27	5.2	92	6.4	0.2	0.66		0.8
0.3	11	7.5	98	5.9	0.2	0.04		0.23
0.8	27.5	4.9	99	6.2	0.1	0.05		0.87
0.3	26	5.5	99	6.5	0.1	0.1		1.11
0.5	26	7.6	114	6.7	0.2	0.34		1.11
0.9	16.5	8.3	123	6.5	0.1			1.02
0.3	24	5.6	124	6.2	1	0.02	J	1.11
0.8	27.5	4.5	127	6.7	0.1	0.07		1.2
0.4	25.81	4.55	128	5.96	0.06	0.05	I	1.30
0.3	24.9	5.7	130	6		0.07		1.34
0.5	24	5.4	131	6.6	0.1	0.09		0.92
0.6	20.4	6.2	133	6.1		0.06		0.82
0.6		4.4	134	6.2	0.2			
0.7	25.91	4.64	135	6.4	0.07	0.073		1.037
0.5	16.5	6.3	139	6.5	0.2	0.14		0.44
0.8	27	7	140	7.1		0.12		0.22
0.6	18	6.3	141	7.2	0.2	0.05		0.1
0.3		6.9	145	6.7	0.2			<0.18
0.6	17	8.4	147	7.7	0.2	0.02		0.06
0.5	26	6	150	7.2	0.2	0.06		0.07
0.9	26	7.6	150	6.8	0.2	0.05		0.08
0.4	25.31	6.06	151	6.9	0.07	0.049		1.206
0.6	27.1	5.5	151	6.4	0.1	0.06		1.33
0.6	25.9	6.1	152	6.3	0.1	0.1		1.04
0.6		6	153	7	0.2			0.26
0.5	25.4	5.27	154	6.82	0.08	0.066		1.317
0.2	21.33	9.5	156	6.61	0.08	0.049	G	1.032
0.6	28	6.8	157	6.6	0.2	0.28		0.62
0.3	26	6.6	158	6.9	0.2	<0.09	K	0.15
0.3	26.05	5.28	163	6.42	0.08	0.024		1.641
0.6	25.6	5.1	163	6.1	0.1	0.1		0.95
0.3		6.8	167	6.1	0.2			
0.6	25.5	5.9	168	6.9	0.1	0.1		0.8
1.2	19	10.4	168	7.7	0.2	<0.09	K	<0.17
0.8	26.53	5.43	171	6.93	0.08	0.021	I	0.805
0.8	25.6	5.6	172	6.7	0.1	0.09		1.2
0.4	25.67	5.44	178	6.85	0.09	0.114		1.108
0.9	19.2	7.8	178	6.7	0.1	0.05		0.45
0.8	18.3	5.8	178	6.7	0.1	0.1		1.27
0.9		6.8	179	6.5	0.2	0.12		
0.8	24.8	5.2	180	6.2		0.01	J	1.37
0.2	24.69	8.15	181	7.07	0.09	0.044		0.928
0.8	26	7.7	182	7.5	0.2	<0.05	K	0.38

0.6	14	9.2	183	7.2	0.2	0.1		0.1
0.6	26.79	4.81	186	6.66	0.09	0.08	I	1.22
0.6		7.5	186		0.2			0.22
0.1	16.5	8.5	187	7.5	0.2	0.07		0.21
0.9	27.35	4.96	189	6.88	0.09	0.032		1.410
0.6	27	7.3	191	7.3	0.2	<0.05	K	0.4
0.5	26.2	6.02	194	6.84	0.09	0.038		1.208
0.4	25.3	5.49	195	6.42	0.1	0.02		1.37
0.5	24.28	6.05	197	6.48	0.1	0.053	J	1.243
0.1	24.99	6.18	198	6.57	0.1	0.091		1.873
0.5	26.5	4.8	198	7.3	0.1	0.36		0.6
0.8	26.6	6.5	200	7.1	0.1	0.19		2.18
0.5	26.9	6.2	200	6.8	0.1	0.13		0.95
0.6	27.1	6.5	200	7	0.1	0.2		0.5
1.8		7.8	200		0.2			<0.17
0.6		6.6	200	6.7	0.2			<0.18
0.5	18.6	6.83	201	6.49	0.09	0.11		1.16
0.5	25.7	6.2	201	6.3		0.05		1.09
0.6	24.5	6.5	203	7.9	0.2	0.09		0.14
0.6	25.6	6.5	204	6.5	0.1	0.12		0.65
0.6	25	6.1	204	6.7	0.1	0.1		0.68
0.9	28	7.8	204	6.9	0.2	0.16		0.04
0.6	26.5	5.9	205	6.8	0.1	0.06		0.94
0.6	27	7.8	206	7.3	0.2	0.02		0.03
1.5		11.3	206	7.7	0.2			<0.16
0.3	25.3	6.3	208	5.9	0.1	<0.01	K	1.02
0.9	26	7.4	208	6.5	0.2	0.06		0.07
0.6	25.7	6.2	210	6.38		0.06	J	1.15
1.2	17.5	8.1	210	6.3		0.05		0.71
0.9	16	8.1	210	7.2	0.2	0.3		0.69
0.5	24.78	4.99	211	6.32	0	0.09		1.51
0.6	26.5	6.2	216	6.6		<0.01	K	0.95
0.6	24.1	7	216	6.7	1	0.03	J	0.82
0.5	20.1	7.2	216	6.8	0.1	0.11		1.52
1.4	22.5	10	216	7.9	0.2	0.06		0.06
0.9	26.3	6.4	217	6.5	0.1	0.08		1.21
0.4	25.57	5.41	219	6.71	0.11	0.042		1.197
0.5	24.36	4.84	219	6.59	0.1	0.08		1.04
0.8	16.3	8.6	219	6.9	1	0.01	J	0.82
0.8	13.8	8.9	220	7.3	0.1	0.05		0.59
0.5	26.29	4.75	222	6.43	0.11	0.08		1.02
0.8	24.23	6.64	222	6.67	0.11	0.02		0.87
0.6	24.7	6.4	222	6.5	0.1	0.11		1.81
0.2	26.16	5.35	223	6.86	0.11	0.036		0.773
0.9	20	8.9	223	7.2	0.2	0.04		0.25
0.8	19.7	7.6	224	6.5	1	0.02	J	0.62
0.6	26.42	5.93	225	7.44	0.11	0.026	I	0.911

0.5	26.7	5.9	225	6.6		0.1		1
0.5	25.2	5.97	226	6.91	0.11	0.006	U	0.995
0.3	25.08	6.02	227	6.84	0.11	0.065		1.369
0.9	26.1	6.3	227	6.5	1	<0.02	K	1.49
0.9	26.3	7.5	227	7.2	0.1	0.06		0.64
0.3	26	6	228	6.9	0.2	0.14		0.14
0.8	22	8.2	229	7.7	0.2	0.07		0.5
0.7	20.66	6.88	230	6.73	0.11	0.056	I	1.150
0.9	23	7.2	230	6.7	0.1	0.07		1.37
0.8	20.82	7.03	231	7.17	0.11	0.024	I	0.954
0.3	25.1	6.6	231	6.3	0.1	0.07		1.01
1.5		6.6	231	7.8	0.2			
0.6	25.12	5.9	233	7.05	0.11	0.024		1.117
0.8	24.85	6.83	233	6.93	0.11	0.068		0.987
0.6	25	5	237	8	0.1	0.12		0.9
0.8	25.6	6.4	239	6.5	1	0.1		0.73
0.5	26.97	5.31	240	6.98	0.12	0.029		1.167
1.2		7.6	240	7.3	0.2			
0.6	17.1	8.4	242	6.9	1	0.03	J	0.36
0.5	26	6	243	6.5	0.2	0.22		0.05
0.8	26.69	6.12	245	6.94	0.12	0.077		0.941
0.6	24.97	5.95	245	7.31	0.12	0.079		1.049
0.6	26.15	5.87	246	6.85	0.12	15.325		1.129
0.6	13.5	9.4	250	7.9	0.2	0.05	C	0.44
0.8	26.05	6.62	251	6.9	0.12	0.020	U	0.610
0.6	22.2	7.6	251	7	1	0.07	J	0.35
0.6	27	7	251	6.8	0.2			
0.6	26.07	6.37	252	7.22	0.12	0.020	I	0.670
0.5	22.39	7.27	253	7.54	0.12	0.068	IJ	0.708
0.8	22.22	12.73	254	6.75	0.1	<0.02	K	1.17
0.8	11.8	9.5	255	7.5	0.1	0.11		1.04
0.7	26.57	5.77	257	6.77	0.12	0.043		0.985
0.2	21.76	7.38	257	6.87	0.12	0.148		1.680
0.9	23.5	7.2	257	7.5	0.2	0.16		0.44
0.6	23.7	6.5	258	6.7		0.06		1.14
1	16.55	7.57	259	6.95	0.12	0.073		0.919
0.7	26.19	6.59	261	7.21	0.13	0.043		0.926
0.3	20.11	7.05	262	6.56	0.13	0.09		1.45
0.8	24.2	7.2	262	7.7	0.1	0.2		1.58
1.1	26.4	5.7	262	7.3	0.1	0.06		1.03
1.2		10.5	263	7.8	0.2			0.41
0.8	26.3	6.17	264	7.27	0.13	0.074		1.013
0.9	12.36	9.23	264	6.86	0.12	0.08	I	0.72
0.6	25.4	6.5	264	6.6	1	0.04	J	0.85
0.3	24.37	5.72	265	6.29	0.13	0.02	U	1.39
0.8	26.34	6.09	265	6.69	0.13	0.03		0.94
0.5	27	6.3	266	6.2	0.1	<0.06	K	1

0.7	26.94	5.44	267	6.98	0.13	0.05	I	1.21
0.8	25.66	6.17	268	7.27	0.13	0.02		0.75
0.8	25.5	6.9	268	6.7	1	<0.01	K	0.89
0.7	27.32	6.47	269	7.24	0.13	0.051		0.904
0.8	26.1	6.51	271	6.93	0.13	0.005	U	0.541
0.6	25.69	6.64	271	7.17	0.13	<0.02	K	0.9
0.6	26.04	6.15	272	7.03	0.13	0.109	Y	1.123
0.8	16.5	10	272	8.5	0.2	0.07		0.47
0.7	25.82	5.89	273	6.71	0.13	0.071		0.865
0.4	15.94	8.02	273	7.28	0.13	0.071		0.643
0.4	25.08	6.56	274	7.41	0.13	0.024		0.864
1.6	14.72	8.57	274	7.48	0.13	0.05	U	0.43
1.2		6.9	274	7.3	0.2			
0.5	26.03	5.96	275	6.99	0.13	0.058	J	0.847
0.5	16.54	8.44	277	7.43	0.13	0.159		1.137
0.6	22	6.5	277	7	0.2	0.1		0.59
0.9	26	8.2	277	8.4	0.2	0.03		0.04
0.6	26.69	6.24	278	7.26	0.13	0.030		0.781
0.6	26.01	6	278	6.82	0.13	0.105		1.083
1.1	21.89	7.13	278	6.87	0.13	0.04		0.66
0.2	26.55	6.49	279	7.34	0.14	0.079		1.631
0.9	26.15	5.87	279	6.78	0.13	0.081		1.022
0.2	23.9	6.1	279	6.7	1	0.13		1.33
0.7	25.99	5.97	280	7.3	0.14	0.028		0.730
0.4	19.23	7.7	281	7.3	0.13	0.038		1.024
0.8	23.7	6.61	281	7.12	0.14	0.157		0.793
0.3	26.7	7.3	281	6.8	1	0.04	J	0.63
1.2	24	7.6	281	7.1		0.04		0.15
0.5	17.14	8.76	282	7.34	0.13	0.020	U	0.735
1.1	17.1	7.9	282	6.5	0.1	0.1		0.91
1.5	29	7.5	282	7.4	0.2	0.4		0.92
0.9	17.1	8.2	283	6.8	0.1	0.15		0.93
0.6	20.2	7.79	285	7.25	0.14	0.068		0.935
0.4	18.22	9.04	286	7.77	0.14	0.020	U	0.566
1	22.77	7.24	286	7.67	0.14	0.021	I	0.718
0.6	27	5.8	286	6.8	0.2	0.15		1.15
0.6		8.8	286	6.7	0.2	0.17		0.79
0.4	12.68	9.83	288	7.42	0.14	0.021	I	1.289
0.8	17.1	8.4	288	6.8		0.03	J	0.59
0.4	27.42	6.73	289	7.11	0.14	0.005	U	0.181
0.6	14.9	8.9	290	7.4		0.02	J	0.27
0.9	26.9	6.4	290	6.6	0.1	0.13		0.75
0.8	25	6.4	290	7.5	0.1	0.09		0.98
0.5	19.18	8.01	291	7.44	0.14	0.026		0.786
0.8	26.6	6.6	291	7.8	0.1	0.04		0.77
0.5	18.46	8.84	292	7.67	0.14	0.020	U	0.387
0.4	20.25	7.48	292	7.35	0.14	0.016	I	1.821

0.8	25.9	6.2	292	6.7		0.05		1.15
1.8		10.5	292	7.9	0.2			<0.14
1.5	12.64	9.53	293	7.16	0.14	0.032		0.534
0.6	28	3.6	293	7.9	0.2	0.05		0.45
1.2	16.85	8.33	294	7.23	0.14	0.05	U	0.40
0.9	16.27	8.1	294	6.62	0.14	0.07		0.98
0.4	22.5	6.43	296	6.73	0.14	0.016	I	1.070
0.6	25.3	6.4	296	6.6	1	0.02	J	0.99
0.5	16.2	8.56	297	7.39	0.14	0.022	I	0.548
0.7	24	6.7	297	7.07	0.14	0.049		0.814
0.5	25.37	6.43	297	6.91	0.14	0.058		0.793
0.9	16.8	8.5	297	7		0.02	J	0.47
0.9	22.6	7.2	297	6.9	1	0.04		0.4
0.5	25.5	7	297	6.8	1	<0.02	K	0.57
0.8	15.18	8.57	298	7.42	0.14	0.029	I	0.733
0.5	19.02	8.08	298	7.13	0.14	0.032		0.616
0.7	11.95	9.61	299	7.19	0.14	0.059		0.885
0.5	21	8.1	299	7.3	0.2	0.02		0.56
0.8	17	8.3	299	7.2	0.2	0.1		1.16
1.2	16.5	8.8	300	6.9		0.04		0.51
0.3	26.9	6.2	300	6.7		0.06		1.1
0.6	25.2	6.45	300	6.95	1	0.12		0.83
0.9	24.4	7.2	300	6.5	0.1	0.09		0.63
0.6	24.3	6.9	300	6.7	0.1	0.13		2.08
0.5	22	6.8	300	7.5	0.1	0.22		2.63
0.9	25	7.5	300	7.9	0.1	0.18		1.25
0.3	23	7.7	300	7.3	0.2	0.07		0.07
0.7	17.41	8.47	301	7.18	0.14	0.006	U	0.366
0.5	14.71	8.66	301	7.27	0.14	0.031	J	0.656
0.7	23.21	6.83	301	7.1	0.14	0.063		0.693
1.2	27.5	7.6	301	8.3	0.1	0.12		1.03
0.3	26.3	5.63	303	7.11	0.15	0.034		0.411
0.6	20.33	7.53	303	7.23	0.15	0.088		0.597
1.2		7.6	303	7.3	0.2			0.35
0.6	26.87	6.77	305	7.44	0.15	0.039	I	0.593
1.4	12.47	9.52	305	7.5	0.14	0.02	U	0.41
0.2	25.37	6.15	306	6.8	0.15	0.052	J	0.722
0.9	26.6	6.2	306	6.9		0.06		1.2
0.5	19.9	8.1	306	7.9	0.1	0.18		1.53
0.6	21.48	7.12	307	7.55	0.15	0.038		0.605
0.3	27.26	6.04	307	7.46	0.15	0.026		0.664
1.5	24	7.8	307	7.4	0.2	0.04		0.04
0.8	27.33	6.15	308	7.77	0.15	0.053	IG	0.685
1.4	22	10	308	7	0.2	0.1		0.11
1.8		6.6	309	7.1	0.2			
0.2	15.59	8.74	310	7.4	0.15	0.049		0.506
0.8	16.88	8.14	310	7.35	0.15	0.013		0.527

0.6	19.2	7.8	310	7.4		0.03	J	0.37
0.6	25.7	6.8	310	7.1	1	0.02	J	0.78
0.3	25.9	8.3	310	7.9	0.1	0.06		0.49
0.6	12	8.8	310	7.9	0.2	0.1		0.17
0.8	26.27	6.82	311	7.19	0.15	0.033		0.888
0.7	24.48	6.7	311	7.25	0.15	0.027		0.877
0.3	23	7.2	311	7.2		<0.01	K	0.5
0.8	17	8.6	311	7.1	1	0.07	J	0.44
0.5	20.2	8.2	312	7.5	0.1	0.09		0.35
0.8	17	8.1	313	7.4		0.02	J	0.34
0.9	26.7	6.3	313	6.8		0.07		0.65
0.8	25.52	6.49	314	7.64	0.15	0.021		0.828
0.5	19.08	7.81	314	7.08	0.15	0.040		0.706
1	21.28	7.19	314	7.28	0.15	0.104		0.736
1.1	12.95	9.34	314	7.38	0.15	0.082		0.829
0.6	25.23	6.77	315	7.1	0.15	0.020	U	0.459
0.7	17.96	8.74	315	7.48	0.15	0.006	U	0.570
0.3	21.11	7.29	315	7.36	0.15	0.022	I	0.808
0.9	21.11	7.22	315	7.31	0.15	0.050		0.578
0.6	24.26	8.3	315	7.65	0.15	0.048		0.740
0.4	20.32	7.51	316	7.53	0.15	0.021	I	0.575
1	19.53	8.1	316	7.09	0.15	0.02	U	0.38
0.7	22.08	6.55	317	7.32	0.15	0.050		0.521
0.8	18.56	7.12	317	7.66	0.15	0.041		0.717
1.2	19.98	7.84	317	7.07	0.15	0.07	I	0.55
1.4	19.5	7.8	318	7.2		0.03	J	0.4
1.1	21.1	7.7	318	7	0.1	0.08		0.83
0.6	20.14	6.9	319	8.05	0.15	0.032		0.515
0.5	25.59	6.07	319	7.36	0.15	0.072		0.991
0.2	20.55	7.47	319	7.55	0.15	0.022		0.737
0.6	24.07	6.51	319	6.68	0.15	0.03		0.78
0.2	20.9	7.23	320	7.18	0.15	0.003	U	0.379
0.6	26.5	6.3	320	6.6		0.06		0.73
0.5	22	8.5	320	7.8	0.1	0.05		0.23
0.9	18	8.1	320	7.6	0.2	0.3		0.39
0.7	25.06	6.13	322	7.05	0.16	0.035		1.048
0.6	17	8.1	322	7.4		0.03	J	0.27
0.3	25.9	6.8	322	6.8		0.04		0.69
0.9	23.59	6.67	323	7.11	0.16	0.04	I	0.86
0.2	20.8	6.4	323	6.4	1	0.29		1.16
0.8	26.6	7.1	323	7	0.1	0.24		1.33
0.3	17.18	8.4	324	7.55	0.15	0.019	I	0.255
0.9	22.27	6.61	324	6.99	0.1	0.09		0.59
0.6	19.5	7.9	324	7.5	0.1	0.2		0.83
0.9	14.95	8.68	325	6.82	0.15	0.068		0.755
0.4	17.03	8.24	325	7.31	0.15	0.061		0.458
0.7	19.58	7.84	325	7.25	0.16	0.055		0.622

1	26.13	6.11	325	6.88	0.16	0.098		0.783
0.9	28	4.2	325	7	0.2	0.06		1.55
0.6	23.13	6.76	326	7.2	0.16	0.045		1.039
0.6	17.9	8.2	326	7		0.04		0.7
0.8	19.4	8	326	7.3	0.2	0.13		0.4
1.5		10	326	7.7	0.2			0.22
0.8	16.57	8.72	327	7.8	0.16	0.005	U	0.753
0.4	20.28	7.51	328	7.18	0.16	0.047	J	0.418
0.6	25.3	6.1	328	6.1	1	<0.02	K	1.03
0.9	23.91	6.97	329	7.02	0.16	0.02	I	0.34
1	21.68	7.22	329	7.11	0.16	0.05		0.50
1.4	15.87	9.22	330	7.52	0.16	0.052		0.658
1.6	20.93	7.24	330	7.12	0.16	0.05	U	0.40
0.3	15.8	9.3	330	7.3	1	0.03	J	0.22
0.9	26.3	6.7	330	7.9	0.1	0.12		1.06
0.6	28.5	7.7	330	7.3	0.2	0.08		0.71
1.5		10.3	330	7.9	0.2			
0.1	17.35	8.49	331	7.4	0.16	0.016		0.276
0.7	25.96	6.19	331	7.18	0.16	0.04		0.89
1.5	27	8.1	331	7.3	0.2	0.16		0.41
1	12	9.88	332	7.21	0.16	0.03		0.43
0.5	18.7	7.8	332	6.7		0.08		0.7
0.8	20.2	8.1	332	7		0.04		0.33
0.6	14.2	9.4	332	7.8	0.1	0.1		0.41
0.5	25.4	6.6	333	6.9		0.07		0.89
0.6	26.3	4.4	333	5.8	1	0.06	J	1.27
0.8	18.77	8.09	334	7.48	0.16	0.030		0.416
0.9	22.5	7.2	334	7.8	0.2	0.08		0.25
0.5	11.74	10.12	335	7.42	0.16	0.060		0.576
0.2	17.75	7.65	335	7.44	0.16	0.067		0.601
0.6	21.2	8.1	335	7.1	1	0.08	J	0.29
1.1	10.2	9.8	336	7.72	0.16	0.094		0.588
0.8	20.6	8.3	336	7.3	0.1	0.06	J	0.25
1.2	26.9	6.5	336	7.2	0.1	0.13		0.79
0.3	20.74	7.92	337	7.39	0.16	0.008	U	0.236
0.4	21.49	7.28	337	7.56	0.16	0.035		0.481
0.6	21.5	7.3	337	7.2	0.1	0.21		1.62
0.4	26.25	6.61	338	7.01	0.16	0.050		0.695
0.4	14.53	8.27	338	7.3	0.16	0.006	UJ	0.639
0.6	25.45	6.02	338	7.24	0.16	0.05		0.95
0.5	22.2	7	338	6.4	1	0.08	J	1.43
0.5	19.6	8.2	338	7.2	0.1	0.08		0.41
0.7	21.76	7.09	339	7.26	0.16	0.060		0.810
0.1	21.51	7.17	339	7.44	0.16	0.035		0.595
0.3	17.8	8.7	340	7.2	1	0.07	J	0.39
0.5	18	9.6	340	7.5	0.1	0.07		0.4
0.6	20.1	7.4	340	7.5	0.2	<0.05	K	0.45

0.9	27.03	6.01	341	7.29	0.16	0.031	I	0.609
0.6	18.08	7.29	341	7.04	0.16	0.029	U	1.623
0.4	14.21	8.82	341	7.74	0.16	0.176	J	0.385
0.9	18.9	8.4	341	7.2		0.02	J	0.35
0.4	14.65	8.99	342	8.05	0.16	0.059		0.879
1.6	22.38	6.94	343	7.39	0.16	0.05	U	0.44
0.2	25.52	6.15	344	7.06	0.17	0.031		0.547
1.8	15.99	8.81	346	7.81	0.16	0.034		0.36
0.7	26.53	5.91	347	7.19	0.17	0.027	I	0.810
0.4	19.66	7.62	347	7.27	0.17	0.022		0.251
0.9	18.56	10.34	347	7.73	0.17	0.015		0.337
1.2	20.5	9.3	347	7.2	0.2	0.02		0.04
0.2	15.67	8.35	348	7.34	0.17	0.008	I	0.630
0.5	13	9.9	348	7.9	0.1	0.1		0.53
1	24.38	6.16	349	7.07	0.17	0.049		0.950
1.1	24.6	6.7	349	7		0.06	J	0.51
0.6	24	6	349	7.7	0.2	0.05		0.9
0.5	25.6	6.4	350	6.7		0.07		0.59
0.3	26.6	5.8	350	7.2		0.04		0.42
0.6	26.7	6.9	350	6.6	0.1	0.07		0.65
1.3	21.52	6.98	351	7.64	0.17	0.069		0.119
2.4		6.5	351	7.4	0.2			<0.18
1.8	23	16.6	351	7.7	0.2	0.1		0.28
0.9		8	351	7.3	0.2	<0.1	K	<0.1
1.3	20.22	7.58	352	7.33	0.17	0.05	U	0.71
0.6	15.91	8.77	353	7.42	0.17	0.006	U	0.703
0.4	13.49	10.03	353	7.67	0.17	0.034		0.463
1.1	27.63	6.04	353	7.43	0.17	0.05	U	0.76
0.2	24.6	5.7	353	7	0.1	<0.02	K	0.37
0.6	19.1	7.9	353	7.2	1	<0.01	K	0.35
0.3	17	11.5	353	7.5	0.2	0.05		0.05
1.4	20.09	7.3	354	7.65	0.17	0.048		0.419
1.2	14.81	8.94	354	7.22	0.17	0.04	I	0.60
0.9	21.38	7.18	354	7.05	0.1	0.03	J	0.47
0.6	21.1	7	354	7.1		0.18		0.81
1	12.59	9.45	355	7.28	0.17	0.02		0.67
1.6	24.08	6.59	356	7.36	0.17	0.046	J	0.694
1.1	19.59	7.88	356	7.13	0.1	0.03	J	0.44
0.1	21	7.41	357	7.64	0.17	0.006	U	0.279
0.3	23.52	6.73	358	7.24	0.17	0.027		0.722
0.9	14	9	358	7.8	0.2	0.14		0.94
0.2	18.97	7.29	360	7.34	0.17	0.038		0.413
0.6	24	6.4	360	7.3	0.17	0.08		0.87
0.9	25.4	6.9	360	7.5	0.1	0.16		0.67
0.9	16	9.1	360	7.6	0.1	0.06		0.52
1.5	18	10	360	7.6	0.2	0.1		0.85
0.3	15.38	8.69	361	7.22	0.17	0.003	U	0.315

0.3	23.94	6.81	361	7.25	0.17	0.056		0.386
0.8	22.01	6.81	363	7.28	0.17	0.011	I	0.391
0.5	16.5	8.51	363	7.43	0.17	0.026		0.784
0.6	25.2	6.14	363	6.57	0.18	0.04	I	1.11
0.9	15.4	8.4	363	6.6	1	<0.02	K	0.49
1.1	18	10.8	363	7.9	0.2	0.17		0.28
0.6	24.5	6.6	365	6.8		0.05		0.87
1.2	19.4	7.81	367	7.45	0.18	0.038	J	0.825
0.5	23.4	6.98	368	7.3	0.18	0.021	I	0.483
0.6	26.01	6.12	368	7.33	0.18	0.07		0.91
0.8	24.1	7.5	368	7.2		0.03	J	0.43
0.6	15.95	8.66	369	7.22	0.1	0.11		0.32
0.8	16.5	8.4	369	7.4		0.02	J	0.27
0.8	21.8	7.5	370	7.1	1	0.04		0.61
0.6	14.99	8.84	371	7.65	0.18	0.031	I	0.444
0.1	20.05	7.05	371	7.26	0.18	0.068		0.419
0.6	15.4	9.2	371	7.2		0.03	J	0.13
0.2	25.4	6.4	372	6.9		0.07		0.82
0.3	11.4	10	372	7.1		<0.01	K	0.36
0.4	17.68	7.93	373	7.39	0.18	0.032		0.703
0.5	23.65	6.4	373	7.43		0.04		1.14
0.4	20.88	7.34	374	7.46	0.18	0.031		0.438
0.2	24	6.87	375	7.81	0.18	0.019		0.369
0.2	17.59	8.14	375	7.16	0.18	0.078		1.315
0.5	24	6.8	375	6.9	0.1	0.1		0.79
1.3	18.98	8.02	376	7.55	0.18	0.017	I	0.605
0.3	14.15	8.63	377	6.92	0.18	0.044	J	0.476
0.6	21.75	7.25	378	7.36	0.1	0.04		0.3
0.3	19.2	8.6	378	7	1	0.08	J	0.25
0.2	23.8	7.06	379	7.09	0.18	0.048	J	0.470
1.4	20.5	8.5	381	7.6	0.1	0.12		0.53
1.5	19	8.8	381	6.6	0.2	0.06		0.33
0.8	22.02	7.6	382	7.61	0.18	0.005	U	0.667
0.7	27.24	6.41	384	7.72	0.19	0.019	I	1.253
0.9	23	6.8	384	7		0.07		0.65
0.9		8	384	7.3	0.2			
0.9	21.5	7.7	385	6.9	1	0.03	J	0.46
0.6	18.4	8	386	7.5		0.07		0.37
0.5	22.5	7.4	386	7.2		<0.01	K	0.56
0.2	18.26	7.14	387	7.68	0.19	0.027		0.748
0.7	25.37	6.26	388	7.26	0.19	0.028		0.960
0.8	15.5	8.58	388	7.15	0.1	0.06		1.36
0.6	13.4	9.4	390	6.9		0.06		0.77
0.9	27.01	5.83	391	7.16	0.19	0.066		1.042
0.2	23.78	6.67	395	7.43	0.19	0.020	U	0.320
0.5	23.2	6.9	395	6.9		0.03	J	0.42
0.4	24.39	6.84	396	7.57	0.19	0.028	J	0.595

1	16.17	8.8	396	7.16	0.19	0.02		0.41
0.6	23.3	8	396	7.2	0.1	0.07		0.37
1.2	16.29	8.49	398	7.27	0.19	0.02		0.64
0.9	20.1	7.4	400	7.3		0.02	J	0.25
1.2	19.4	8	400	7.3		0.13		0.65
0.3	13.8	9.6	400	7.2	0.1	0.09		0.44
0.3	19.9	9	400	7	0.1	0.03	J	0.41
0.5	22.8	8.5	400	6.7	0.1	0.06		0.27
0.2	26.3	7.5	400	7.3		0.1		0.44
0.5	20.3	8.7	400	8.2	0.1	0.08		0.63
0.5	27	7.7	400	7.3	0.1	0.07		0.66
1.5	25.72	6.26	401	7.33	0.19	0.05	U	0.44
0.4	20.38	7.07	402	6.95	0.19	0.021		0.403
0.6	14.5	8.6	403	8.3	0.2	0.1		0.45
0.9	22.56	6.97	404	7.53	0.19	0.026		0.738
0.3	19.3	7.9	404	7.2		0.03	J	0.48
1.8		8.5	404	7.9	0.2			
1.5	24	9.3	406	7.3	0.3	0.17		0.17
0.2	25.8	6.24	408	7.57	0.2	0.049	G	0.537
0.5	22.6	7.6	409	7.2	0.1	0.05	J	0.62
0.5	26	5.4	409	7.4	0.2	<0.05	K	0.63
0.9	19.3	7.9	410	7.3		0.03	J	0.37
0.9	16.2	8.4	410	7.3		0.03	J	0.11
1.2	24	10.2	410	7.6	0.3	0.39		0.7
0.6	25	6.7	411	6.9	0.2	0.1		0.4
0.4	21.03	7.34	414	7	0.2	0.081		0.629
0.5	20.5	7.3	415	7.4		0.07		0.39
0.6	25.4	7.5	416	7.1	0.1	0.16		0.93
0.6	19.4	8.2	416	7.6	0.1	0.09		0.64
0.5	26.12	6.22	420	7.56	0.2	0.019		0.886
1	19.12	7.71	422	7.47	0.2	0.058	J	0.500
0.5	12.29	9.41	423	7.71	0.2	0.021		0.555
0.3	18.75	7.91	424	7.45	0.2	0.026	J	0.642
1.5	24	9.2	424	8.2	0.3	0.13		0.31
0.5	21.5	7.9	425	7.5	0.1	0.14		0.51
0.9	18.9	8.5	425	7.5	0.1	0.13		0.92
0.9	17.78	8.12	426	7.63	0.2	0.008	U	0.525
0.6	17.6	7.7	426	7.3		0.04		0.59
1.5	19.21	7.68	428	7.62	0.21	0.05	U	0.59
0.6	24.99	6.63	429	7.57	0.21	0.019	IY	0.611
0.2	19.5	8.24	429	7.76	0.21	0.005	U	0.572
0.6	26.2	6.9	429	7	0.1	0.04	J	0.66
0.6		9	429	7.5	0.1	0.18		0.28
0.6	19.9	8.8	430	7.4	0.1	0.07		0.53
0.3	24.4	8	430	6.9	0.1	0.06	J	0.4
0.4	25.7	5.82	431	7.21	0.21	0.063		1.100
0.3	22.94	6.82	431	7.58	0.21	0.003	U	0.367

0.8	26.5	6.9	431	7.3	0.1	0.07		0.51
0.6	26.1	6.2	432	7.2		0.02	J	0.46
0.5	24.01	6.76	433	7.55	0.2	0.05		0.41
0.5	23.3	8.5	433	7.7	0.1	0.04	J	0.21
0.3	20.4	7.7	434	7.1		0.02	J	0.42
0.5	19.7	7.9	435	7	1	<0.02	K	0.53
0.5	22.5	7.51	436	7.48	0.21	0.006	U	0.614
1.2	25.8	7.1	437	7.7	0.1	0.2		1.17
0.9	20.8	8.7	437	7.7	0.1	0.06		0.35
0.6	19.57	7.6	438	7.35	0.21	0.070		0.662
0.5	24.3	7.8	438	7.4	0.1	0.03	J	0.36
1.5	18.8	8.2	438	7	0.1	0.11		0.71
0.6	19.3	8.7	439	7.3	0.1	0.09		0.45
1.1	23.83	6.83	441	7.58	0.21	0.05	U	0.69
0.4	19.77	7.41	443	7.81	0.21	0.014	IG	0.444
0.9	18.3	7.7	444	7.2	0.2	0.05		0.61
1.3	18.55	7.93	445	7.59	0.21	0.02	I	0.38
0.2	25.1	6.9	447	7.4		0.02	J	0.24
0.6	23.1	8.1	447	7.4	0.1	0.11		0.6
0.5	20.17	7.52	448	7.48	0.22	0.008	U	0.541
0.6	21.9	6.7	450	7.4		0.03	J	0.27
1	17.43	9.93	451	7.76	0.22	0.005	UG	0.590
0.3	8.04	12.32	451	7.9	0.21	0.066		0.445
0.6		10.3	451	7.3	0.3	0.13		0.26
0.8	25.2	6.4	454	7		0.05		0.8
0.6	19.2	7.4	455	7.3	0.2	0.03	J	0.13
0.3	22.7	8.6	456	7.3	1	<0.02	K	0.02
0.9	17.5	8	458	7.7		0.01	J	0.34
0.9	15.96	8.97	459	7.82	0.22	0.005	U	0.587
0.8	23.7	6.8	459	7.3		0.15		0.51
1.4	22.5	8.9	459	7.6	0.3	0.03		0.03
0.9	17.2	8.2	460	7.4		0.01	J	0.06
0.6	16.5	9.5	461	7.9	0.3	0.1		0.47
0.9	25.7	6.6	464	7.2	1	<0.02	K	0.71
0.5	23.6	6.5	465	6.8		<0.01	K	0.35
0.6	21.8	9.5	465	7.4	0.1	0.02	J	0.32
0.6	26	6.4	468		0.1	0.14		0.72
1.2	23.68	7.35	475	7.35	0.23	0.071		0.525
1.7	13	11.6	475	7.3	0.2	0.26		0.61
1.1	19.9	8	478	7.3		0.02	J	0.48
1.3	25.86	5.64	480	6.88	0.23	0.184		1.286
0.8	11.8	9.7	481	6.2	1	<0.01	K	0.48
0.6	12	10.4	481	7.7	0.1	0.1		0.43
0.6	20.9	7.9	482	7.1	1	0.01	J	0.29
0.2	24	8.6	483	7.4	1	0.07	J	0.34
1.2	18.7	8.2	487	6.9	1	<0.02	K	0.24
0.9	18.9	8.1	488	7.2		0.02	J	0.53

0.9	16.2	8.4	490	7.5		0.04		0.4
0.6	20.5	8.5	493	7.5	0.1	0.04	J	0.36
0.9	10.1	10.8	496	7.7	0.1	0.14		0.56
0.5	23.8	7.2	497	7.4		0.06		0.5
	18.4	8.9	497	7.4		0.05	J	0.42
0.6	21		500	7.2	0.1	0.15		1.32
0.6	23.5	8	500	7	0.1	0.04		0.5
0.5	25.9	6.9	506	7.4	1	0.07	J	0.63
0.8	25.4	9.2	507	7.5	0.3	<0.05	K	0.57
0.2	18.3	8.2	509	7.4		<0.01	K	0.15
0.6	22.5	8.5	515	7.5	0.1	0.04	J	0.58
0.6	17.25	8.6	521	7.77	0.25	0.038		0.672
0.3	26.3	8	524	7.8	0.1	0.05		0.41
0.6	23.5	7.5	528	7.3	0.1	0.1		0.48
0.6	19.54	8.25	531	7.42	0.26	0.042		0.560
0.8	21.95	6.53	534	6.96	0.26	0.074		1.437
0.9	26	6.6	535	7.4		0.02	J	0.53
0.8	26.5	8.2	543	7.9	0.3	0.1		0.44
1.4	21.1	6.59	546	7.4	0.26	0.065		1.135
0.6	22.5	7.6	550	8.7	0.3	0.1		0.46
0.3	22.9	8.6	565	7.7	1	0.03	J	0.04
0.3	23.12	7.09	573	7.65	0.28	0.045		0.371
0.5	27.3	8.8	582	7.8	0.1	0.08		0.44
1.4	26		588	7.6	0.3	0.24		0.44
0.6	23.2	6.4	600	7.7		0.01	J	0.02
0.6	23.2	7.7	600	8	0.1	0.08		0.77
0.5	30	6.4	600	7.5	0.1	0.18		0.58
0.6	27.3	6.6	603	7.4		0.03	J	0.89
0.6	26.5	5.2	612	8.8	0.3	0.1		0.76
0.5	22.4	7.8	629	7.3	1	0.05	J	0.32
0.3	22.1	7.8	641	7.5	1	0.04	J	0.53
0.6	25.3	7.2	670	7.4	0.1	0.13		0.62
0.6	24	6.9	687	7.4	0.1	0.76		3.17
0.3	25.4	5.9	773	7.3	0.1	0.37		1.42
1.2	18.2	8.5	800	8.1	0.1	0.09		0.81
0.8	19	8.4	800	7.7	0.1	0.09		0.55
0.6	23	9.2	804	7.9	0.4	<0.05	K	0.5
0.6	17	8.8	874		0.2	0.07		0.27
0.5	25	6.9	900	7.9	0.2	0.08		0.74
0.9	23.5	7.8	942		0.2	0.07		0.63
0.6	27	3.7	1030	6.5	0.5	0.21		0.42
0.6	26	3.2	1100	6.5	0.5	0.18		0.6
1.2	23	6.6	1430	7.5	0.7	0.36		0.21
0.9	19	7.6	2135	6.9	1.1	0.05		0.65
0.6	19.5	8.7	2876	8	1.4	0.07		0.25
0.5	25	7.2	9283	6.9	5.1	<0.05	K	0.87
0.6	21.5	8.2	22175	7.3	13.3	<0.05	K	0.73

0.9	14.3	7.6	24400	8.2	14.7	0.1	0.79

Kjeldahl_N	Nitrates	NitratesQ	Nitrates_N	Nitrates_N	Organic_Ni	Organic_Ni	Ortho_Pho	Ortho_Pho
	0.17				0.01	C		
	0.1				0.01	C		
	0.08				0.12	C		
	0.07				0.14	C		
	0.19				0.19	C		
	0.29				0.82	C	0.38	
	0.31				1.01	C		
	0.26				0.77	C		
	0.37						0.44	
			0.292		1.09	C	0.52	
	0.26				1.13	C	0.71	
			0.230		1.25		0.57	
			0.364		1.27	C	0.35	
	0.3				0.83	C		
			0.347		0.76	C	0.51	
	0.23						0.88	
			0.195		0.964		0.413	
	0.18				0.3	C		
	0.45				0.1	C		
	0.16				0.05	C		
K	0.13							
	0.11				0.04	C		
	0.3				0.01	C		
	0.43				0.03	C		
			0.279		1.157		0.286	
			0.37		1.27	C		
			0.18		0.94	C		
	0.22							
			0.217		1.251		0.333	
			0.506		0.983		0.319	
	0.15				0.34	C		
	0.19				0.06	C		
			0.201		1.617		0.367	
			0.46		0.85	C		
	0.16						2.32	
			0.26		0.7	C		
K	0.59				0.08	C		
I			0.117		0.784	I	0.325	
			0.26		1.11	C		
			0.336		0.994		0.352	
			0.5		0.4	C		
			0.28		1.17	C		
	0.28						0.53	
			0.499		1.36	C	0.48	
			0.180		0.884		0.238	
	0.36				0.33	C		

	0.42		0.01	C		
		0.208	1.14		0.53	
	0.22					
	0.38		0.14	C		
		0.175	1.378		0.382	
	0.34		0.35	C		
		0.376	1.17		0.349	
		0.519	1.35		0.46	
J		0.403	1.190		0.264	
		0.259	1.782		0.314	
		0.26	0.24	C		
		0.41	1.99	C		
		0.46	0.82	C		
		0.55	0.3	C		
K	0.18					
K	0.31					
		1.091	1.05		0.42	
		0.408	1.04	C	0.54	
	0.41		0.05	C		
		0.45	0.53	C		
	0.37		0.58	C	0.48	
	0.04					
		0.47	0.88	C		
	0.27		0.01	C		
K	0.41					
		0.31	1.01	C	0.65	
	0.3		0.01	C		
		0.456	1.09	C	0.5	
		0.695	0.66	C	0.49	
	0.28		0.39	C		
		0.419	1.42	C	0.53	
		0.436	0.95	C	0.43	
		0.51	0.79	C	0.41	
		0.56	1.41	C		
	0.33		0.02	UC		
		0.5	1.13	C		
		0.468	1.155		0.347	
		0.299	0.96	C	0.53	
		0.617	0.81	C	0.46	
	0.35		0.54	C		
		0.327	0.94		0.60	
		0.507			0.35	
		0.79	1.7	C		
I		0.256	0.737	I	0.307	Q
	0.32		0.21	C		
		0.51	0.6	C	0.36	
		0.187			0.389	

		0.878		0.9	C	0.56	
		0.341		0.989		0.321	
J		0.340		1.304		0.351	
		0.51		1.48	C	0.37	
		0.61		0.58	C		
	0.73			0.01	C		
	0.53			0.43	C		
		0.229		1.094		0.455	J
		0.27		1.3	C		
		0.176		0.930		0.355	J
		0.76		0.94	C	0.34	
	0.02					0.82	
		0.342		1.093		0.305	
		0.371		0.919		0.270	
	0.61			0.78	C		
		0.885		0.63	C	0.29	
		0.292		1.138		0.290	
	0.43					0.38	
		0.666		0.33	C	0.29	
	0.2						
		0.539		0.864		0.340	
		0.524		0.97		0.408	
		0.006	I	0.03	U	0.454	
	0.76			0.39	C		
I		0.347		0.591	I	0.321	Q
		0.556		0.28	C	0.39	
	0.26						
		0.303		0.650		0.335	
I		0.256		0.640	I	0.348	
		0.416		1.15		0.42	
		0.55		0.93	C		
		0.337		0.942		0.328	
		0.322		1.532		0.181	
	0.77			0.28	C	0.27	
		0.482		1.08	C	0.47	
		0.429		0.846		0.288	
		0.316		0.883		0.343	
		1.432		1.36		0.35	
		0.71		1.38	C		
		0.53		0.97	C		
	0.27						
		0.429		0.939		0.357	
		0.753		0.64		0.24	
		0.905		0.81	C	0.38	
		0.605		1.38		0.40	
		0.685		0.91		0.51	
		0.41		0.94	C	0.51	

		0.321		1.16		0.44	
		0.526		0.73		0.36	
		0.726		0.89	C	0.38	
		0.285		0.853		0.272	
I		0.393		0.537	I	0.260	G
		0.676		0.88		0.39	
Y		0.525	Y	1.014		0.340	Y
	0.75			0.4	C		
		0.593		0.794		0.287	
		0.824		0.572		0.364	
G		0.324		0.840	G	0.281	
		0.697		0.41		0.25	
	0.14					0.87	
		0.486		0.789		0.301	
		0.854		0.978		0.187	
	0.36			0.49	C		
	0.24			0.01	C		
I		0.468		0.751	I	0.299	
		0.509		0.978		0.289	
		0.767		0.62		0.32	
Y		0.344		1.552		0.217	
		0.631		0.941		0.328	
		1.329		1.2	C	0.47	
I		0.288		0.702	I	0.349	Q
J		0.555		0.986	J	0.197	
		0.727		0.636		0.332	
		0.644		0.59	C	0.25	
	0.5			0.11	C		
		0.471		0.735	I	0.193	J
		0.93		0.81	C		
	0.26			0.52	C		
		0.68		0.78	C		
		0.477		0.867		0.294	
I		0.375		0.552	I	0.235	
		0.631		0.697		0.270	
	0.42			1	C	0.48	
	0.79						
YG		0.803		1.268	G	0.190	
		0.877		0.56	C	0.29	
U		0.563		0.186	U	0.394	
		0.582		0.25	C	0.23	
		0.75		0.62	C		
		0.67		0.89	C		
		0.757		0.76		0.224	
		0.7		0.73	C		
I		0.475		0.387	I	0.168	QJ
		0.625		1.805		0.214	

		1.246	1.1	C	0.44	
K	0.36					
		0.903	0.502		0.163	
	0.22		0.4	C		
		1.438	0.37		0.16	
		0.814	0.91		0.33	
I		0.299	0.452	U	0.284	
		0.572	0.97	C	0.5	
I		0.654	0.526	I	0.226	
J		0.513	0.765		0.294	
		0.476	0.735		0.246	
		0.792	0.45	C	0.24	
		0.839	0.36	C	0.3	
		0.501	0.57	C	0.3	
I		0.468	0.704	I	0.195	
		0.567	0.584		0.191	
		0.702	0.826		0.170	
		0.43	0.54	C		
	0.62		1.06	C	0.22	
		0.636	0.47	C	0.39	
		0.594	1.04	C	0.69	
		0.693	0.71	C	0.49	
		1.22	0.54	C		
		0.83	1.95	C		
		0.93	2.41	C		
		0.5	1.07	C		
	0.7		0.01	C		
I		0.551	0.366	I	0.193	
		0.446	0.625		0.184	
		0.521	0.63		0.298	
		0.61	0.91	C		
		0.363	0.377		0.242	
		0.753	0.509		0.217	
	0.31				0.37	
I		0.278	0.554	I	0.228	
		0.987	0.41		0.26	
		0.547	0.670		0.266	
		0.476	1.14	C	0.4	
		1.02	1.35	C		
		0.422	0.567		0.295	
		0.594	0.638		0.269	
	0.37					
IQ		0.226	0.632	I	0.333	I
	0.38		0.01	C		
	0.24				1.09	
		0.627	0.457		0.225	
		0.592	0.514		0.200	

		0.584	0.34	C	0.24	
		0.681	0.76	C	0.4	
		0.42	0.43	C		
	0.57		0.07	C	0.19	
		0.382	0.855		0.321	
		0.599	0.85		0.228	
		0.646	0.5	C	0.25	
		0.695	0.37	C	0.35	
		1.02	0.26	C		
		0.583	0.32	C	0.24	
		0.778	0.58	C	0.34	
		0.222	0.807		0.289	G
		0.551	0.666		0.186	
		0.614	0.632		0.239	
		1.005	0.747		0.311	
I		0.537	0.458	I	0.281	
I		0.586	0.570	I	0.207	
		0.443	0.786		0.208	
		0.552	0.528		0.266	
		0.454	0.692		0.321	
		0.416	0.554		0.255	
		0.778	0.37		0.26	
		0.552	0.471		0.207	
		0.637	0.676		0.193	
		0.875	0.48		0.26	
		0.601	0.37	C	0.29	
		0.57	0.75	C		
		0.678	0.483		0.175	
		0.343	0.919		0.381	
		0.679	0.715		0.269	
		0.472			0.40	
		0.752	0.379		0.179	
		0.723	0.67	C	0.35	
		0.67	0.18	C		
	0.5		0.09	C		
		0.428	1.013		0.290	
		0.668	0.24	C	0.24	
		0.609	0.65	C	0.32	
		0.610	0.82		0.41	
		1.752	0.87	C	0.5	
		0.48	1.09	C		
		0.440	0.236		0.207	
		0.927	0.5	C	0.33	
		0.76	0.63	C		
		0.798	0.687		0.212	
		0.770	0.397		0.185	
		0.726	0.567		0.232	

		0.492	0.685		0.260
	0.45		1.49	C	
JG		0.551	0.994	G	0.247
		0.736	0.66	C	0.34
		0.6	0.27	C	
	0.45				
		0.324	0.753		0.179
		0.432	0.371		0.181
		0.37	1.03	C	0.54
		0.570	0.32		0.23
		0.764			0.28
		0.734	0.606		0.158
		0.681	0.38		0.25
		0.838	0.19	C	0.15
		0.46	0.94	C	
	0.61		0.63	C	0.23
	0.09				
		0.876	0.26		0.165
		0.559	0.85		0.41
	0.59		0.25	C	
		0.922	0.40		0.23
		0.69	0.62	C	0.34
		0.806	0.29	C	0.22
		0.65	0.31	C	
		0.604	0.82	C	0.36
		0.432	1.21	C	0.78
		0.544	0.386		0.173
	0.85		0.17	C	
		0.644	0.516		0.187
		0.850	0.534		0.261
		0.986	0.21	C	0.16
		0.774	0.494		0.215
		1.11	0.19	C	
		0.64	0.66	C	
I		0.702	0.228	I	0.165
I		0.511	0.446	I	0.228
		0.64	1.41	C	
G		0.598	0.645	G	0.215
J		0.737	0.633		0.192
		0.522			0.43
		0.833	1.35	C	0.33
		0.93	0.33	C	
		0.679	0.75		0.223
		0.639	0.56		0.180
		0.742	0.32	C	0.14
		0.88	0.33	C	
		0.45	0.4	C	

IJ		0.272	0.578	I	0.300	Q
		0.791	1.608		0.248	
		0.603	0.209		0.136	
		0.851	0.33	C	0.36	
		0.619	0.82		0.208	
		0.731	0.42		0.30	
		0.384	0.516		0.219	
		0.640	0.33		0.18	
I		0.246	0.783	I	0.343	
		0.816	0.229		0.195	
		0.550	0.322		0.167	
	0.3		0.02	C		
		0.612	0.622		0.144	
		0.52	0.43	C		
		0.441	0.901		0.217	
		0.671	0.45	C	0.41	
	0.3		0.85	C		
		0.556	0.52	C	0.5	
		0.604	0.38	C	0.44	
		0.94	0.58	C		
I		0.432	0.05		0.205	
K	0.04					
	0.02		0.18	C		
K	0.33					
		0.401	0.68		0.31	
		0.400	0.697		0.239	
		0.790	0.429		0.157	
		0.345	0.73		0.45	
		0.424	0.36	C	0.19	
		0.666	0.35	C	0.3	
	0.62		0.01	C		
		0.463	0.371		0.231	
		0.545	0.56		0.41	
		0.962	0.44	C	0.27	
		0.985	0.63	C	0.36	
		0.849	0.65		0.31	
		0.559	0.648		0.266	
		0.949	0.41	C	0.25	
IJ		0.324	0.273	G	0.158	
G		0.579	0.695	G	0.216	
	0.79		0.8	C		
		0.546	0.375		0.206	
		1.134	0.79		0.27	
		0.53	0.51	C		
		0.34	0.46	C		
	0.66		0.75	C		
		0.568	0.312		0.137	

		0.695		0.33		0.147	
IJ		0.665		0.380	I	0.246	
		0.576		0.758		0.234	
		0.462		1.07		0.42	
		0.763		0.48	C	0.18	
	0.5			0.11	C		
		0.533		0.82	C	0.36	
		0.578		0.787		0.255	
I		0.450		0.462	I	0.199	Q
		0.666		0.84		0.46	
		0.662		0.4	C	0.26	
		0.782		0.21		0.18	
		0.554		0.25	C	0.24	
		0.802		0.57	C	0.3	
U		0.396		0.452	U	0.157	
		0.760		0.351		0.171	
		0.697		0.1	C	0.25	
		0.771		0.75	C	0.44	
		0.933		0.36	C	0.16	
		0.625		0.671		0.145	
		0.487		1.1		0.31	
J		0.566		0.407		0.207	
		0.715		0.35		0.147	
		0.808		1.237		0.225	
		1.06		0.69	C	0.39	
JG		0.370		0.588	G	0.227	
		0.733		0.432		0.148	
		0.532		0.26		0.27	
		0.768		0.17	C	0.27	
J		0.528		0.422		0.181	
		0.82		0.41	C		
	0.19			0.27	C		
I		0.234		0.667	I	0.205	
G		0.195		1.234	G	0.273	
		0.702		0.58	C	0.37	
	0.53					0.5	
		0.691		0.43	C	0.32	
		0.45		0.3	C	0.2	
		0.798		0.56	C	0.28	
		0.587		0.721		0.182	
		0.331		0.932		0.302	
		1.317		1.3		0.26	
		0.716		0.71	C	0.46	
		0.388		0.976		0.256	
I		0.014	I	0.312	I	0.246	
		1.025		0.39	C	0.33	
I		0.337		0.567	I	0.233	

		0.834				0.19	
		0.885		0.3	C	0.24	
		0.630		0.62		0.33	
		0.784		0.23	C	0.18	
		0.62		0.52	C	0.26	
		0.69		0.35	C	0.38	
		0.85		0.38	C	0.17	
		1.56		0.21	C	0.32	
		2.27		0.34	C		
		0.59		0.55	C		
		1		0.59	C		
		0.571		0.44		0.32	
		0.583		0.382		0.229	
	0.55			0.35	C		
		0.411		0.712		0.332	
		0.966		0.45	C	0.23	
	0.06					0.39	
	0.06			0.02	UC		
		0.238		0.189		0.185	
		0.62		0.57	C	0.38	
	0.31			0.58	C	0.09	
		0.727		0.34	C	0.26	
		1.021		0.08	C	0.13	
	0.06			0.31	C		
		0.59		0.3	C		
		0.507		0.548		0.187	
		0.52		0.32	C	0.19	
		0.58		0.77	C		
		0.64		0.55	C		
		0.384		0.867		0.446	
		0.479		0.442		0.236	
		0.707		0.534		0.139	
J		0.500		0.616		0.195	
	0.02			0.18	C		
		0.66		0.37	C		
		0.53		0.79	C		
I		0.253		0.518	I	0.193	
		0.529		0.55	C	0.43	
		0.461		0.59		0.27	
IY		0.366	Y	0.592	I	0.300	Y
I		0.209		0.572	I	0.216	
		0.862		0.62	C	0.29	
		1.24		0.1	C		
		1.26		0.46	C	0.26	
		0.99		0.34	C		
		0.346		1.037		0.493	
		0.240		0.367		0.185	

		0.69	0.44	C		
		0.429	0.44	C	0.32	
		0.28	0.36		0.23	
		0.53	0.17	C		
		0.891	0.4	C	0.27	
		0.875	0.53	C	0.2	
		0.388	0.608		0.315	
		0.47	0.97	C		
		0.47	0.29	C		
I		0.608	0.592	I	0.252	
		0.57	0.33	C	0.28	
		1.01	0.6	C		
		0.59	0.36	C		
		0.352	0.65		0.38	
J		0.491	0.430	G	0.154	
		0.995	0.56	C	0.37	
		0.450	0.36		0.56	
		0.355	0.22	C	0.17	
		0.61	0.49	C		
I		0.263	0.539	I	0.177	
		0.281	0.24	C	0.2	
I		0.193	0.590	I	0.162	
		0.803	0.379		0.130	
	0.32					
		0.494	0.75	C	0.32	
		0.392	0.1	C	0.18	
		0.478	0.01	C	0.21	
		0.743	0.33	C	0.17	
I		0.238	0.587	I	0.238	G
		0.566	0.36	C	0.22	
	0.09		0.01	C		
		0.794	0.05	C	0.19	
	0.66		0.37	C		
		0.44	0.7	C	0.51	
		0.439	0.35	C	0.44	
		0.823	0.3	C	0.12	
		0.88	0.58	C		
		0.354	0.454		0.187	
	0.56		0.35	C		
		0.574	0.46	C	0.47	
		0.349	1.102		0.310	
		0.721	0.48	C	0.34	
		0.83	0.33	C		
		0.574	0.28	C	0.25	
		0.403	0.27	C	0.2	
		0.659	0.24	C	0.4	
		0.554	0.51	C	0.39	

	0.475		0.36	C	0.31
	0.716		0.32	C	0.29
	0.87		0.42	C	
	0.594		0.44	C	0.73
	0.727		0.37	C	0.11
	0.68		1.17	C	
	0.54		0.46	C	
	0.403		0.56	C	0.33
	0.56		0.52	C	
	0.463		0.15	C	0.17
	0.73		0.54	C	
	0.191	J	0.634		0.553
	0.44		0.36	C	
	0.57		0.38	C	
	0.797		0.518		0.173
	1.375		1.363		0.196
	0.463		0.51	C	0.38
0.53			0.34	C	0.13
	0.766		1.070		0.357
0.06			0.36	C	
	0.22		0.01	C	0.19
	0.395		0.326		0.162
	0.45		0.36	C	
0.04			0.2	C	
	0.061		0.01	C	0.19
	0.37		0.69	C	
	0.59		0.4	C	
	0.717		0.86	C	0.68
0.36			0.66	C	
	0.39		0.27	C	0.32
	0.456		0.49	C	0.34
	0.09		0.49	C	
	10.18		2.41	C	
	1.26		1.05	C	
	0.46		0.72	C	
	0.53		0.46	C	
0.27			0.45	C	0.15
	0.68		0.2	C	
	0.48		0.66	C	
	0.7		0.56	C	
0.23			0.21	C	
0.35			0.42	C	
0.19					
	0.33		0.6	C	
0.39			0.18	C	
0.57			0.82	C	
0.26			0.68	C	

0.48	0.69	C

Silica	SilicaQ	Total_Nitr	Total_Nitr	Total_Phos	Total_Phos	BOD	Chloride	ChlorideQ
				0.63		1.5		
				0.69		1.5		
				0.68		1.8		
				0.57		1.1		
				0.42		2.7		
		1.16		0.36		1.4		
		1.42		0.45		1.9		
				0.49		1.7		
		1.39		0.27		1.4		
		1.4	C	0.64		0.4		
		1.46		0.67		3.6		
		1.53		0.70		0.8		
		1.7	C	0.53		3.2		
		1.22		0.41		1.6		
		1.17	C	0.52		2.5		
				0.91		1		
		1.232		0.466				
				0.49		1.5		
				0.45		1.2		
				0.4		2.6		
				0.5		0.9		
				0.72		0.6		
				0.54		1.2		
				0.49		1		
		1.485		0.388				
		1.7	C	0.69		1.5		
		1.22		0.36		2.4		
				0.36		0.3		
		1.534		0.390				
		1.538		0.463				
				0.67		1.7		
				0.4		1.6		
		1.842		0.497		1.1		
		1.41	C	0.54		1.4		
				2.33		0.8		
		1.06		0.51		1.3		
				0.44		1.4		
		0.922	I	0.384				
		1.46	C	0.66		0.9		
		1.444		0.460				
		0.95		0.34		<0.1		
		1.55		0.41		2.1		
				0.29		0.3		
		1.87	C	0.63		1.6		
		1.108		0.466				
				0.48		1		

		0.45		1.4
1.43		0.69		1.0
		0.35		1.2
		0.97		3
1.585		0.459		
		0.5		1
1.584		0.466		0.7
1.89		0.56		1.1
1.646		0.353		
2.132		0.848		3.6
0.86		0.33		1
2.59	C	0.63		1.3
1.41		0.19		1
1.05		0.62		0.9
		0.4		0.9
		0.8		2.3
2.251		0.52		2
1.5	C	0.66		1.4
		0.58		1.3
1.1		0.31		3.1
1.05		0.39		0.5
		0.48		>8.7
1.41	C	0.58		2.3
		0.37		1.1
		0.29		1
1.33	C	0.56		1.3
		0.47		0.8
1.61	C	0.62		1.07
1.41	C	0.49		1.1
		0.46		0.9
1.93	C	0.87		1.54
1.39	C	0.57		1.6
1.33	C	0.48		1
2.08		1.09		3.5
		0.37		1
1.71	C	0.53		1.4
1.665		0.471		
1.34	C	0.62		1.71
1.44	C	0.57		1.1
0.94		0.21		2
1.35		0.68		1.1
		0.41		0.9
2.6	C	0.87		3.8
1.029	I	0.456		
		0.38		1
1.13	C	0.34		1.2
		0.465	I	

1.88	C	0.68		0.75
1.336		0.435		
1.709		0.499		
2	C	0.61		1
1.25		0.34		0.6
		1.02		2.2
		0.65		1.4
1.379		0.515	J	
1.64		0.3		0.9
1.130		0.358	IJ	
1.77	C	0.59		1.7
		1.25		1.1
1.459		0.369	I	
1.358		0.330		
1.51		0.35		1.1
1.62	C	0.28		0.1
1.459		0.398	I	
		0.48		1.1
1.03	C	0.32		1.1
		0.47		1.6
1.48		0.419		
1.573		0.483		1.1
1.135		0.548		
1.2		0.36		2
0.957		0.441	I	
0.91	C	0.39		1.1
		0.54		0.8
0.973		0.408		
0.964		0.440	I	
1.586		0.47		1
1.59	C	0.56		1.9
1.322		0.435		
2.002		0.951		
1.21		0.4		0.1
1.62	C	0.47		1
1.348		0.392		
1.242		0.405		
2.88		0.65		1.9
2.29	C	0.56		1.6
1.56		0.71		1.6
		0.38		0.8
1.442		0.416		
1.47		0.28		1.2
1.76	C	0.45		1.3
2.00		0.56		1.1
1.625		0.62		1
1.41	C	0.63		1.3

1.53		0.57		0.3
1.28		0.42		0.8
1.62	C	0.53		0.9
1.189		0.451	I	
3.564		0.411	I	
1.576		0.54		1
1.648		0.373	Y	
1.22		0.38		1.1
1.458		0.390		
1.467		0.453		0.7
1.188	G	0.395		
1.13		0.29		0.8
		1.14		0.9
1.333		0.347		
1.991		0.331		
0.95		0.4		1.4
		0.43		0.8
1.249		0.410		
1.592		0.357		
1.43		0.40		0.8
1.975		0.558	Y	
1.653		0.430		0.5
2.66	C	0.61		4
1.018		0.399		
1.579	J	0.264		
1.52		0.432		0.2
1.27	C	0.25		1
		0.42		0.7
1.206		0.165	IQJ	
1.84	C	0.64		1.1
		0.35		0.5
1.61	C	0.56		1.9
1.412		0.328		
0.941		0.327	I	
1.349		0.329		
1.57		0.48		2.3
		0.26		2.8
2.092	G	0.237	Y	
1.47	C	0.37		1.3
0.728	I	0.429	I	
0.85	C	0.24		1.2
1.5	C	0.44		1.7
1.65	C	0.44		0.2
1.543		0.243		0.8
1.47		0.36		1.6
0.862		0.222	IJ	
2.446		0.251		

2.4	C	0.55		0.6
		0.35		0.9
1.437		0.188		
		0.38		1.2
1.84		0.23		1.2
1.794		0.4		1
0.738	I	0.439		
1.56	C	0.56		0.2
1.202	I	0.381	G	
1.327		0.358		
1.269		0.323		
1.26	C	0.37		0.2
1.24	C	0.34		1.4
1.07	C	0.32		1.8
1.201	I	0.228	I	
1.183		0.241		
1.587		0.215		
0.99		0.32		0.4
1.78		0.2		2.1
1.15	C	0.39		2.2
1.69	C	0.72		0.8
1.52	C	0.65		0.77
1.85	C	0.39		1.2
2.91	C	0.91		1.6
3.56	C	0.53		3.2
1.75	C	0.28		2.3
		0.41		1.3
0.917		0.261		
1.102		0.234		
1.214		0.349		
1.64	C	0.41		1.3
0.774		0.280		
1.35		0.257		
		0.4		
0.871		0.341	I	
1.40		0.26		0.4
1.269		0.332		
1.68	C	0.57		1.1
2.55	C	0.47		0.8
1.027		0.351		
1.258		0.284		
		0.36		0.8
0.911		0.419	IQ	
		0.36		1.9
		1.22		1.1
1.133		0.213		
1.119		0.261		1.1

0.95	C	0.27		1
1.46	C	0.48		1.1
0.91	C	0.2		0.7
0.74		0.19		1.1
1.270		0.402		
1.476		0.299		0.8
1.15	C	0.29		0.2
1.14	C	0.5		1.2
1.37	C	0.26		1.2
0.92	C	0.27		1.1
1.43	C	0.4		0.4
1.050		0.349	I	
1.257		0.249		
1.35		0.271		
1.834		0.198		1.1
0.996		0.426	IJ	
1.156		0.262		
1.251		0.261		
1.13		0.325		
1.194		0.353		
0.991		0.298		
1.16		0.31		1.0
1.073		0.231		
1.354		0.246		
1.42		0.29		0.6
1	C	0.29		0.7
1.4	C	0.36		0.4
1.193		0.211		
1.334		0.455		
1.416		0.335		0.8
		0.47		0.9
1.131		0.226		0.7
1.45	C	0.44		0.5
0.9		0.29		0.5
		0.37		1.3
1.476		0.368		0.8
0.94	C	0.24		0.7
1.3	C	0.43		
1.47		0.53		1.3
2.91	C	0.98		2.9
1.81	C	0.5		1
0.695		0.246		
1.52	C	0.39		0.66
1.59	C	0.68		1.2
1.553		0.306		
1.228		0.230		
1.348		0.290		

1.275		0.361		0.7
2		0.47		0.3
1.590		0.315		
1.44	C	0.4		1.7
1		0.4		1.6
		0.4		1.4
1.077		0.260	I	
0.850		0.222		
1.4	C	0.58		0.8
0.91		0.29		1.0
		0.32		1.4
1.392		0.189		
1.08		0.30		1.1
1.06	C	0.15		0.2
1.52		0.48		1.2
1.32		0.25		1
		0.32		1.6
1.152		0.191		
1.45		0.50		1.1
		0.54		
1.35		0.26		1.0
1.39	C	0.41		1.7
1.14	C	0.31		1.14
1.06		0.33		0.6
1.49	C	0.49		1.2
1.7	C	0.78		1.4
0.96		0.221		0.1
1.1		0.4		1.6
1.22		0.226		
1.451		0.337		0.9
1.28	C	0.21		0.8
1.362		0.272		1.0
1.36	C	0.5		0.3
1.43	C	0.46		1
0.938		0.203		
0.992		0.280	I	
2.26	C	0.82		1.8
1.293		0.349		
1.376		0.239		
		0.44		0.6
2.26	C	0.62		2.2
1.34	C	0.32		1.8
1.489		0.265		
1.234		0.224		
1.13	C	0.25		0.9
1.28		0.37		0.8
0.9		0.28		1.1

0.881	I	0.370		
2.414		0.429		
0.988		0.151		
1.2	C	0.47		0.45
1.498		0.248		
1.17		0.33		0.4
0.931		0.288		
1.00		0.23		1.0
1.056	I	0.404		
1.067		0.235		0.6
0.887		0.210		1.6
		0.35		1.6
1.242		0.179		
1.05	C	0.31		1.1
1.391		0.282		1.1
1.18	C	0.42		0.8
		0.75		1.9
1.15	C	0.56		0.6
1.02	C	0.44		0.8
1.59	C	0.35		1
0.55		0.157		0.8
		0.32		6.5
		0.33		1.2
		0.25		
1.11		0.38		0.7
1.103		0.290		
1.253		0.190		
1.11		0.51		0.2
0.79	C	0.29		1.42
1.02	C	0.36		2.7
		0.31		1.5
0.882		0.249		0.8
1.14		0.50		0.7
1.43	C	0.34		0.73
1.8	C	0.41		2.9
1.52		0.38		0.8
1.253		0.316		
1.39	C	0.29		0.98
0.603		0.194		
1.301		0.259	G	
1.73		0.4		1.9
0.959		0.233		
2.004		0.35		1
1.2	C	0.4		1.3
0.86	C	0.34		0.9
		0.26		4.3
0.883		0.163		

1.081		0.194		
1.056		0.297		
1.360		0.293		
1.57		0.53		1.5
1.25	C	0.36		1.5
		0.3		0.6
1.4	C	0.43		0.5
1.403		0.291		
0.933		0.253		
1.576		0.55		1
1.09	C	0.32		0.4
1.102		0.28		2
0.82	C	0.3		1.3
1.41	C	0.35		1
0.795	I	0.192	I	
1.179		0.182		
0.83	C	0.26		1.82
1.59	C	0.75		5.3
1.29	C	0.23		1
1.328		0.158		
1.627		0.51		2
1.004		0.227		
1.084		0.173		0.6
2.123		0.566		2.1
1.85	C	0.41		1.2
0.975	G	0.285		
1.209		0.194		
0.832		0.35		1
1.02	C	1.34		0.3
0.998		0.216		
1.35	C	0.3		1
		0.42		1
0.901		0.234	I	
1.448	G	0.356	I	
1.35	C	0.45		1.4
				0.6
1.15	C	0.38		1.6
0.82	C	0.26		0.7
1.36	C	0.32		0.71
1.335		0.198		
1.291		0.428		1.7
2.677		0.38		1
1.49	C	0.53		2.1
1.430		0.419	J	
0.334	I	0.286	I	
1.45	C	0.43		0.8
0.932		0.273	I	

		0.23		0.8
1.26	C	0.24		0.8
1.27		0.44		2.2
1.03	C	0.2		1.4
1.27	C	0.31		0.9
1.13	C	0.31		2.1
1.26	C	0.2		1.3
1.83	C	0.29		1
2.71	C	0.28		0.9
1.22	C	0.45		1.8
1.66		0.36		1
1.01		0.37		0.5
0.986		0.221		
1		0.49		1.1
1.149		0.396		0.8
1.45	C	0.29		
		0.42		0.8
		0.38		1.8
0.775		0.200		
1.24	C	0.42		0.5
0.94		0.24		3.2
1.1	C	0.29		0.9
1.13	C	0.16		0.9
		0.24		0.8
0.99		0.52		1.1
1.136		0.219		
0.91	C	0.22		0.8
1.51	C	0.42		2
1.28		0.37		1.5
1.27		0.533		0.6
0.979		0.253		
1.262		0.152		
1.142		0.238		
		0.33		0.1
1.17	C	0.28		1.5
1.45	C	0.36		1.6
0.778	I	0.220	I	
1.12	C	0.49		1.71
1.05		0.30		0.4
0.977		0.345	IY	
0.781	I	0.249	I	
1.52	C	0.44		1.3
1.52	C	0.22		1.2
1.79	C	0.28		1.7
1.39	C	0.35		1.1
1.446		0.541		
0.607		0.222		1.2

1.2	C	0.35		1
0.89	C	0.37		1.1
0.69		0.29		2
0.74	C	0.26		1.3
1.31	C	0.29		1.5
1.41	C	0.23		1.5
1.002		0.355		
1.64	C	0.33		1.9
0.82		0.26		0.8
1.270	I	0.335		
0.93	C	0.33		1.1
1.72	C	0.29		0.5
1.04	C	0.3		0.8
1.04		0.46		0.7
0.935		0.204		
1.61	C	0.46		1.4
0.83		0.67		0.9
0.6	C	0.31		0.7
1.21	C	0.27		0.9
0.804	I	0.260		
0.55	C	0.19		0.7
0.783	I	0.221	I	
1.248		0.174		
		0.46		1.2
1.29	C	0.39		0.9
0.52	C	0.21		0.8
0.5	C	0.2		0
1.08	C	0.17		0.7
0.825		0.177	I	
1.08	C	0.22		0.8
		0.2		1
0.85	C	0.19		0.9
		0.51		1.3
1.15	C	0.57		0.7
0.79	C	0.45		0.8
1.14	C	0.19		0.2
1.6		0.34		0.7
0.879		0.211		
		0.13		2.6
1.05	C	0.48		0.9
1.635		0.379		0.7
1.2	C	0.38		0.9
1.26		0.28		1.4
0.86	C	0.28		1.1
0.74	C	0.24		0.4
0.9	C	0.41		0.2
1.08	C	0.43		2.4

0.88	C	0.34		1
1.08	C	0.15		0.3
1.43	C	0.3		1.6
1.09	C	0.8		>0.1
1.15	C	0.13		0.6
2	C	0.41		1.1
1.04		0.31		0.9
1.03	C	0.35		1.2
1.13		0.29		0.9
0.61	C	0.13	J	0.86
1.31	C	0.2		1.8
0.863		0.555		0.8
0.85		0.38		1
1.05	C	0.29		1.7
1.357		0.212		
2.812		0.213		
0.99	C	0.42		0.8
0.97		<0.05	K	1.3
1.901		0.462		1.1
0.52		0.15		0.1
0.26	C	0.27		1.4
0.766		0.196		
0.89	C	0.28		2.4
		0.27		2.4
0.08	C	0.21		0.6
1.14	C	0.43		0.9
1.17		0.47		0.7
1.61	C	0.69		1.3
1.12		0.33		<0.1
0.71	C	0.33		1.63
0.99	C	0.33		1.1
0.71	C	0.53		1
13.35	C	1.09		8
2.68		0.27		4
1.27	C	0.55		1.1
1.08	C	0.24		0.8
0.77		<0.05	K	1.2
0.95		0.18		0.1
1.22	C	0.34		2.8
1.33		0.4		0.9
		0.74		1.3
		0.5		1.2
		0.22		0.7
0.98		0.32		<0.1
		0.45		2.5
		1.24		1.7
		0.68		1

		1.27	C	0.48		0.8		

Color(345)	Conductivi	Conductivi	Fluoride	FluorideQ	Sulfates(m	Sulfates(m	Total_Diss	Total_Diss
152	34				38			
183	73		0.13		35			
129			0.4		23			
154	92		0.3		25			
111	98		0.26		29			
151	99		0.19		31			
119	99		0.26		30			
109	114		<0.01	K	30			
116			0.23		27			
137			0.229		24			
164	127		0.36		34			
					35			
109			0.284		41			
144	131		0.43		24			
97			0.239		35			
142			0.44		31			
161.1			0.32		41			
141	139		0.43		20			
84	140		0.52		48			
96	141				33			
128			0.3		47			
101	147		0.25		25			
143	150				25			
62	150				38			
			0.26		2	UJ		
165			0.32		28			
130			0.24					
81			0.35		40			
			0.32		38			
			0.25		58			
177			0.42		28			
130			0.3		26			
148.5			0.39		57			
182			0.25		41			
177			0.28		15			
98	168		0.3		34			
38			0.46		28			
			0.44		61			
177			0.31		62			
			0.28		56			
65			0.2		36			
110			0.16		19			
102			0.2					
143			0.25		56			
			0.28		64			
51	182		1.07		50			

71	183	0.16	30
164.9		0.46	52
102		0.43	
85	187		100
		0.40	53
39	191	0.32	55
110.4		0.37	70
168		0.40	55.0
		0.32	64
114.0		0.37	60
118	198	0.23	45
128		0.24	59
77		0.19	51
64		0.25	41
42		0.4	31
85		0.34	34
111		0.34	62
161		0.363	77
118	203		65
73		0.36	
97	204	0.41	29
89		0.46	31
138		0.31	79
36	206		65
29		0.32	33
155		0.23	53
106	208		50
196		0.355	61
196		0.278	56
85	210		43
258		0.359	58
114		0.382	60
129		0.33	73
83		0.21	69
28	216		55
187		0.39	65
		0.38	76
188		0.454	51
97		0.277	53
73		0.22	48
139		0.46	64
82		0.53	66.0
92		0.28	69
		0.48	80
63	223		58
94		0.3	55
		0.51	51

113		0.315		57	
		0.42		54	
131.4		0.32		75	
120		0.43		64	
41		0.25		139	
67	228			90	
74	229	0.25		60	
			O		O
60		0.43		50	
			O		O
122		0.24		47	
48		0.34		24	
		0.35		72	
		0.33		63	
123	237	0.86		46	
82		0.29		66	
		0.47		62	
50		0.29		33	
54		0.273		57	
155	243			42	
		0.34		75	
126.2		0.51		83	
		0.40		65	
25	250	0.32		95	
			O		O
101		0.335		66	
118		0.42		27	
		0.53		71	
			O		O
122		0.41		70	
88		0.24		154	
		0.47		75	
		0.27		79	
40	257	0.22		68	
161		0.453		58	
		0.29		78	
		0.55		73	
75		0.37		79	
74		0.37		89	
117		0.48		74	
38		0.42		62	
		0.45		83	
62.6		0.34		85	
110		0.305			
108		0.34		98	
140		0.452		68	
163		0.29		67	

109.4		0.48		69	
78		0.53		70.0	
95		0.269		74	
			O		O
			O		
108		0.505		71	
		0.29		81	
45	272	0.26		59	
		0.32		79	
65.1		0.41		70	
		0.53		77	
34.6		0.34		77	
47		0.5		32	
		0.42		70	
		0.30		82	
101	277	1.37		38	
52	277			55	
		0.44		75	
		0.30		170	
54		0.36		77.0	
		0.32		84	
94.8		0.49		90	
104		0.495		106	
		0.44		75	
		0.36		69	
74.6		0.64		92	
41		0.283		72	
57	281	0.32		85	
			O		O
97		0.36		73	
70				59	
97		0.28		90	
63.0		0.39		88	
			O		O
		0.42		78	
89	286	0.65		51	
82		0.68		59	
		0.34		76	
54		0.441		66	
			O		
34		0.504		75	
98		0.34		84	
84		0.28		106	
46.5		0.47		90	
68		0.36			
			O		O
		0.36		86	

110		0.333		76	
31		0.36		40	
		0.33		72	
25	293	0.3		120	
25.6		0.34		78	
87		0.36		90	
		0.28		162	
160		0.294		65	
		0.36		76	
		0.46		82	
		0.36		104	
49		0.44		68	
60		0.342		86	
77		0.323		90	
		0.34		84	
		0.29		91	
		0.32		79	
44		0.56		82	
72	299	0.55		86	
85		0.414		79	
137		0.581		79	
94		0.538		78	
46		0.32		108	
74		0.45		299	
72	300	0.3		330	
44	300	0.28		240	
55	300	0.31		65	
		0.49		91	
		0.38		72	
		0.37		90	
29		0.32		88	
		0.36		78	
		0.35		180	
34		0.26			
			O		O
32		0.35		81.0	
		0.32		78	
111		0.554		80	
53		0.38		93	
		0.51		77	
		0.32		75	
26	307			93	
		0.72		70	
42	308			80	
16		0.4		50	
		0.33		66	
27.4		0.40		87	

35		0.524	80
79		0.587	81
27		0.34	208
55	310	0.38	85
		0.60	80
82.4		0.39	105
41		0.212	70
58		0.339	77
33		0.32	87
33		0.524	83
66		0.34	77
		0.65	75
		0.37	80
		0.37	84
42.8		0.41	85
		O	O
		0.41	87
		0.42	79
		0.34	90
		0.51	80
		0.39	67
33		0.48	79.0
		0.34	72
		0.37	78
34		0.40	84
43		0.474	71
68		0.44	82
		0.39	73
99.3		0.55	104
51.2		0.44	73
83		0.66	72.0
26.7		0.37	95
62		0.309	80
28		0.36	116
64	320		50
100.0		0.42	127
29		0.494	82
46		0.287	77
76		0.63	78
95		0.36	98
73		0.33	138
		0.35	97
69		0.481	77
66	324	0.31	
		0.31	93
27.3		0.37	94
41.4		0.38	100

44.0		0.41	90
174	325		10
		0.35	104
78		0.44	76
43		0.36	96
27		0.52	77
		0.77	84
		0.33	81
178		0.345	41
22		0.43	87
34		0.45	92.0
		0.38	75
34.0		0.42	94
32		0.338	86
103		0.8	85
45	330	0.52	55
42		0.36	68
		0.34	88
86		0.65	93.0
67		0.68	68
26		0.38	88
70		0.276	83
40		0.373	86
31		0.41	92
93		0.451	93
191		0.347	59
27.8		0.42	98
35	334	0.59	63
		0.31	99
49.1		0.48	93
34		0.36	88
37.7		0.40	90
44		0.34	73
83		0.37	76
		0.38	117
		0.47	112
45		0.33	91
		0.33	101
		0.36	77
82		0.65	77.0
126		0.389	69
34		0.33	117
		0.36	88
		0.33	88
32		0.421	85
25		0.4	81
37		0.24	69

		0.74	123
		0.41	134
21.2		0.19	116
44		0.463	81
		0.33	106
34.1		0.43	89
		0.40	89
24.1		0.42	96
		0.88	132
22.0		0.42	121
22.5		0.49	110
50	347		73
25.2		0.41	106
48		0.55	83
69.0		0.44	106
67		0.538	94
33	349	0.28	80
130		0.383	78
29		0.589	69
63		0.35	
15.4		0.45	102
24		0.6	77
22		0.88	71
39			55
65.6		0.57	79
		0.61	78
		0.32	85
64.3		0.84	79
34		0.383	83
46		0.365	86
32	353	0.2	40
22.9		0.46	95
64		0.58	94
49		0.396	83
55		0.507	92
51		0.66	97.0
		0.63	85
40		0.401	91
		0.41	95
		0.41	96
11	358	0.5	48
		0.38	98
69		0.458	120
48		0.54	113
49		0.39	97
32	360		88
		0.36	111

		0.33		117	
		0.40		50	
		0.40		110	
90		0.40		130.0	
94		0.314		56	
25	363			63	
97		0.366		73	
		0.68		84	
		0.36		119	
105		0.71		94	
41		0.379		99	
39		0.42		92	
31		0.447		85	
44		0.363		85	
		0.53		90	
20.4		0.39		88	
25		0.51		89	
71		0.381		99	
22		0.33		140	
30.1		0.41		113	
61		0.518		115	
33.4		0.48		129	
17.5		0.35		102	
60.1		0.38		146	
96		0.31		79	
		0.62		109	
		0.40		104	
47		0.42		93	
28		0.57		105	
		0.34		112	
47		0.37		95	
29				68	
		0.84		88	
		0.95		109	
		0.592			
44		0.3		37	
47		0.585		100	
23		0.501		94	
44		0.362		103	
		0.34		115	
91.5		0.65		135	
61		0.36		110	
64				112	
		0.44		136	
			O		O
41		0.949		98	
		0.96		93	

22		0.44	140.0
37		0.34	84
55		0.61	115.0
25		0.378	96
36		0.391	112
84		0.36	89
27		0.3	115
30		0.3	96
32		0.38	49
36	400	0.59	86
49	400		52
32.0		0.85	110
23.9		0.41	131
48	403	0.27	80
52.9		0.74	97
38		0.334	108
16		0.56	73
30		0.72	82
		0.43	113
49		0.33	108
100	409	0.16	78
26		0.461	120
21		0.34	110
19	410	1	95
63	411	0.22	50
		0.41	123
25		0.506	89
74		0.36	137
41		0.4	107
67.8		0.83	121
		0.79	116
19.4		0.53	28
		0.64	104
17		0.74	103
27		0.38	91
49		0.61	119
		0.99	116
56		0.705	93
52.8		0.70	95
		0.55	133
		0.85	103
45		0.38	114
26	429	0.38	60
29		0.33	121
32		0.39	164
85.1		0.78	122
16.5		0.52	116

58		0.35	107
33		0.439	95
27		0.617	105
23		0.62	112
33		0.37	123
45		0.47	84
		0.68	130
42		0.41	258
25			138
		0.69	134
47		0.32	98
54		0.31	79
28		0.5	128
62.7		0.88	105
		0.45	142
38		0.412	125
51		0.72	125
27		0.391	133
29		0.51	119
		0.78	123
20		0.464	100
		0.96	107
		0.42	155
15		0.64	67
66		0.553	140
22		0.445	120
22		0.75	140
23		0.509	104
		0.94	124
34		0.473	140
21	459		118
21		0.581	130
33	461	0.31	85
73		0.76	110
41		0.899	117
22		0.23	108
45	468	0.35	
		0.47	152
40	475		51
40		0.999	138
61.4		0.46	180
58		0.299	65
24	481	0.31	75
26		0.393	113
27		0.67	150
48		0.458	108
47		0.864	128

32		0.931	138
23		0.22	123
28		0.38	173
42		1.01	122
22		0.4	114
35	500	0.44	110
36	500	0.9	102
52		0.829	166
23		0.5	87
17		0.368	153
20	515	0.43	158
56.1		1.07	157
23			175
26		0.43	146
		0.49	197
60.3		0.39	227
40		0.844	170
18	543	0.5	122
29.8		0.49	220
18	550		119
17		0.502	182
		0.51	191
18		0.6	165
26	588	0.72	235
18		0.473	175
56	600	0.7	102
44	600	0.98	95
92		1.19	167
92	612		62
55		0.618	117
33		0.694	162
55	670	0.64	92
64		0.55	1254
40		0.88	306
52	800	0.21	
44	800	0.24	203
19	804	0.54	125
20	874	0.46	47
34	900	0.41	259
24	942	0.52	
182	1030	0.35	28
163	1100		54
26	1430	0.64	186
67	2135	0.36	34
24	2876	0.42	
120	9283		50
41	22175		855

91	0.29	168

Total_Solic	Total_SolidsQ	Total_Suspended_Soli	Total_Susp	Turbidity	TOC_L
		7		4	
		2		2	
		13		7	
		5		2	32.3
		5		4	18.3
		4		6	20.8
		17		22	
		6		3	17
		5		7	18.6
		8		18	
				6	29
		3		4.2	
		24		25	
		13		10	19.5
		4		9	
				3	
				4.1	
		4			27.1
		2		2	
		6		3	12.9
				2	
		4		3	13.3
		4		3	22.6
		3		3	
				9.3	25.1
		11		8	
		18		14	16.2
				3	
				6.2	23.8
				16.0	18.2
		2		2	
		4		2	
		15		10.1	
		5		8	
		7		3	
		16		11	11.6
		2		1	
				1.9	13.2
		3		5	
				10.7	26.6
		5		5	12.5
		5		7	20
		4		4	
		2		5	
				33.5	18.8
		<1	K	1	7.9

3		2	8.9
2	I	2.3	
		5	
138		25	
		3.2	23.3
2		1	8.6
4	I	4.7	
3		4	
		4.6	22.4
74		41.6	
16		18	21
5		6	
13		15	16.8
1		3	11.8
		1	4.8
		33	7.2
5		9	
9		11	
2		2	8.7
6		5	4.8
5		7	16.6
1		2	
9		6	
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3		8	
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		5	
38		16	12.2
9		2	
8		7	
		7.3	25.9
2		3	
4		3	
		4	14.4
3		3.6	
3		3	
56		41	
		8.6	22.8
2		2	9.5
3		5	
		2.6	28.7

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		10.7	
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		2.5	
2		4	10.3
		2.4	
27		36	
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5		9	
		7.7	15.8
4		2	9.2
1		3	
7		2	
		3.9	16.50
3	I	3.0	
		2.5	19.8
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		2.7	
2		2	
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		7.8	12.7
		1.4	
2		2	
12		13	
		4.6	27.9
		111	8.7
		4	8.9
5		4	
		3.6	
		8.5	19.3
22		19.1	
4		4	
6		6	23.7
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3		3.2	
8		10	
12		12.8	
2		4	
6		15	

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2		2	14.8
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		13.4	14.8
44		5	13.8
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		2	
4		6	
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2	I	1.8	
9		7	16
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		1.7	9.6
		6.5	13.6
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6		6	
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		3	
2		4	
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		1	
3		3	
		3.0	14.1
		2.7	11.7
		2.9	11.8
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		2.1	
		1.6	7.9
		2.4	11.4
		1.9	8.7
		2.3	13.42
		1.4	10.6
3		7	
		1.5	7.2
		2.1	13.1
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		1.4	6.1
		5.5	
2	U	1.7	
6		5.26	
2	U	1.1	
2		3	
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3		2	15
19		2.8	
12		1	
1		2	
6		5.7	
26		50	
3		4	
		3.0	9.6
11		3	
8		6	
		2.9	
		2.2	
		3.0	

5		4.7	
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		4.8	12.0
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1		2	
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		2.3	13.3
		2.0	7.9
3		7	
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		2	
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2		3	
8		1	
2		2.4	
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3	I	2.9	
2		4	
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		1.6	7.6
2		4	
		15.1	10.7
		1.4	7.3
6		2.66	
26		42	
0	U	2	
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		1.0	11.0
<1	K	2	
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1		2	7.5

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		8.8	14.5
		1.6	
3		4	
		1.6	13.03
2	I	1.5	
		7.5	7.7
1	I	1.4	
		2.9	19.0
2	I	1.6	
2	I	1.3	
2		2	4.2
		1.6	
4		5	
2	U	2.6	
2		4	
<1	K	2	
5		2	
2		3	
2		6	
2	I	1.2	
		2	
5		3	
1		5	
3	I	3.7	
		1.6	12.6
		1.1	7.08
5		2.5	
3		2	
1		2	
2		2	4.7
1	I	1.3	
2		2.4	
3		3	
4		5	
5		3	
		3.9	10.7
3		3	
		1.6	6.1
		1.4	7.2
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		1.2	6.5
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2		1	9.9
		1.2	5.9

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		2.3	10.1
		4.7	12.4
5		5.3	
3		5	
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5		3	
		2.0	9.5
		1.7	8.1
4		4	
		2	
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2		4	
		1.6	11.5
		1.4	
1.6		2	
47		37	
2		6	
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19		11	
		2.7	
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46		32.0	
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		2.7	12.9
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1		4	
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9		5	5.3
		2	
		1	
		2	
		2.2	10.3
7	I	7.1	
9		4	
3		3	
		3.8	19.7
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3		5	
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2		3	
21		21	19.8
2		1	
2		2	
5		1	
9		5	7.7
		1.6	7.6
		1	
15		15	
3		7	8.5
2	I	4.5	
		3.2	13.1
		1.3	
		2.2	11.6
5		2	1
1		3	
6		7	
		3.7	11.7
2		2	
4	I	2.9	
		1.3	12.2
		1.3	11.2
20		20	
2		6	
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1		3	
		3.9	
2	U	1.0	

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		2	
2		1	
2		4	
1		1	
1		4	
		3.3	10.5
5		4	
3		24	4.1
		4.4	10.4
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1		5	
<1	K	2	
3	I	3.2	
		2.0	5.8
		2	
6		2.8	
1		2	
1		3	
		2.7	12.1
		1	
		1.5	13.5
		2.3	4.54
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3		5	
		1	
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		2	
		1.1	13.7
2		2	
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2		1	
7		4	6.4
5		6	
2		2	
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6		3	9.2
		1.5	6.9
5		1	
2		2	
2	I	2.5	
5		6	
2		3	4
1		4	
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1		3	
2		3	

		1	
<1	K	3	
6		6	
2		2	
1		4	
3		4	
<1	K	2	7.2
5		2	
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		1	
1		3	
2	I	1.5	
3		2	5.6
1		2	
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		1.5	
5		6	
6		3	5.2
1	I	1.8	
2		1	4.8
1		2	
		1.0	5.9
5		4	
21		3	12.6
2		1	
2		4	
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2		3	
2		3	18.9
3		2	
1		2	
8		6	
46		38	
18		12	13
4		5	
4		6	
1		2	5.6
1		2	5.9
4		4	
6		7	6.6
7		2	16
4		3	27
4		2	
4		5	11.6
<1	K	1	1.8
4		2	14.7
9		2	9.7

4

condo for 2016 - 2000
282
230
315
251
269
289
271
451
459
382
327
314
396
240
233
384
429
429
426
448
371
298
297
438
341
171
223
347
296
368
337
337
341
301
315
363
280
278
257
391
408
357
443
316
324
292

288	
297	
274	
311	
252	
261	
326	
436	
363	
376	
277	
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Agency	Gage number	Date	Flow (cfs)	Gage Ht.	Sp. Conductance
USGS	2300500	10/1/1967	404		62
USGS	2300500	10/2/1967	273		61
USGS	2300500	10/3/1967	194		62
USGS	2300500	10/4/1967	149		69
USGS	2300500	10/5/1967	118		70
USGS	2300500	10/6/1967	112		74
USGS	2300500	10/7/1967	185		81
USGS	2300500	10/8/1967	149		80
USGS	2300500	10/9/1967	181		81
USGS	2300500	10/10/1967	282		80
USGS	2300500	10/11/1967	201		82
USGS	2300500	10/12/1967	163		80
USGS	2300500	10/13/1967	133		82
USGS	2300500	10/14/1967	107		82
USGS	2300500	10/15/1967	88		81
USGS	2300500	10/16/1967	76		69
USGS	2300500	10/17/1967	67		71
USGS	2300500	10/18/1967	64		75
USGS	2300500	10/19/1967	61		62
USGS	2300500	10/20/1967	56		61
USGS	2300500	10/21/1967	52		62
USGS	2300500	10/22/1967	48		62
USGS	2300500	10/23/1967	44		61
USGS	2300500	10/24/1967	43		62
USGS	2300500	10/25/1967	42		68
USGS	2300500	10/26/1967	39		71
USGS	2300500	10/27/1967	38		69
USGS	2300500	10/28/1967	37		81
USGS	2300500	10/29/1967	36		80
USGS	2300500	10/30/1967	34		80
USGS	2300500	10/31/1967	32		80
USGS	2300500	11/1/1967	30		62
USGS	2300500	11/2/1967	39		52
USGS	2300500	11/3/1967	48		69
USGS	2300500	11/4/1967	45		69
USGS	2300500	11/5/1967	40		63
USGS	2300500	11/6/1967	37		68
USGS	2300500	11/7/1967	34		89
USGS	2300500	11/8/1967	31		80
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USGS	2300500	11/10/1967	28		60
USGS	2300500	11/11/1967	28		60
USGS	2300500	11/12/1967	27		60
USGS	2300500	11/13/1967	26		64
USGS	2300500	11/14/1967	26		82
USGS	2300500	11/15/1967	26		69
USGS	2300500	11/16/1967	25		61
USGS	2300500	11/17/1967	26		69
USGS	2300500	11/18/1967	25		63
USGS	2300500	11/19/1967	25		51
USGS	2300500	11/20/1967	24		59
USGS	2300500	11/21/1967	24		71
USGS	2300500	11/22/1967	24		59
USGS	2300500	11/23/1967	25		68

USGS	2300500	11/24/1967	25	71
USGS	2300500	11/25/1967	25	66
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USGS	2300500	11/27/1967	26	80
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USGS	2300500	12/2/1967	24	210
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USGS	2300500	12/7/1967	24	68
USGS	2300500	12/8/1967	24	68
USGS	2300500	12/9/1967	24	69
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USGS	2300500	12/13/1967	93	73
USGS	2300500	12/14/1967	72	71
USGS	2300500	12/15/1967	60	69
USGS	2300500	12/16/1967	52	69
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USGS	2300500	12/24/1967	33	225
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USGS	2300500	12/27/1967	32	69
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USGS	2300500	12/30/1967	37	74
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USGS	2300500	1/14/1968	27	
USGS	2300500	1/15/1968	26	
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USGS	2300500	1/17/1968	28	

USGS	2300500	1/18/1968	30	
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USGS	2300500	1/20/1968	29	
USGS	2300500	1/21/1968	28	
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USGS	2300500	1/23/1968	27	
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USGS	2300500	1/31/1968	28	
USGS	2300500	2/1/1968	28	
USGS	2300500	2/2/1968	28	
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USGS	2300500	3/2/1968	46	93
USGS	2300500	3/3/1968	42	93
USGS	2300500	3/4/1968	40	92
USGS	2300500	3/5/1968	38	100
USGS	2300500	3/6/1968	38	130
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USGS	2300500	3/9/1968	52	94
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USGS	2300500	3/14/1968	63	89
USGS	2300500	3/15/1968	55	92
USGS	2300500	3/16/1968	48	89
USGS	2300500	3/17/1968	42	96
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USGS	2300500	3/22/1968	27	150
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USGS	2300500	3/31/1968	21	140
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USGS	2300500	4/18/1968	14	119
USGS	2300500	4/19/1968	15	129
USGS	2300500	4/20/1968	15	149
USGS	2300500	4/21/1968	14	210
USGS	2300500	4/22/1968	12	199
USGS	2300500	4/23/1968	11	185
USGS	2300500	4/24/1968	11	151
USGS	2300500	4/25/1968	11	185
USGS	2300500	4/26/1968	11	230
USGS	2300500	4/27/1968	11	230
USGS	2300500	4/28/1968	11	230
USGS	2300500	4/29/1968	10	219
USGS	2300500	4/30/1968	9	195
USGS	2300500	5/1/1968	10	150
USGS	2300500	5/2/1968	10	182
USGS	2300500	5/3/1968	10	150
USGS	2300500	5/4/1968	11	190
USGS	2300500	5/5/1968	12	245
USGS	2300500	5/6/1968	10	245

USGS	2300500	5/7/1968	10	160
USGS	2300500	5/8/1968	10	125
USGS	2300500	5/9/1968	10	120
USGS	2300500	5/10/1968	10	150
USGS	2300500	5/11/1968	11	175
USGS	2300500	5/12/1968	12	210
USGS	2300500	5/13/1968	17	169
USGS	2300500	5/14/1968	126	170
USGS	2300500	5/15/1968	126	110
USGS	2300500	5/16/1968	65	140
USGS	2300500	5/17/1968	45	130
USGS	2300500	5/18/1968	33	130
USGS	2300500	5/19/1968	28	121
USGS	2300500	5/20/1968	44	112
USGS	2300500	5/21/1968	42	112
USGS	2300500	5/22/1968	29	102
USGS	2300500	5/23/1968	24	102
USGS	2300500	5/24/1968	61	110
USGS	2300500	5/25/1968	332	131
USGS	2300500	5/26/1968	317	110
USGS	2300500	5/27/1968	215	100
USGS	2300500	5/28/1968	141	109
USGS	2300500	5/29/1968	135	110
USGS	2300500	5/30/1968	102	100
USGS	2300500	5/31/1968	73	100
USGS	2300500	6/1/1968	61	110
USGS	2300500	6/2/1968	51	107
USGS	2300500	6/3/1968	46	104
USGS	2300500	6/4/1968	558	94
USGS	2300500	6/5/1968	1600	76
USGS	2300500	6/6/1968	1640	85
USGS	2300500	6/7/1968	1060	75
USGS	2300500	6/8/1968	461	79
USGS	2300500	6/9/1968	265	80
USGS	2300500	6/10/1968	182	74
USGS	2300500	6/11/1968	144	72
USGS	2300500	6/12/1968	115	88
USGS	2300500	6/13/1968	97	94
USGS	2300500	6/14/1968	91	88
USGS	2300500	6/15/1968	191	83
USGS	2300500	6/16/1968	235	68
USGS	2300500	6/17/1968	226	78
USGS	2300500	6/18/1968	349	96
USGS	2300500	6/19/1968	566	70
USGS	2300500	6/20/1968	538	89
USGS	2300500	6/21/1968	466	75
USGS	2300500	6/22/1968	424	80
USGS	2300500	6/23/1968	310	70
USGS	2300500	6/24/1968	378	56
USGS	2300500	6/25/1968	632	62
USGS	2300500	6/26/1968	245	63
USGS	2300500	6/27/1968	391	80
USGS	2300500	6/28/1968	1520	61
USGS	2300500	6/29/1968	1400	64
USGS	2300500	6/30/1968	1210	69

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USGS	2300500	7/2/1968	524	69
USGS	2300500	7/3/1968	704	68
USGS	2300500	7/4/1968	1320	64
USGS	2300500	7/5/1968	2110	52
USGS	2300500	7/6/1968	3570	42
USGS	2300500	7/7/1968	2400	48
USGS	2300500	7/8/1968	1760	50
USGS	2300500	7/9/1968	1780	52
USGS	2300500	7/10/1968	2900	42
USGS	2300500	7/11/1968	2220	40
USGS	2300500	7/12/1968	1320	49
USGS	2300500	7/13/1968	704	62
USGS	2300500	7/14/1968	529	56
USGS	2300500	7/15/1968	645	49
USGS	2300500	7/16/1968	1320	40
USGS	2300500	7/17/1968	1100	46
USGS	2300500	7/18/1968	1020	47
USGS	2300500	7/19/1968	855	50
USGS	2300500	7/20/1968	732	65
USGS	2300500	7/21/1968	734	55
USGS	2300500	7/22/1968	597	55
USGS	2300500	7/23/1968	352	57
USGS	2300500	7/24/1968	312	60
USGS	2300500	7/25/1968	213	69
USGS	2300500	7/26/1968	156	75
USGS	2300500	7/27/1968	119	73
USGS	2300500	7/28/1968	94	77
USGS	2300500	7/29/1968	77	80
USGS	2300500	7/30/1968	65	81
USGS	2300500	7/31/1968	57	100
USGS	2300500	8/1/1968	52	100
USGS	2300500	8/2/1968	48	68
USGS	2300500	8/3/1968	46	62
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USGS	2300500	8/7/1968	51	56
USGS	2300500	8/8/1968	45	93
USGS	2300500	8/9/1968	156	53
USGS	2300500	8/10/1968	78	75
USGS	2300500	8/11/1968	52	74
USGS	2300500	8/12/1968	47	89
USGS	2300500	8/13/1968	97	72
USGS	2300500	8/14/1968	158	99
USGS	2300500	8/15/1968	313	54
USGS	2300500	8/16/1968	138	94
USGS	2300500	8/17/1968	80	65
USGS	2300500	8/18/1968	116	54
USGS	2300500	8/19/1968	222	75
USGS	2300500	8/20/1968	129	78
USGS	2300500	8/21/1968	115	54
USGS	2300500	8/22/1968	97	31
USGS	2300500	8/23/1968	75	83
USGS	2300500	8/24/1968	77	64

USGS	2300500	8/25/1968	143	67
USGS	2300500	8/26/1968	210	42
USGS	2300500	8/27/1968	325	75
USGS	2300500	8/28/1968	2410	64
USGS	2300500	8/29/1968	2360	73
USGS	2300500	8/30/1968	1620	70
USGS	2300500	8/31/1968	919	65
USGS	2300500	9/1/1968	445	45
USGS	2300500	9/2/1968	302	66
USGS	2300500	9/3/1968	230	61
USGS	2300500	9/4/1968	173	64
USGS	2300500	9/5/1968	135	63
USGS	2300500	9/6/1968	156	56
USGS	2300500	9/7/1968	302	57
USGS	2300500	9/8/1968	406	57
USGS	2300500	9/9/1968	379	61
USGS	2300500	9/10/1968	261	48
USGS	2300500	9/11/1968	208	77
USGS	2300500	9/12/1968	254	53
USGS	2300500	9/13/1968	999	44
USGS	2300500	9/14/1968	1800	56
USGS	2300500	9/15/1968	1930	45
USGS	2300500	9/16/1968	1250	38
USGS	2300500	9/17/1968	571	52
USGS	2300500	9/18/1968	322	63
USGS	2300500	9/19/1968	227	67
USGS	2300500	9/20/1968	227	47
USGS	2300500	9/21/1968	195	57
USGS	2300500	9/22/1968	155	47
USGS	2300500	9/23/1968	128	52
USGS	2300500	9/24/1968	115	43
USGS	2300500	9/25/1968	100	64
USGS	2300500	9/26/1968	89	57
USGS	2300500	9/27/1968	84	56
USGS	2300500	9/28/1968	90	64
USGS	2300500	9/29/1968	81	65
USGS	2300500	9/30/1968	68	65
USGS	2300500	10/1/1968	58	74
USGS	2300500	10/2/1968	52	92
USGS	2300500	10/3/1968	49	82
USGS	2300500	10/4/1968	45	85
USGS	2300500	10/5/1968	41	80
USGS	2300500	10/6/1968	39	87
USGS	2300500	10/7/1968	38	80
USGS	2300500	10/8/1968	36	90
USGS	2300500	10/9/1968	34	102
USGS	2300500	10/10/1968	38	84
USGS	2300500	10/11/1968	45	79
USGS	2300500	10/12/1968	42	102
USGS	2300500	10/13/1968	34	99
USGS	2300500	10/14/1968	31	78
USGS	2300500	10/15/1968	30	104
USGS	2300500	10/16/1968	30	91
USGS	2300500	10/17/1968	38	96
USGS	2300500	10/18/1968	83	102

USGS	2300500	10/19/1968	185	80
USGS	2300500	10/20/1968	275	89
USGS	2300500	10/21/1968	325	90
USGS	2300500	10/22/1968	255	78
USGS	2300500	10/23/1968	173	77
USGS	2300500	10/24/1968	131	78
USGS	2300500	10/25/1968	125	94
USGS	2300500	10/26/1968	115	75
USGS	2300500	10/27/1968	106	72
USGS	2300500	10/28/1968	99	83
USGS	2300500	10/29/1968	85	75
USGS	2300500	10/30/1968	71	73
USGS	2300500	10/31/1968	62	92
USGS	2300500	11/1/1968	56	80
USGS	2300500	11/2/1968	51	160
USGS	2300500	11/3/1968	48	91
USGS	2300500	11/4/1968	46	90
USGS	2300500	11/5/1968	42	81
USGS	2300500	11/6/1968	44	100
USGS	2300500	11/7/1968	40	80
USGS	2300500	11/8/1968	39	88
USGS	2300500	11/9/1968	46	152
USGS	2300500	11/10/1968	211	133
USGS	2300500	11/11/1968	326	
USGS	2300500	11/12/1968	384	70
USGS	2300500	11/13/1968	426	70
USGS	2300500	11/14/1968	348	71
USGS	2300500	11/15/1968	257	79
USGS	2300500	11/16/1968	197	70
USGS	2300500	11/17/1968	155	72
USGS	2300500	11/18/1968	126	79
USGS	2300500	11/19/1968	119	109
USGS	2300500	11/20/1968	116	80
USGS	2300500	11/21/1968	109	108
USGS	2300500	11/22/1968	99	138
USGS	2300500	11/23/1968	88	88
USGS	2300500	11/24/1968	79	85
USGS	2300500	11/25/1968	73	87
USGS	2300500	11/26/1968	65	89
USGS	2300500	11/27/1968	62	81
USGS	2300500	11/28/1968	59	80
USGS	2300500	11/29/1968	56	82
USGS	2300500	11/30/1968	55	88
USGS	2300500	12/1/1968	55	81
USGS	2300500	12/2/1968	54	86
USGS	2300500	12/3/1968	54	81
USGS	2300500	12/4/1968	50	77
USGS	2300500	12/5/1968	47	84
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USGS	2300500	12/7/1968	47	110
USGS	2300500	12/8/1968	46	120
USGS	2300500	12/9/1968	45	120
USGS	2300500	12/10/1968	45	140
USGS	2300500	12/11/1968	44	110
USGS	2300500	12/12/1968	44	130

USGS	2300500	12/13/1968	44	120
USGS	2300500	12/14/1968	44	130
USGS	2300500	12/15/1968	42	94
USGS	2300500	12/16/1968	42	92
USGS	2300500	12/17/1968	42	100
USGS	2300500	12/18/1968	44	100
USGS	2300500	12/19/1968	44	110
USGS	2300500	12/20/1968	43	100
USGS	2300500	12/21/1968	45	88
USGS	2300500	12/22/1968	45	110
USGS	2300500	12/23/1968	42	94
USGS	2300500	12/24/1968	42	110
USGS	2300500	12/25/1968	41	100
USGS	2300500	12/26/1968	39	110
USGS	2300500	12/27/1968	41	110
USGS	2300500	12/28/1968	42	94
USGS	2300500	12/29/1968	47	91
USGS	2300500	12/30/1968	50	110
USGS	2300500	12/31/1968	48	100
USGS	2300500	1/1/1969	45	128
USGS	2300500	1/2/1969	43	120
USGS	2300500	1/3/1969	42	136
USGS	2300500	1/4/1969	236	157
USGS	2300500	1/5/1969	460	114
USGS	2300500	1/6/1969	412	114
USGS	2300500	1/7/1969	329	112
USGS	2300500	1/8/1969	248	98
USGS	2300500	1/9/1969	191	103
USGS	2300500	1/10/1969	150	106
USGS	2300500	1/11/1969	130	124
USGS	2300500	1/12/1969	172	97
USGS	2300500	1/13/1969	139	98
USGS	2300500	1/14/1969	114	94
USGS	2300500	1/15/1969	100	91
USGS	2300500	1/16/1969	90	93
USGS	2300500	1/17/1969	81	98
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USGS	2300500	1/22/1969	77	85
USGS	2300500	1/23/1969	72	88
USGS	2300500	1/24/1969	67	87
USGS	2300500	1/25/1969	64	86
USGS	2300500	1/26/1969	65	91
USGS	2300500	1/27/1969	65	90
USGS	2300500	1/28/1969	62	89
USGS	2300500	1/29/1969	59	86
USGS	2300500	1/30/1969	57	94
USGS	2300500	1/31/1969	54	112
USGS	2300500	2/1/1969	52	110
USGS	2300500	2/2/1969	51	112
USGS	2300500	2/3/1969	50	111
USGS	2300500	2/4/1969	48	132
USGS	2300500	2/5/1969	46	136

USGS	2300500	2/6/1969	46	139
USGS	2300500	2/7/1969	47	155
USGS	2300500	2/8/1969	46	112
USGS	2300500	2/9/1969	112	140
USGS	2300500	2/10/1969	116	99
USGS	2300500	2/11/1969	101	87
USGS	2300500	2/12/1969	85	90
USGS	2300500	2/13/1969	75	108
USGS	2300500	2/14/1969	66	94
USGS	2300500	2/15/1969	113	87
USGS	2300500	2/16/1969	289	88
USGS	2300500	2/17/1969	221	87
USGS	2300500	2/18/1969	181	89
USGS	2300500	2/19/1969	146	92
USGS	2300500	2/20/1969	119	86
USGS	2300500	2/21/1969	99	91
USGS	2300500	2/22/1969	85	90
USGS	2300500	2/23/1969	76	90
USGS	2300500	2/24/1969	69	87
USGS	2300500	2/25/1969	65	98
USGS	2300500	2/26/1969	63	132
USGS	2300500	2/27/1969	60	132
USGS	2300500	2/28/1969	58	135
USGS	2300500	3/1/1969	55	138
USGS	2300500	3/2/1969	51	
USGS	2300500	3/3/1969	50	118
USGS	2300500	3/4/1969	50	108
USGS	2300500	3/5/1969	49	100
USGS	2300500	3/6/1969	53	96
USGS	2300500	3/7/1969	77	140
USGS	2300500	3/8/1969	101	96
USGS	2300500	3/9/1969	810	75
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USGS	2300500	3/13/1969	285	69
USGS	2300500	3/14/1969	214	73
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USGS	2300500	3/16/1969	235	75
USGS	2300500	3/17/1969	1130	70
USGS	2300500	3/18/1969	1160	67
USGS	2300500	3/19/1969	991	67
USGS	2300500	3/20/1969	570	69
USGS	2300500	3/21/1969	329	70
USGS	2300500	3/22/1969	230	77
USGS	2300500	3/23/1969	171	85
USGS	2300500	3/24/1969	137	86
USGS	2300500	3/25/1969	116	86
USGS	2300500	3/26/1969	103	
USGS	2300500	3/27/1969	100	
USGS	2300500	3/28/1969	92	
USGS	2300500	3/29/1969	86	
USGS	2300500	3/30/1969	79	107
USGS	2300500	3/31/1969	72	
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USGS	2300500	4/4/1969	53	
USGS	2300500	4/5/1969	50	
USGS	2300500	4/6/1969	47	
USGS	2300500	4/7/1969	41	88
USGS	2300500	4/8/1969	39	107
USGS	2300500	4/9/1969	38	127
USGS	2300500	4/10/1969	37	150
USGS	2300500	4/11/1969	42	
USGS	2300500	4/12/1969	61	
USGS	2300500	4/13/1969	52	112
USGS	2300500	4/14/1969	43	117
USGS	2300500	4/15/1969	39	114
USGS	2300500	4/16/1969	38	116
USGS	2300500	4/17/1969	58	103
USGS	2300500	4/18/1969	121	90
USGS	2300500	4/19/1969	62	92
USGS	2300500	4/20/1969	50	
USGS	2300500	4/21/1969	45	
USGS	2300500	4/22/1969	41	149
USGS	2300500	4/23/1969	40	154
USGS	2300500	4/24/1969	35	165
USGS	2300500	4/25/1969	31	157
USGS	2300500	4/26/1969	28	167
USGS	2300500	4/27/1969	25	152
USGS	2300500	4/28/1969	21	129
USGS	2300500	4/29/1969	23	125
USGS	2300500	4/30/1969	24	161
USGS	2300500	5/1/1969	22	116
USGS	2300500	5/2/1969	20	124
USGS	2300500	5/3/1969	20	103
USGS	2300500	5/4/1969	21	97
USGS	2300500	5/5/1969	20	122
USGS	2300500	5/6/1969	19	128
USGS	2300500	5/7/1969	20	174
USGS	2300500	5/8/1969	19	199
USGS	2300500	5/9/1969	18	231
USGS	2300500	5/10/1969	20	240
USGS	2300500	5/11/1969	18	160
USGS	2300500	5/12/1969	17	114
USGS	2300500	5/13/1969	16	105
USGS	2300500	5/14/1969	16	103
USGS	2300500	5/15/1969	17	138
USGS	2300500	5/16/1969	16	116
USGS	2300500	5/17/1969	20	102
USGS	2300500	5/18/1969	26	123
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USGS	2300500	5/20/1969	87	105
USGS	2300500	5/21/1969	101	126
USGS	2300500	5/22/1969	66	117
USGS	2300500	5/23/1969	48	
USGS	2300500	5/24/1969	38	100
USGS	2300500	5/25/1969	31	104
USGS	2300500	5/26/1969	27	100

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USGS	2300500	5/28/1969	72	84
USGS	2300500	5/29/1969	58	85
USGS	2300500	5/30/1969	38	97
USGS	2300500	5/31/1969	28	100
USGS	2300500	6/1/1969	23	105
USGS	2300500	6/2/1969	21	98
USGS	2300500	6/3/1969	22	100
USGS	2300500	6/4/1969	23	106
USGS	2300500	6/5/1969	21	104
USGS	2300500	6/6/1969	19	
USGS	2300500	6/7/1969	24	109
USGS	2300500	6/8/1969	30	96
USGS	2300500	6/9/1969	50	120
USGS	2300500	6/10/1969	69	106
USGS	2300500	6/11/1969	67	97
USGS	2300500	6/12/1969	105	96
USGS	2300500	6/13/1969	120	84
USGS	2300500	6/14/1969	182	97
USGS	2300500	6/15/1969	217	114
USGS	2300500	6/16/1969	138	139
USGS	2300500	6/17/1969	127	141
USGS	2300500	6/18/1969	103	90
USGS	2300500	6/19/1969	91	74
USGS	2300500	6/20/1969	164	
USGS	2300500	6/21/1969	204	83
USGS	2300500	6/22/1969	226	82
USGS	2300500	6/23/1969	226	
USGS	2300500	6/24/1969	212	78
USGS	2300500	6/25/1969	228	77
USGS	2300500	6/26/1969	203	76
USGS	2300500	6/27/1969	143	78
USGS	2300500	6/28/1969	101	80
USGS	2300500	6/29/1969	74	81
USGS	2300500	6/30/1969	58	80
USGS	2300500	7/1/1969	48	80
USGS	2300500	7/2/1969	43	80
USGS	2300500	7/3/1969	62	70
USGS	2300500	7/4/1969	133	77
USGS	2300500	7/5/1969	121	77
USGS	2300500	7/6/1969	72	80
USGS	2300500	7/7/1969	51	80
USGS	2300500	7/8/1969	128	67
USGS	2300500	7/9/1969	75	77
USGS	2300500	7/10/1969	61	82
USGS	2300500	7/11/1969	45	87
USGS	2300500	7/12/1969	37	88
USGS	2300500	7/13/1969	32	85
USGS	2300500	7/14/1969	30	85
USGS	2300500	7/15/1969	30	85
USGS	2300500	7/16/1969	33	85
USGS	2300500	7/17/1969	40	80
USGS	2300500	7/18/1969	41	80
USGS	2300500	7/19/1969	43	75
USGS	2300500	7/20/1969	138	73

USGS	2300500	7/21/1969	104	85
USGS	2300500	7/22/1969	69	82
USGS	2300500	7/23/1969	57	80
USGS	2300500	7/24/1969	81	75
USGS	2300500	7/25/1969	81	75
USGS	2300500	7/26/1969	76	75
USGS	2300500	7/27/1969	85	78
USGS	2300500	7/28/1969	71	73
USGS	2300500	7/29/1969	59	77
USGS	2300500	7/30/1969	52	77
USGS	2300500	7/31/1969	47	80
USGS	2300500	8/1/1969	52	
USGS	2300500	8/2/1969	307	72
USGS	2300500	8/3/1969	378	76
USGS	2300500	8/4/1969	562	58
USGS	2300500	8/5/1969	1030	62
USGS	2300500	8/6/1969	934	66
USGS	2300500	8/7/1969	909	61
USGS	2300500	8/8/1969	473	67
USGS	2300500	8/9/1969	341	63
USGS	2300500	8/10/1969	274	62
USGS	2300500	8/11/1969	194	65
USGS	2300500	8/12/1969	353	58
USGS	2300500	8/13/1969	410	60
USGS	2300500	8/14/1969	361	68
USGS	2300500	8/15/1969	740	
USGS	2300500	8/16/1969	1040	
USGS	2300500	8/17/1969	1020	50
USGS	2300500	8/18/1969	644	55
USGS	2300500	8/19/1969	509	55
USGS	2300500	8/20/1969	605	48
USGS	2300500	8/21/1969	693	49
USGS	2300500	8/22/1969	412	
USGS	2300500	8/23/1969	256	
USGS	2300500	8/24/1969	195	
USGS	2300500	8/25/1969	207	70
USGS	2300500	8/26/1969	168	66
USGS	2300500	8/27/1969	129	69
USGS	2300500	8/28/1969	97	70
USGS	2300500	8/29/1969	77	75
USGS	2300500	8/30/1969	69	78
USGS	2300500	8/31/1969	135	
USGS	2300500	9/1/1969	290	
USGS	2300500	9/2/1969	668	56
USGS	2300500	9/3/1969	1780	39
USGS	2300500	9/4/1969	1210	52
USGS	2300500	9/5/1969	596	54
USGS	2300500	9/6/1969	316	
USGS	2300500	9/7/1969	218	60
USGS	2300500	9/8/1969	195	63
USGS	2300500	9/9/1969	165	66
USGS	2300500	9/10/1969	142	68
USGS	2300500	9/11/1969	112	73
USGS	2300500	9/12/1969	94	73
USGS	2300500	9/13/1969	84	75

USGS	2300500	9/14/1969	81	
USGS	2300500	9/15/1969	86	77
USGS	2300500	9/16/1969	151	76
USGS	2300500	9/17/1969	174	
USGS	2300500	9/18/1969	241	70
USGS	2300500	9/19/1969	252	67
USGS	2300500	9/20/1969	275	64
USGS	2300500	9/21/1969	233	64
USGS	2300500	9/22/1969	1230	38
USGS	2300500	9/23/1969	1430	36
USGS	2300500	9/24/1969	1030	46
USGS	2300500	9/25/1969	626	53
USGS	2300500	9/26/1969	334	57
USGS	2300500	9/27/1969	231	
USGS	2300500	9/28/1969	176	
USGS	2300500	9/29/1969	146	65
USGS	2300500	9/30/1969	129	67
USGS	2300500	10/1/1969	139	
USGS	2300500	10/2/1969	287	68
USGS	2300500	10/3/1969	897	51
USGS	2300500	10/4/1969	988	
USGS	2300500	10/5/1969	822	51
USGS	2300500	10/6/1969	596	56
USGS	2300500	10/7/1969	383	60
USGS	2300500	10/8/1969	258	62
USGS	2300500	10/9/1969	195	64
USGS	2300500	10/10/1969	152	72
USGS	2300500	10/11/1969	124	70
USGS	2300500	10/12/1969	103	
USGS	2300500	10/13/1969	89	74
USGS	2300500	10/14/1969	79	72
USGS	2300500	10/15/1969	72	77
USGS	2300500	10/16/1969	67	78
USGS	2300500	10/17/1969	63	79
USGS	2300500	10/18/1969	60	75
USGS	2300500	10/19/1969	60	77
USGS	2300500	10/20/1969	64	76
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USGS	2300500	10/22/1969	69	75
USGS	2300500	10/23/1969	66	76
USGS	2300500	10/24/1969	61	75
USGS	2300500	10/25/1969	69	
USGS	2300500	10/26/1969	146	83
USGS	2300500	10/27/1969	175	
USGS	2300500	10/28/1969	159	80
USGS	2300500	10/29/1969	126	79
USGS	2300500	10/30/1969	108	79
USGS	2300500	10/31/1969	101	78
USGS	2300500	11/1/1969	102	79
USGS	2300500	11/2/1969	103	78
USGS	2300500	11/3/1969	89	
USGS	2300500	11/4/1969	78	83
USGS	2300500	11/5/1969	71	84
USGS	2300500	11/6/1969	67	85
USGS	2300500	11/7/1969	63	84

USGS	2300500	11/8/1969	61	83
USGS	2300500	11/9/1969	60	81
USGS	2300500	11/10/1969	59	84
USGS	2300500	11/11/1969	58	81
USGS	2300500	11/12/1969	54	80
USGS	2300500	11/13/1969	58	81
USGS	2300500	11/14/1969	306	80
USGS	2300500	11/15/1969	407	78
USGS	2300500	11/16/1969	325	80
USGS	2300500	11/17/1969	257	78
USGS	2300500	11/18/1969	205	76
USGS	2300500	11/19/1969	164	77
USGS	2300500	11/20/1969	131	77
USGS	2300500	11/21/1969	105	78
USGS	2300500	11/22/1969	91	78
USGS	2300500	11/23/1969	82	81
USGS	2300500	11/24/1969	76	81
USGS	2300500	11/25/1969	71	80
USGS	2300500	11/26/1969	69	81
USGS	2300500	11/27/1969	66	84
USGS	2300500	11/28/1969	65	86
USGS	2300500	11/29/1969	92	80
USGS	2300500	11/30/1969	94	83
USGS	2300500	12/1/1969	81	82
USGS	2300500	12/2/1969	73	80
USGS	2300500	12/3/1969	69	84
USGS	2300500	12/4/1969	67	86
USGS	2300500	12/5/1969	64	
USGS	2300500	12/6/1969	61	
USGS	2300500	12/7/1969	68	88
USGS	2300500	12/8/1969	118	88
USGS	2300500	12/9/1969	219	
USGS	2300500	12/10/1969	1140	68
USGS	2300500	12/11/1969	1120	72
USGS	2300500	12/12/1969	813	72
USGS	2300500	12/13/1969	507	
USGS	2300500	12/14/1969	326	77
USGS	2300500	12/15/1969	248	
USGS	2300500	12/16/1969	199	76
USGS	2300500	12/17/1969	166	76
USGS	2300500	12/18/1969	142	80
USGS	2300500	12/19/1969	127	82
USGS	2300500	12/20/1969	115	82
USGS	2300500	12/21/1969	107	84
USGS	2300500	12/22/1969	187	78
USGS	2300500	12/23/1969	195	79
USGS	2300500	12/24/1969	168	78
USGS	2300500	12/25/1969	145	78
USGS	2300500	12/26/1969	177	78
USGS	2300500	12/27/1969	169	
USGS	2300500	12/28/1969	149	77
USGS	2300500	12/29/1969	132	77
USGS	2300500	12/30/1969	119	77
USGS	2300500	12/31/1969	110	77
USGS	2300500	1/1/1970	103	81

USGS	2300500	1/2/1970	103	82
USGS	2300500	1/3/1970	217	80
USGS	2300500	1/4/1970	291	83
USGS	2300500	1/5/1970	217	83
USGS	2300500	1/6/1970	342	77
USGS	2300500	1/7/1970	652	
USGS	2300500	1/8/1970	535	73
USGS	2300500	1/9/1970	399	72
USGS	2300500	1/10/1970	288	73
USGS	2300500	1/11/1970	223	74
USGS	2300500	1/12/1970	187	76
USGS	2300500	1/13/1970	161	76
USGS	2300500	1/14/1970	141	78
USGS	2300500	1/15/1970	146	80
USGS	2300500	1/16/1970	299	72
USGS	2300500	1/17/1970	188	79
USGS	2300500	1/18/1970	149	81
USGS	2300500	1/19/1970	130	80
USGS	2300500	1/20/1970	117	80
USGS	2300500	1/21/1970	107	80
USGS	2300500	1/22/1970	97	81
USGS	2300500	1/23/1970	92	
USGS	2300500	1/24/1970	89	
USGS	2300500	1/25/1970	85	84
USGS	2300500	1/26/1970	81	
USGS	2300500	1/27/1970	78	
USGS	2300500	1/28/1970	77	
USGS	2300500	1/29/1970	75	88
USGS	2300500	1/30/1970	73	84
USGS	2300500	1/31/1970	71	85
USGS	2300500	2/1/1970	68	90
USGS	2300500	2/2/1970	65	116
USGS	2300500	2/3/1970	136	95
USGS	2300500	2/4/1970	192	93
USGS	2300500	2/5/1970	151	87
USGS	2300500	2/6/1970	124	86
USGS	2300500	2/7/1970	107	85
USGS	2300500	2/8/1970	97	84
USGS	2300500	2/9/1970	91	86
USGS	2300500	2/10/1970	88	95
USGS	2300500	2/11/1970	82	91
USGS	2300500	2/12/1970	78	88
USGS	2300500	2/13/1970	75	
USGS	2300500	2/14/1970	73	
USGS	2300500	2/15/1970	71	107
USGS	2300500	2/16/1970	74	122
USGS	2300500	2/17/1970	95	101
USGS	2300500	2/18/1970	92	86
USGS	2300500	2/19/1970	85	85
USGS	2300500	2/20/1970	79	109
USGS	2300500	2/21/1970	72	110
USGS	2300500	2/22/1970	69	
USGS	2300500	2/23/1970	68	
USGS	2300500	2/24/1970	68	141
USGS	2300500	2/25/1970	76	144

USGS	2300500	2/26/1970	121	97
USGS	2300500	2/27/1970	125	84
USGS	2300500	2/28/1970	116	98
USGS	2300500	3/1/1970	103	108
USGS	2300500	3/2/1970	92	101
USGS	2300500	3/3/1970	83	104
USGS	2300500	3/4/1970	77	119
USGS	2300500	3/5/1970	200	91
USGS	2300500	3/6/1970	411	79
USGS	2300500	3/7/1970	330	
USGS	2300500	3/8/1970	829	89
USGS	2300500	3/9/1970	812	78
USGS	2300500	3/10/1970	619	79
USGS	2300500	3/11/1970	424	80
USGS	2300500	3/12/1970	855	70
USGS	2300500	3/13/1970	770	72
USGS	2300500	3/14/1970	558	73
USGS	2300500	3/15/1970	370	74
USGS	2300500	3/16/1970	262	76
USGS	2300500	3/17/1970	200	77
USGS	2300500	3/18/1970	160	79
USGS	2300500	3/19/1970	135	80
USGS	2300500	3/20/1970	122	84
USGS	2300500	3/21/1970	108	99
USGS	2300500	3/22/1970	109	94
USGS	2300500	3/23/1970	142	79
USGS	2300500	3/24/1970	147	
USGS	2300500	3/25/1970	173	
USGS	2300500	3/26/1970	1200	
USGS	2300500	3/27/1970	1910	57
USGS	2300500	3/28/1970	1970	58
USGS	2300500	3/29/1970	1260	64
USGS	2300500	3/30/1970	636	64
USGS	2300500	3/31/1970	362	66
USGS	2300500	4/1/1970	258	
USGS	2300500	4/2/1970	199	
USGS	2300500	4/3/1970	159	
USGS	2300500	4/4/1970	136	76
USGS	2300500	4/5/1970	121	76
USGS	2300500	4/6/1970	107	79
USGS	2300500	4/7/1970	92	78
USGS	2300500	4/8/1970	81	90
USGS	2300500	4/9/1970	75	102
USGS	2300500	4/10/1970	70	110
USGS	2300500	4/11/1970	64	101
USGS	2300500	4/12/1970	61	100
USGS	2300500	4/13/1970	58	93
USGS	2300500	4/14/1970	56	89
USGS	2300500	4/15/1970	54	115
USGS	2300500	4/16/1970	50	120
USGS	2300500	4/17/1970	47	139
USGS	2300500	4/18/1970	43	128
USGS	2300500	4/19/1970	39	119
USGS	2300500	4/20/1970	36	100
USGS	2300500	4/21/1970	34	95

USGS	2300500	4/22/1970	33	116
USGS	2300500	4/23/1970	33	116
USGS	2300500	4/24/1970	33	125
USGS	2300500	4/25/1970	32	133
USGS	2300500	4/26/1970	31	135
USGS	2300500	4/27/1970	31	123
USGS	2300500	4/28/1970	30	125
USGS	2300500	4/29/1970	29	134
USGS	2300500	4/30/1970	28	210
USGS	2300500	5/1/1970	27	200
USGS	2300500	5/2/1970	25	230
USGS	2300500	5/3/1970	24	155
USGS	2300500	5/4/1970	24	169
USGS	2300500	5/5/1970	23	130
USGS	2300500	5/6/1970	22	132
USGS	2300500	5/7/1970	23	160
USGS	2300500	5/8/1970	23	219
USGS	2300500	5/9/1970	23	220
USGS	2300500	5/10/1970	22	178
USGS	2300500	5/11/1970	21	148
USGS	2300500	5/12/1970	21	170
USGS	2300500	5/13/1970	20	
USGS	2300500	5/14/1970	20	
USGS	2300500	5/15/1970	20	
USGS	2300500	5/16/1970	20	180
USGS	2300500	5/17/1970	19	169
USGS	2300500	5/18/1970	17	180
USGS	2300500	5/19/1970	16	138
USGS	2300500	5/20/1970	16	140
USGS	2300500	5/21/1970	17	132
USGS	2300500	5/22/1970	17	121
USGS	2300500	5/23/1970	16	123
USGS	2300500	5/24/1970	37	140
USGS	2300500	5/25/1970	84	250
USGS	2300500	5/26/1970	78	175
USGS	2300500	5/27/1970	57	155
USGS	2300500	5/28/1970	45	130
USGS	2300500	5/29/1970	80	150
USGS	2300500	5/30/1970	413	88
USGS	2300500	5/31/1970	653	74
USGS	2300500	6/1/1970	541	65
USGS	2300500	6/2/1970	454	70
USGS	2300500	6/3/1970	304	73
USGS	2300500	6/4/1970	205	78
USGS	2300500	6/5/1970	148	77
USGS	2300500	6/6/1970	112	86
USGS	2300500	6/7/1970	88	80
USGS	2300500	6/8/1970	71	82
USGS	2300500	6/9/1970	59	
USGS	2300500	6/10/1970	50	85
USGS	2300500	6/11/1970	44	86
USGS	2300500	6/12/1970	39	89
USGS	2300500	6/13/1970	34	89
USGS	2300500	6/14/1970	33	92
USGS	2300500	6/15/1970	33	

USGS	2300500	6/16/1970	32	
USGS	2300500	6/17/1970	32	87
USGS	2300500	6/18/1970	42	87
USGS	2300500	6/19/1970	51	
USGS	2300500	6/20/1970	40	89
USGS	2300500	6/21/1970	34	89
USGS	2300500	6/22/1970	30	87
USGS	2300500	6/23/1970	129	78
USGS	2300500	6/24/1970	173	74
USGS	2300500	6/25/1970	101	74
USGS	2300500	6/26/1970	114	75
USGS	2300500	6/27/1970	189	75
USGS	2300500	6/28/1970	149	76
USGS	2300500	6/29/1970	107	75
USGS	2300500	6/30/1970	122	75
USGS	2300500	7/1/1970	83	85
USGS	2300500	7/2/1970	62	82
USGS	2300500	7/3/1970	51	
USGS	2300500	7/4/1970	44	86
USGS	2300500	7/5/1970	39	85
USGS	2300500	7/6/1970	34	86
USGS	2300500	7/7/1970	38	90
USGS	2300500	7/8/1970	37	88
USGS	2300500	7/9/1970	34	89
USGS	2300500	7/10/1970	35	
USGS	2300500	7/11/1970	52	95
USGS	2300500	7/12/1970	81	95
USGS	2300500	7/13/1970	73	95
USGS	2300500	7/14/1970	66	94
USGS	2300500	7/15/1970	68	92
USGS	2300500	7/16/1970	52	95
USGS	2300500	7/17/1970	43	
USGS	2300500	7/18/1970	36	95
USGS	2300500	7/19/1970	30	97
USGS	2300500	7/20/1970	28	96
USGS	2300500	7/21/1970	45	86
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USGS	2300500	7/25/1970	51	76
USGS	2300500	7/26/1970	39	87
USGS	2300500	7/27/1970	32	90
USGS	2300500	7/28/1970	35	98
USGS	2300500	7/29/1970	28	94
USGS	2300500	7/30/1970	25	95
USGS	2300500	7/31/1970	24	104
USGS	2300500	8/1/1970	34	
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USGS	2300500	8/3/1970	23	
USGS	2300500	8/4/1970	21	
USGS	2300500	8/5/1970	18	
USGS	2300500	8/6/1970	18	
USGS	2300500	8/7/1970	19	
USGS	2300500	8/8/1970	44	
USGS	2300500	8/9/1970	130	

USGS	2300500	8/10/1970	206	
USGS	2300500	8/11/1970	128	
USGS	2300500	8/12/1970	85	
USGS	2300500	8/13/1970	63	
USGS	2300500	8/14/1970	57	
USGS	2300500	8/15/1970	50	
USGS	2300500	8/16/1970	50	
USGS	2300500	8/17/1970	49	
USGS	2300500	8/18/1970	40	
USGS	2300500	8/19/1970	35	
USGS	2300500	8/20/1970	33	
USGS	2300500	8/21/1970	38	
USGS	2300500	8/22/1970	45	
USGS	2300500	8/23/1970	52	
USGS	2300500	8/24/1970	59	
USGS	2300500	8/25/1970	62	
USGS	2300500	8/26/1970	56	
USGS	2300500	8/27/1970	56	
USGS	2300500	8/28/1970	89	
USGS	2300500	8/29/1970	92	
USGS	2300500	8/30/1970	77	
USGS	2300500	8/31/1970	58	
USGS	2300500	9/1/1970	46	83
USGS	2300500	9/2/1970	38	88
USGS	2300500	9/3/1970	33	92
USGS	2300500	9/4/1970	31	97
USGS	2300500	9/5/1970	33	103
USGS	2300500	9/6/1970	36	95
USGS	2300500	9/7/1970	34	85
USGS	2300500	9/8/1970	51	82
USGS	2300500	9/9/1970	132	83
USGS	2300500	9/10/1970	126	87
USGS	2300500	9/11/1970	72	
USGS	2300500	9/12/1970	55	
USGS	2300500	9/13/1970	67	95
USGS	2300500	9/14/1970	71	87
USGS	2300500	9/15/1970	119	81
USGS	2300500	9/16/1970	158	80
USGS	2300500	9/17/1970	115	
USGS	2300500	9/18/1970	75	85
USGS	2300500	9/19/1970	59	85
USGS	2300500	9/20/1970	51	83
USGS	2300500	9/21/1970	48	83
USGS	2300500	9/22/1970	47	85
USGS	2300500	9/23/1970	46	
USGS	2300500	9/24/1970	48	
USGS	2300500	9/25/1970	77	81
USGS	2300500	9/26/1970	91	78
USGS	2300500	9/27/1970	77	77
USGS	2300500	9/28/1970	62	79
USGS	2300500	9/29/1970	52	82
USGS	2300500	9/30/1970	46	85
USGS	2300500	10/1/1970	40	92
USGS	2300500	10/2/1970	36	100
USGS	2300500	10/3/1970	33	107

USGS	2300500	10/4/1970	33	93
USGS	2300500	10/5/1970	32	90
USGS	2300500	10/6/1970	27	87
USGS	2300500	10/7/1970	25	91
USGS	2300500	10/8/1970	24	110
USGS	2300500	10/9/1970	26	93
USGS	2300500	10/10/1970	24	92
USGS	2300500	10/11/1970	21	91
USGS	2300500	10/12/1970	19	91
USGS	2300500	10/13/1970	18	94
USGS	2300500	10/14/1970	18	108
USGS	2300500	10/15/1970	17	
USGS	2300500	10/16/1970	17	101
USGS	2300500	10/17/1970	16	97
USGS	2300500	10/18/1970	16	95
USGS	2300500	10/19/1970	16	97
USGS	2300500	10/20/1970	16	127
USGS	2300500	10/21/1970	18	108
USGS	2300500	10/22/1970	20	96
USGS	2300500	10/23/1970	25	94
USGS	2300500	10/24/1970	24	88
USGS	2300500	10/25/1970	23	101
USGS	2300500	10/26/1970	22	97
USGS	2300500	10/27/1970	21	110
USGS	2300500	10/28/1970	21	98
USGS	2300500	10/29/1970	20	111
USGS	2300500	10/30/1970	24	113
USGS	2300500	10/31/1970	30	110
USGS	2300500	11/1/1970	27	107
USGS	2300500	11/2/1970	25	98
USGS	2300500	11/3/1970	23	106
USGS	2300500	11/4/1970	23	108
USGS	2300500	11/5/1970	21	128
USGS	2300500	11/6/1970	21	139
USGS	2300500	11/7/1970	20	146
USGS	2300500	11/8/1970	19	
USGS	2300500	11/9/1970	18	118
USGS	2300500	11/10/1970	19	
USGS	2300500	11/11/1970	20	
USGS	2300500	11/12/1970	22	161
USGS	2300500	11/13/1970	22	145
USGS	2300500	11/14/1970	20	103
USGS	2300500	11/15/1970	29	101
USGS	2300500	11/16/1970	37	98
USGS	2300500	11/17/1970	32	98
USGS	2300500	11/18/1970	26	97
USGS	2300500	11/19/1970	24	101
USGS	2300500	11/20/1970	23	
USGS	2300500	11/21/1970	23	140
USGS	2300500	11/22/1970	21	103
USGS	2300500	11/23/1970	20	110
USGS	2300500	11/24/1970	18	99
USGS	2300500	11/25/1970	19	
USGS	2300500	11/26/1970	19	145
USGS	2300500	11/27/1970	19	106

USGS	2300500	11/28/1970	20	106
USGS	2300500	11/29/1970	18	106
USGS	2300500	11/30/1970	18	99
USGS	2300500	12/1/1970	18	97
USGS	2300500	12/2/1970	19	105
USGS	2300500	12/3/1970	19	129
USGS	2300500	12/4/1970	18	138
USGS	2300500	12/5/1970	17	
USGS	2300500	12/6/1970	17	101
USGS	2300500	12/7/1970	16	98
USGS	2300500	12/8/1970	16	97
USGS	2300500	12/9/1970	18	109
USGS	2300500	12/10/1970	18	135
USGS	2300500	12/11/1970	18	147
USGS	2300500	12/12/1970	19	121
USGS	2300500	12/13/1970	20	
USGS	2300500	12/14/1970	19	119
USGS	2300500	12/15/1970	19	127
USGS	2300500	12/16/1970	20	121
USGS	2300500	12/17/1970	21	108
USGS	2300500	12/18/1970	24	117
USGS	2300500	12/19/1970	23	114
USGS	2300500	12/20/1970	22	134
USGS	2300500	12/21/1970	20	125
USGS	2300500	12/22/1970	20	108
USGS	2300500	12/23/1970	21	126
USGS	2300500	12/24/1970	20	134
USGS	2300500	12/25/1970	21	112
USGS	2300500	12/26/1970	21	107
USGS	2300500	12/27/1970	23	114
USGS	2300500	12/28/1970	23	116
USGS	2300500	12/29/1970	22	127
USGS	2300500	12/30/1970	23	128
USGS	2300500	12/31/1970	27	
USGS	2300500	1/1/1971	28	
USGS	2300500	1/2/1971	31	134
USGS	2300500	1/3/1971	28	122
USGS	2300500	1/4/1971	25	123
USGS	2300500	1/5/1971	24	121
USGS	2300500	1/6/1971	24	121
USGS	2300500	1/7/1971	24	107
USGS	2300500	1/8/1971	27	
USGS	2300500	1/9/1971	28	113
USGS	2300500	1/10/1971	26	112
USGS	2300500	1/11/1971	25	111
USGS	2300500	1/12/1971	24	
USGS	2300500	1/13/1971	23	
USGS	2300500	1/14/1971	23	108
USGS	2300500	1/15/1971	22	114
USGS	2300500	1/16/1971	22	118
USGS	2300500	1/17/1971	21	128
USGS	2300500	1/18/1971	22	137
USGS	2300500	1/19/1971	24	178
USGS	2300500	1/20/1971	23	186
USGS	2300500	1/21/1971	23	192

USGS	2300500	1/22/1971	23	200
USGS	2300500	1/23/1971	24	179
USGS	2300500	1/24/1971	24	170
USGS	2300500	1/25/1971	23	173
USGS	2300500	1/26/1971	23	174
USGS	2300500	1/27/1971	22	174
USGS	2300500	1/28/1971	21	173
USGS	2300500	1/29/1971	21	187
USGS	2300500	1/30/1971	22	172
USGS	2300500	1/31/1971	24	157
USGS	2300500	2/1/1971	23	150
USGS	2300500	2/2/1971	24	170
USGS	2300500	2/3/1971	25	210
USGS	2300500	2/4/1971	26	258
USGS	2300500	2/5/1971	27	
USGS	2300500	2/6/1971	31	236
USGS	2300500	2/7/1971	34	
USGS	2300500	2/8/1971	244	
USGS	2300500	2/9/1971	480	142
USGS	2300500	2/10/1971	348	
USGS	2300500	2/11/1971	216	145
USGS	2300500	2/12/1971	153	160
USGS	2300500	2/13/1971	138	154
USGS	2300500	2/14/1971	116	150
USGS	2300500	2/15/1971	93	135
USGS	2300500	2/16/1971	78	
USGS	2300500	2/17/1971	69	135
USGS	2300500	2/18/1971	63	142
USGS	2300500	2/19/1971	59	145
USGS	2300500	2/20/1971	56	143
USGS	2300500	2/21/1971	53	145
USGS	2300500	2/22/1971	51	150
USGS	2300500	2/23/1971	50	145
USGS	2300500	2/24/1971	49	140
USGS	2300500	2/25/1971	48	145
USGS	2300500	2/26/1971	45	160
USGS	2300500	2/27/1971	43	155
USGS	2300500	2/28/1971	40	135
USGS	2300500	3/1/1971	38	133
USGS	2300500	3/2/1971	38	137
USGS	2300500	3/3/1971	38	147
USGS	2300500	3/4/1971	38	135
USGS	2300500	3/5/1971	38	
USGS	2300500	3/6/1971	38	168
USGS	2300500	3/7/1971	46	165
USGS	2300500	3/8/1971	59	130
USGS	2300500	3/9/1971	54	129
USGS	2300500	3/10/1971	47	120
USGS	2300500	3/11/1971	43	116
USGS	2300500	3/12/1971	41	
USGS	2300500	3/13/1971	39	160
USGS	2300500	3/14/1971	36	142
USGS	2300500	3/15/1971	34	
USGS	2300500	3/16/1971	34	135
USGS	2300500	3/17/1971	36	117

USGS	2300500	3/18/1971	37	114
USGS	2300500	3/19/1971	35	115
USGS	2300500	3/20/1971	34	117
USGS	2300500	3/21/1971	33	117
USGS	2300500	3/22/1971	32	195
USGS	2300500	3/23/1971	30	123
USGS	2300500	3/24/1971	31	124
USGS	2300500	3/25/1971	30	142
USGS	2300500	3/26/1971	29	168
USGS	2300500	3/27/1971	27	165
USGS	2300500	3/28/1971	24	140
USGS	2300500	3/29/1971	23	134
USGS	2300500	3/30/1971	25	133
USGS	2300500	3/31/1971	27	137
USGS	2300500	4/1/1971	26	139
USGS	2300500	4/2/1971	24	
USGS	2300500	4/3/1971	22	
USGS	2300500	4/4/1971	23	241
USGS	2300500	4/5/1971	25	171
USGS	2300500	4/6/1971	29	122
USGS	2300500	4/7/1971	26	
USGS	2300500	4/8/1971	23	
USGS	2300500	4/9/1971	20	135
USGS	2300500	4/10/1971	19	127
USGS	2300500	4/11/1971	18	156
USGS	2300500	4/12/1971	17	177
USGS	2300500	4/13/1971	16	140
USGS	2300500	4/14/1971	16	141
USGS	2300500	4/15/1971	15	132
USGS	2300500	4/16/1971	15	123
USGS	2300500	4/17/1971	16	133
USGS	2300500	4/18/1971	16	187
USGS	2300500	4/19/1971	15	258
USGS	2300500	4/20/1971	16	255
USGS	2300500	4/21/1971	16	188
USGS	2300500	4/22/1971	15	222
USGS	2300500	4/23/1971	14	193
USGS	2300500	4/24/1971	16	200
USGS	2300500	4/25/1971	15	235
USGS	2300500	4/26/1971	13	220
USGS	2300500	4/27/1971	12	212
USGS	2300500	4/28/1971	12	200
USGS	2300500	4/29/1971	12	220
USGS	2300500	4/30/1971	13	203
USGS	2300500	5/1/1971	13	
USGS	2300500	5/2/1971	14	362
USGS	2300500	5/3/1971	12	260
USGS	2300500	5/4/1971	11	228
USGS	2300500	5/5/1971	11	169
USGS	2300500	5/6/1971	12	321
USGS	2300500	5/7/1971	11	253
USGS	2300500	5/8/1971	10	198
USGS	2300500	5/9/1971	11	173
USGS	2300500	5/10/1971	11	284
USGS	2300500	5/11/1971	12	292

USGS	2300500	5/12/1971	12	307
USGS	2300500	5/13/1971	13	200
USGS	2300500	5/14/1971	12	191
USGS	2300500	5/15/1971	24	
USGS	2300500	5/16/1971	35	269
USGS	2300500	5/17/1971	36	161
USGS	2300500	5/18/1971	28	146
USGS	2300500	5/19/1971	21	147
USGS	2300500	5/20/1971	16	
USGS	2300500	5/21/1971	13	155
USGS	2300500	5/22/1971	11	156
USGS	2300500	5/23/1971	10	160
USGS	2300500	5/24/1971	10	185
USGS	2300500	5/25/1971	10	171
USGS	2300500	5/26/1971	9	189
USGS	2300500	5/27/1971	8	163
USGS	2300500	5/28/1971	8	134
USGS	2300500	5/29/1971	8	133
USGS	2300500	5/30/1971	7	138
USGS	2300500	5/31/1971	7	171
USGS	2300500	6/1/1971	6	182
USGS	2300500	6/2/1971	6	167
USGS	2300500	6/3/1971	6	188
USGS	2300500	6/4/1971	6	
USGS	2300500	6/5/1971	6	204
USGS	2300500	6/6/1971	4	221
USGS	2300500	6/7/1971	4	191
USGS	2300500	6/8/1971	13	161
USGS	2300500	6/9/1971	17	
USGS	2300500	6/10/1971	9	150
USGS	2300500	6/11/1971	7	160
USGS	2300500	6/12/1971	7	154
USGS	2300500	6/13/1971	7	
USGS	2300500	6/14/1971	13	127
USGS	2300500	6/15/1971	12	114
USGS	2300500	6/16/1971	8	111
USGS	2300500	6/17/1971	7	118
USGS	2300500	6/18/1971	6	117
USGS	2300500	6/19/1971	6	118
USGS	2300500	6/20/1971	6	110
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USGS	2300500	6/23/1971	16	117
USGS	2300500	6/24/1971	40	136
USGS	2300500	6/25/1971	54	131
USGS	2300500	6/26/1971	38	130
USGS	2300500	6/27/1971	44	133
USGS	2300500	6/28/1971	27	133
USGS	2300500	6/29/1971	52	104
USGS	2300500	6/30/1971	48	118
USGS	2300500	7/1/1971	35	104
USGS	2300500	7/2/1971	31	105
USGS	2300500	7/3/1971	84	84
USGS	2300500	7/4/1971	69	93
USGS	2300500	7/5/1971	193	90

USGS	2300500	7/6/1971	147	101
USGS	2300500	7/7/1971	89	
USGS	2300500	7/8/1971	62	103
USGS	2300500	7/9/1971	50	106
USGS	2300500	7/10/1971	38	105
USGS	2300500	7/11/1971	32	102
USGS	2300500	7/12/1971	36	99
USGS	2300500	7/13/1971	58	102
USGS	2300500	7/14/1971	53	101
USGS	2300500	7/15/1971	52	100
USGS	2300500	7/16/1971	67	95
USGS	2300500	7/17/1971	58	95
USGS	2300500	7/18/1971	39	97
USGS	2300500	7/19/1971	33	108
USGS	2300500	7/20/1971	27	97
USGS	2300500	7/21/1971	27	98
USGS	2300500	7/22/1971	45	
USGS	2300500	7/23/1971	72	83
USGS	2300500	7/24/1971	182	84
USGS	2300500	7/25/1971	123	98
USGS	2300500	7/26/1971	87	99
USGS	2300500	7/27/1971	60	97
USGS	2300500	7/28/1971	54	
USGS	2300500	7/29/1971	231	100
USGS	2300500	7/30/1971	461	97
USGS	2300500	7/31/1971	236	92
USGS	2300500	8/1/1971	151	128
USGS	2300500	8/2/1971	119	124
USGS	2300500	8/3/1971	93	
USGS	2300500	8/4/1971	80	
USGS	2300500	8/5/1971	258	118
USGS	2300500	8/6/1971	715	123
USGS	2300500	8/7/1971	254	128
USGS	2300500	8/8/1971	145	127
USGS	2300500	8/9/1971	111	121
USGS	2300500	8/10/1971	161	86
USGS	2300500	8/11/1971	317	86
USGS	2300500	8/12/1971	824	88
USGS	2300500	8/13/1971	728	
USGS	2300500	8/14/1971	550	94
USGS	2300500	8/15/1971	1380	67
USGS	2300500	8/16/1971	1940	79
USGS	2300500	8/17/1971	1920	71
USGS	2300500	8/18/1971	1390	79
USGS	2300500	8/19/1971	877	84
USGS	2300500	8/20/1971	470	
USGS	2300500	8/21/1971	330	97
USGS	2300500	8/22/1971	256	98
USGS	2300500	8/23/1971	200	103
USGS	2300500	8/24/1971	173	106
USGS	2300500	8/25/1971	162	111
USGS	2300500	8/26/1971	293	94
USGS	2300500	8/27/1971	374	95
USGS	2300500	8/28/1971	272	75
USGS	2300500	8/29/1971	389	84

USGS	2300500	8/30/1971	302	92
USGS	2300500	8/31/1971	263	92
USGS	2300500	9/1/1971	277	83
USGS	2300500	9/2/1971	274	81
USGS	2300500	9/3/1971	400	79
USGS	2300500	9/4/1971	367	78
USGS	2300500	9/5/1971	318	75
USGS	2300500	9/6/1971	289	78
USGS	2300500	9/7/1971	308	83
USGS	2300500	9/8/1971	406	79
USGS	2300500	9/9/1971	720	78
USGS	2300500	9/10/1971	945	
USGS	2300500	9/11/1971	1050	
USGS	2300500	9/12/1971	877	73
USGS	2300500	9/13/1971	1000	78
USGS	2300500	9/14/1971	1110	66
USGS	2300500	9/15/1971	1240	68
USGS	2300500	9/16/1971	967	66
USGS	2300500	9/17/1971	559	71
USGS	2300500	9/18/1971	487	73
USGS	2300500	9/19/1971	559	60
USGS	2300500	9/20/1971	512	67
USGS	2300500	9/21/1971	311	70
USGS	2300500	9/22/1971	247	76
USGS	2300500	9/23/1971	192	84
USGS	2300500	9/24/1971	149	82
USGS	2300500	9/25/1971	121	85
USGS	2300500	9/26/1971	99	88
USGS	2300500	9/27/1971	85	92
USGS	2300500	9/28/1971	71	96
USGS	2300500	9/29/1971	63	98
USGS	2300500	9/30/1971	57	110
USGS	2300500	10/1/1971	51	
USGS	2300500	10/2/1971	46	104
USGS	2300500	10/3/1971	42	97
USGS	2300500	10/4/1971	40	98
USGS	2300500	10/5/1971	38	99
USGS	2300500	10/6/1971	61	99
USGS	2300500	10/7/1971	78	91
USGS	2300500	10/8/1971	117	79
USGS	2300500	10/9/1971	256	78
USGS	2300500	10/10/1971	534	
USGS	2300500	10/11/1971	1440	
USGS	2300500	10/12/1971	1040	
USGS	2300500	10/13/1971	722	66
USGS	2300500	10/14/1971	838	58
USGS	2300500	10/15/1971	743	60
USGS	2300500	10/16/1971	529	63
USGS	2300500	10/17/1971	380	65
USGS	2300500	10/18/1971	558	61
USGS	2300500	10/19/1971	366	72
USGS	2300500	10/20/1971	276	
USGS	2300500	10/21/1971	271	78
USGS	2300500	10/22/1971	189	35
USGS	2300500	10/23/1971	407	31

USGS	2300500	10/24/1971	547	60
USGS	2300500	10/25/1971	241	75
USGS	2300500	10/26/1971	170	81
USGS	2300500	10/27/1971	133	82
USGS	2300500	10/28/1971	111	83
USGS	2300500	10/29/1971	97	85
USGS	2300500	10/30/1971	89	85
USGS	2300500	10/31/1971	81	84
USGS	2300500	11/1/1971	77	94
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USGS	2300500	11/3/1971	87	88
USGS	2300500	11/4/1971	134	86
USGS	2300500	11/5/1971	112	
USGS	2300500	11/6/1971	97	91
USGS	2300500	11/7/1971	79	90
USGS	2300500	11/8/1971	69	
USGS	2300500	11/9/1971	62	95
USGS	2300500	11/10/1971	65	96
USGS	2300500	11/11/1971	74	93
USGS	2300500	11/12/1971	68	91
USGS	2300500	11/13/1971	62	92
USGS	2300500	11/14/1971	57	93
USGS	2300500	11/15/1971	54	98
USGS	2300500	11/16/1971	51	
USGS	2300500	11/17/1971	49	107
USGS	2300500	11/18/1971	47	104
USGS	2300500	11/19/1971	46	105
USGS	2300500	11/20/1971	45	118
USGS	2300500	11/21/1971	42	110
USGS	2300500	11/22/1971	39	100
USGS	2300500	11/23/1971	38	102
USGS	2300500	11/24/1971	36	107
USGS	2300500	11/25/1971	36	101
USGS	2300500	11/26/1971	35	106
USGS	2300500	11/27/1971	36	131
USGS	2300500	11/28/1971	35	137
USGS	2300500	11/29/1971	39	115
USGS	2300500	11/30/1971	53	112
USGS	2300500	12/1/1971	57	109
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USGS	2300500	12/3/1971	73	94
USGS	2300500	12/4/1971	168	405
USGS	2300500	12/5/1971	161	
USGS	2300500	12/6/1971	130	99
USGS	2300500	12/7/1971	104	98
USGS	2300500	12/8/1971	84	98
USGS	2300500	12/9/1971	73	98
USGS	2300500	12/10/1971	68	106
USGS	2300500	12/11/1971	64	108
USGS	2300500	12/12/1971	57	100
USGS	2300500	12/13/1971	54	101
USGS	2300500	12/14/1971	51	103
USGS	2300500	12/15/1971	50	118
USGS	2300500	12/16/1971	48	96
USGS	2300500	12/17/1971	44	119

USGS	2300500	12/18/1971	42	96
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USGS	2300500	12/20/1971	38	101
USGS	2300500	12/21/1971	37	
USGS	2300500	12/22/1971	39	107
USGS	2300500	12/23/1971	38	113
USGS	2300500	12/24/1971	36	117
USGS	2300500	12/25/1971	36	85
USGS	2300500	12/26/1971	34	96
USGS	2300500	12/27/1971	32	
USGS	2300500	12/28/1971	32	104
USGS	2300500	12/29/1971	32	117
USGS	2300500	12/30/1971	32	150
USGS	2300500	12/31/1971	32	117
USGS	2300500	1/1/1972	32	119
USGS	2300500	1/2/1972	32	127
USGS	2300500	1/3/1972	32	134
USGS	2300500	1/4/1972	35	134
USGS	2300500	1/5/1972	36	134
USGS	2300500	1/6/1972	37	129
USGS	2300500	1/7/1972	38	
USGS	2300500	1/8/1972	36	116
USGS	2300500	1/9/1972	32	113
USGS	2300500	1/10/1972	31	114
USGS	2300500	1/11/1972	30	110
USGS	2300500	1/12/1972	30	112
USGS	2300500	1/13/1972	32	116
USGS	2300500	1/14/1972	29	126
USGS	2300500	1/15/1972	30	
USGS	2300500	1/16/1972	32	117
USGS	2300500	1/17/1972	33	
USGS	2300500	1/18/1972	32	
USGS	2300500	1/19/1972	32	136
USGS	2300500	1/20/1972	32	122
USGS	2300500	1/21/1972	31	132
USGS	2300500	1/22/1972	36	131
USGS	2300500	1/23/1972	43	124
USGS	2300500	1/24/1972	45	122
USGS	2300500	1/25/1972	40	114
USGS	2300500	1/26/1972	38	115
USGS	2300500	1/27/1972	36	120
USGS	2300500	1/28/1972	35	123
USGS	2300500	1/29/1972	34	125
USGS	2300500	1/30/1972	33	138
USGS	2300500	1/31/1972	32	146
USGS	2300500	2/1/1972	210	
USGS	2300500	2/2/1972	2130	50
USGS	2300500	2/3/1972	2150	64
USGS	2300500	2/4/1972	1900	
USGS	2300500	2/5/1972	1290	71
USGS	2300500	2/6/1972	798	75
USGS	2300500	2/7/1972	440	80
USGS	2300500	2/8/1972	361	84
USGS	2300500	2/9/1972	394	88
USGS	2300500	2/10/1972	557	87

USGS	2300500	2/11/1972	409	86
USGS	2300500	2/12/1972	324	87
USGS	2300500	2/13/1972	490	78
USGS	2300500	2/14/1972	382	85
USGS	2300500	2/15/1972	264	87
USGS	2300500	2/16/1972	247	92
USGS	2300500	2/17/1972	259	91
USGS	2300500	2/18/1972	232	
USGS	2300500	2/19/1972	191	
USGS	2300500	2/20/1972	156	94
USGS	2300500	2/21/1972	130	96
USGS	2300500	2/22/1972	116	97
USGS	2300500	2/23/1972	105	108
USGS	2300500	2/24/1972	97	112
USGS	2300500	2/25/1972	85	104
USGS	2300500	2/26/1972	81	111
USGS	2300500	2/27/1972	74	113
USGS	2300500	2/28/1972	68	108
USGS	2300500	2/29/1972	65	106
USGS	2300500	3/1/1972	62	107
USGS	2300500	3/2/1972	62	115
USGS	2300500	3/3/1972	80	123
USGS	2300500	3/4/1972	93	114
USGS	2300500	3/5/1972	80	104
USGS	2300500	3/6/1972	73	108
USGS	2300500	3/7/1972	66	106
USGS	2300500	3/8/1972	62	104
USGS	2300500	3/9/1972	57	108
USGS	2300500	3/10/1972	54	
USGS	2300500	3/11/1972	52	149
USGS	2300500	3/12/1972	50	140
USGS	2300500	3/13/1972	48	144
USGS	2300500	3/14/1972	46	132
USGS	2300500	3/15/1972	46	139
USGS	2300500	3/16/1972	43	142
USGS	2300500	3/17/1972	45	137
USGS	2300500	3/18/1972	46	130
USGS	2300500	3/19/1972	47	119
USGS	2300500	3/20/1972	51	120
USGS	2300500	3/21/1972	49	108
USGS	2300500	3/22/1972	45	104
USGS	2300500	3/23/1972	44	107
USGS	2300500	3/24/1972	41	112
USGS	2300500	3/25/1972	38	114
USGS	2300500	3/26/1972	36	134
USGS	2300500	3/27/1972	35	162
USGS	2300500	3/28/1972	35	192
USGS	2300500	3/29/1972	35	171
USGS	2300500	3/30/1972	32	130
USGS	2300500	3/31/1972	213	95
USGS	2300500	4/1/1972	435	93
USGS	2300500	4/2/1972	444	84
USGS	2300500	4/3/1972	333	84
USGS	2300500	4/4/1972	224	86
USGS	2300500	4/5/1972	152	88

USGS	2300500	4/6/1972	108	88
USGS	2300500	4/7/1972	81	90
USGS	2300500	4/8/1972	67	100
USGS	2300500	4/9/1972	59	107
USGS	2300500	4/10/1972	61	107
USGS	2300500	4/11/1972	59	107
USGS	2300500	4/12/1972	56	125
USGS	2300500	4/13/1972	52	148
USGS	2300500	4/14/1972	47	166
USGS	2300500	4/15/1972	40	
USGS	2300500	4/16/1972	36	140
USGS	2300500	4/17/1972	31	145
USGS	2300500	4/18/1972	28	165
USGS	2300500	4/19/1972	25	155
USGS	2300500	4/20/1972	23	145
USGS	2300500	4/21/1972	23	
USGS	2300500	4/22/1972	24	231
USGS	2300500	4/23/1972	21	208
USGS	2300500	4/24/1972	18	174
USGS	2300500	4/25/1972	17	156
USGS	2300500	4/26/1972	15	140
USGS	2300500	4/27/1972	14	
USGS	2300500	4/28/1972	14	240
USGS	2300500	4/29/1972	18	238
USGS	2300500	4/30/1972	23	236
USGS	2300500	5/1/1972	18	190
USGS	2300500	5/2/1972	17	145
USGS	2300500	5/3/1972	18	130
USGS	2300500	5/4/1972	16	125
USGS	2300500	5/5/1972	15	120
USGS	2300500	5/6/1972	15	130
USGS	2300500	5/7/1972	15	140
USGS	2300500	5/8/1972	15	175
USGS	2300500	5/9/1972	14	205
USGS	2300500	5/10/1972	14	155
USGS	2300500	5/11/1972	14	145
USGS	2300500	5/12/1972	36	145
USGS	2300500	5/13/1972	47	135
USGS	2300500	5/14/1972	68	140
USGS	2300500	5/15/1972	59	130
USGS	2300500	5/16/1972	72	170
USGS	2300500	5/17/1972	176	110
USGS	2300500	5/18/1972	97	110
USGS	2300500	5/19/1972	68	110
USGS	2300500	5/20/1972	52	110
USGS	2300500	5/21/1972	41	105
USGS	2300500	5/22/1972	34	105
USGS	2300500	5/23/1972	30	110
USGS	2300500	5/24/1972	24	120
USGS	2300500	5/25/1972	22	120
USGS	2300500	5/26/1972	20	
USGS	2300500	5/27/1972	20	125
USGS	2300500	5/28/1972	21	120
USGS	2300500	5/29/1972	19	115
USGS	2300500	5/30/1972	18	105

USGS	2300500	5/31/1972	16	115
USGS	2300500	6/1/1972	16	125
USGS	2300500	6/2/1972	14	128
USGS	2300500	6/3/1972	14	133
USGS	2300500	6/4/1972	13	135
USGS	2300500	6/5/1972	13	140
USGS	2300500	6/6/1972	12	140
USGS	2300500	6/7/1972	12	138
USGS	2300500	6/8/1972	12	137
USGS	2300500	6/9/1972	14	
USGS	2300500	6/10/1972	14	109
USGS	2300500	6/11/1972	21	103
USGS	2300500	6/12/1972	27	
USGS	2300500	6/13/1972	26	
USGS	2300500	6/14/1972	26	108
USGS	2300500	6/15/1972	28	105
USGS	2300500	6/16/1972	29	
USGS	2300500	6/17/1972	25	101
USGS	2300500	6/18/1972	48	104
USGS	2300500	6/19/1972	584	101
USGS	2300500	6/20/1972	685	96
USGS	2300500	6/21/1972	663	80
USGS	2300500	6/22/1972	460	75
USGS	2300500	6/23/1972	313	
USGS	2300500	6/24/1972	204	87
USGS	2300500	6/25/1972	153	87
USGS	2300500	6/26/1972	118	87
USGS	2300500	6/27/1972	86	88
USGS	2300500	6/28/1972	67	94
USGS	2300500	6/29/1972	52	95
USGS	2300500	6/30/1972	45	99
USGS	2300500	7/1/1972	39	102
USGS	2300500	7/2/1972	32	106
USGS	2300500	7/3/1972	26	106
USGS	2300500	7/4/1972	22	
USGS	2300500	7/5/1972	45	110
USGS	2300500	7/6/1972	52	108
USGS	2300500	7/7/1972	38	108
USGS	2300500	7/8/1972	36	102
USGS	2300500	7/9/1972	38	98
USGS	2300500	7/10/1972	38	96
USGS	2300500	7/11/1972	34	94
USGS	2300500	7/12/1972	27	100
USGS	2300500	7/13/1972	25	100
USGS	2300500	7/14/1972	50	
USGS	2300500	7/15/1972	99	88
USGS	2300500	7/16/1972	88	91
USGS	2300500	7/17/1972	74	96
USGS	2300500	7/18/1972	63	98
USGS	2300500	7/19/1972	61	98
USGS	2300500	7/20/1972	57	90
USGS	2300500	7/21/1972	59	96
USGS	2300500	7/22/1972	59	90
USGS	2300500	7/23/1972	48	96
USGS	2300500	7/24/1972	39	96

USGS	2300500	7/25/1972	35	96
USGS	2300500	7/26/1972	33	96
USGS	2300500	7/27/1972	33	99
USGS	2300500	7/28/1972	28	
USGS	2300500	7/29/1972	23	
USGS	2300500	7/30/1972	19	
USGS	2300500	7/31/1972	21	104
USGS	2300500	8/1/1972	29	95
USGS	2300500	8/2/1972	32	95
USGS	2300500	8/3/1972	49	97
USGS	2300500	8/4/1972	34	115
USGS	2300500	8/5/1972	28	110
USGS	2300500	8/6/1972	28	100
USGS	2300500	8/7/1972	23	102
USGS	2300500	8/8/1972	23	115
USGS	2300500	8/9/1972	42	108
USGS	2300500	8/10/1972	37	105
USGS	2300500	8/11/1972	24	108
USGS	2300500	8/12/1972	20	110
USGS	2300500	8/13/1972	36	105
USGS	2300500	8/14/1972	36	104
USGS	2300500	8/15/1972	26	95
USGS	2300500	8/16/1972	37	85
USGS	2300500	8/17/1972	55	
USGS	2300500	8/18/1972	176	100
USGS	2300500	8/19/1972	299	95
USGS	2300500	8/20/1972	221	100
USGS	2300500	8/21/1972	219	90
USGS	2300500	8/22/1972	389	85
USGS	2300500	8/23/1972	461	90
USGS	2300500	8/24/1972	528	82
USGS	2300500	8/25/1972	508	
USGS	2300500	8/26/1972	561	
USGS	2300500	8/27/1972	981	62
USGS	2300500	8/28/1972	1330	65
USGS	2300500	8/29/1972	1420	62
USGS	2300500	8/30/1972	1210	67
USGS	2300500	8/31/1972	1190	64
USGS	2300500	9/1/1972	1150	60
USGS	2300500	9/2/1972	791	70
USGS	2300500	9/3/1972	583	77
USGS	2300500	9/4/1972	435	78
USGS	2300500	9/5/1972	415	81
USGS	2300500	9/6/1972	290	83
USGS	2300500	9/7/1972	222	79
USGS	2300500	9/8/1972	173	
USGS	2300500	9/9/1972	133	
USGS	2300500	9/10/1972	105	92
USGS	2300500	9/11/1972	86	95
USGS	2300500	9/12/1972	73	
USGS	2300500	9/13/1972	66	
USGS	2300500	9/14/1972	60	127
USGS	2300500	9/15/1972	55	131
USGS	2300500	9/16/1972	46	130
USGS	2300500	9/17/1972	44	135

USGS	2300500	9/18/1972	38	127
USGS	2300500	9/19/1972	34	158
USGS	2300500	9/20/1972	32	128
USGS	2300500	9/21/1972	30	122
USGS	2300500	9/22/1972	28	144
USGS	2300500	9/23/1972	26	148
USGS	2300500	9/24/1972	22	149
USGS	2300500	9/25/1972	22	162
USGS	2300500	9/26/1972	22	189
USGS	2300500	9/27/1972	21	199
USGS	2300500	9/28/1972	20	181
USGS	2300500	9/29/1972	19	
USGS	2300500	9/30/1972	22	
USGS	2300500	10/1/1972	31	120
USGS	2300500	10/2/1972	52	103
USGS	2300500	10/3/1972	173	99
USGS	2300500	10/4/1972	206	114
USGS	2300500	10/5/1972	173	89
USGS	2300500	10/6/1972	142	94
USGS	2300500	10/7/1972	108	94
USGS	2300500	10/8/1972	83	93
USGS	2300500	10/9/1972	66	94
USGS	2300500	10/10/1972	55	100
USGS	2300500	10/11/1972	47	109
USGS	2300500	10/12/1972	41	130
USGS	2300500	10/13/1972	37	
USGS	2300500	10/14/1972	34	
USGS	2300500	10/15/1972	31	
USGS	2300500	10/16/1972	29	135
USGS	2300500	10/17/1972	27	140
USGS	2300500	10/18/1972	26	114
USGS	2300500	10/19/1972	27	125
USGS	2300500	10/20/1972	24	177
USGS	2300500	10/21/1972	24	199
USGS	2300500	10/22/1972	21	152
USGS	2300500	10/23/1972	19	174
USGS	2300500	10/24/1972	21	192
USGS	2300500	10/25/1972	20	165
USGS	2300500	10/26/1972	20	160
USGS	2300500	10/27/1972	19	140
USGS	2300500	10/28/1972	21	125
USGS	2300500	10/29/1972	22	111
USGS	2300500	10/30/1972	24	123
USGS	2300500	10/31/1972	23	130
USGS	2300500	11/1/1972	22	160
USGS	2300500	11/2/1972	21	185
USGS	2300500	11/3/1972	20	165
USGS	2300500	11/4/1972	19	165
USGS	2300500	11/5/1972	18	137
USGS	2300500	11/6/1972	19	149
USGS	2300500	11/7/1972	22	132
USGS	2300500	11/8/1972	28	129
USGS	2300500	11/9/1972	25	117
USGS	2300500	11/10/1972	24	180
USGS	2300500	11/11/1972	24	221

USGS	2300500	11/12/1972	22	168
USGS	2300500	11/13/1972	50	123
USGS	2300500	11/14/1972	92	139
USGS	2300500	11/15/1972	126	123
USGS	2300500	11/16/1972	81	115
USGS	2300500	11/17/1972	59	116
USGS	2300500	11/18/1972	48	116
USGS	2300500	11/19/1972	52	
USGS	2300500	11/20/1972	154	126
USGS	2300500	11/21/1972	203	111
USGS	2300500	11/22/1972	165	104
USGS	2300500	11/23/1972	115	104
USGS	2300500	11/24/1972	89	107
USGS	2300500	11/25/1972	79	106
USGS	2300500	11/26/1972	113	114
USGS	2300500	11/27/1972	112	109
USGS	2300500	11/28/1972	95	107
USGS	2300500	11/29/1972	143	114
USGS	2300500	11/30/1972	169	106
USGS	2300500	12/1/1972	137	107
USGS	2300500	12/2/1972	102	108
USGS	2300500	12/3/1972	84	107
USGS	2300500	12/4/1972	74	107
USGS	2300500	12/5/1972	67	109
USGS	2300500	12/6/1972	63	107
USGS	2300500	12/7/1972	62	113
USGS	2300500	12/8/1972	57	
USGS	2300500	12/9/1972	54	
USGS	2300500	12/10/1972	51	110
USGS	2300500	12/11/1972	48	121
USGS	2300500	12/12/1972	45	121
USGS	2300500	12/13/1972	43	124
USGS	2300500	12/14/1972	42	138
USGS	2300500	12/15/1972	48	136
USGS	2300500	12/16/1972	75	118
USGS	2300500	12/17/1972	106	101
USGS	2300500	12/18/1972	104	100
USGS	2300500	12/19/1972	86	107
USGS	2300500	12/20/1972	75	106
USGS	2300500	12/21/1972	95	115
USGS	2300500	12/22/1972	659	
USGS	2300500	12/23/1972	659	
USGS	2300500	12/24/1972	510	87
USGS	2300500	12/25/1972	343	
USGS	2300500	12/26/1972	236	94
USGS	2300500	12/27/1972	175	94
USGS	2300500	12/28/1972	138	99
USGS	2300500	12/29/1972	112	99
USGS	2300500	12/30/1972	95	99
USGS	2300500	12/31/1972	86	100
USGS	2300500	1/1/1973	78	116
USGS	2300500	1/2/1973	72	114
USGS	2300500	1/3/1973	66	111
USGS	2300500	1/4/1973	63	113
USGS	2300500	1/5/1973	59	120

USGS	2300500	1/6/1973	57	110
USGS	2300500	1/7/1973	54	109
USGS	2300500	1/8/1973	52	104
USGS	2300500	1/9/1973	50	107
USGS	2300500	1/10/1973	49	118
USGS	2300500	1/11/1973	83	124
USGS	2300500	1/12/1973	331	122
USGS	2300500	1/13/1973	379	149
USGS	2300500	1/14/1973	331	93
USGS	2300500	1/15/1973	260	93
USGS	2300500	1/16/1973	197	98
USGS	2300500	1/17/1973	154	100
USGS	2300500	1/18/1973	123	103
USGS	2300500	1/19/1973	103	108
USGS	2300500	1/20/1973	91	
USGS	2300500	1/21/1973	80	114
USGS	2300500	1/22/1973	276	111
USGS	2300500	1/23/1973	1000	83
USGS	2300500	1/24/1973	1390	71
USGS	2300500	1/25/1973	1490	72
USGS	2300500	1/26/1973	1040	75
USGS	2300500	1/27/1973	551	79
USGS	2300500	1/28/1973	430	86
USGS	2300500	1/29/1973	606	82
USGS	2300500	1/30/1973	554	79
USGS	2300500	1/31/1973	447	80
USGS	2300500	2/1/1973	334	80
USGS	2300500	2/2/1973	260	
USGS	2300500	2/3/1973	267	88
USGS	2300500	2/4/1973	231	85
USGS	2300500	2/5/1973	197	88
USGS	2300500	2/6/1973	165	90
USGS	2300500	2/7/1973	140	93
USGS	2300500	2/8/1973	121	98
USGS	2300500	2/9/1973	114	103
USGS	2300500	2/10/1973	219	
USGS	2300500	2/11/1973	193	90
USGS	2300500	2/12/1973	159	92
USGS	2300500	2/13/1973	136	90
USGS	2300500	2/14/1973	121	95
USGS	2300500	2/15/1973	165	100
USGS	2300500	2/16/1973	198	98
USGS	2300500	2/17/1973	152	93
USGS	2300500	2/18/1973	136	92
USGS	2300500	2/19/1973	203	100
USGS	2300500	2/20/1973	194	92
USGS	2300500	2/21/1973	162	90
USGS	2300500	2/22/1973	134	92
USGS	2300500	2/23/1973	114	95
USGS	2300500	2/24/1973	101	97
USGS	2300500	2/25/1973	91	102
USGS	2300500	2/26/1973	86	110
USGS	2300500	2/27/1973	79	
USGS	2300500	2/28/1973	72	
USGS	2300500	3/1/1973	63	

USGS	2300500	3/2/1973	65	
USGS	2300500	3/3/1973	63	148
USGS	2300500	3/4/1973	60	
USGS	2300500	3/5/1973	57	
USGS	2300500	3/6/1973	56	
USGS	2300500	3/7/1973	53	
USGS	2300500	3/8/1973	53	
USGS	2300500	3/9/1973	65	
USGS	2300500	3/10/1973	89	
USGS	2300500	3/11/1973	87	
USGS	2300500	3/12/1973	81	
USGS	2300500	3/13/1973	73	114
USGS	2300500	3/14/1973	66	122
USGS	2300500	3/15/1973	61	149
USGS	2300500	3/16/1973	56	124
USGS	2300500	3/17/1973	58	128
USGS	2300500	3/18/1973	49	117
USGS	2300500	3/19/1973	45	120
USGS	2300500	3/20/1973	44	136
USGS	2300500	3/21/1973	48	138
USGS	2300500	3/22/1973	54	150
USGS	2300500	3/23/1973	50	95
USGS	2300500	3/24/1973	45	
USGS	2300500	3/25/1973	81	
USGS	2300500	3/26/1973	483	
USGS	2300500	3/27/1973	390	
USGS	2300500	3/28/1973	234	
USGS	2300500	3/29/1973	162	
USGS	2300500	3/30/1973	128	95
USGS	2300500	3/31/1973	102	98
USGS	2300500	4/1/1973	187	
USGS	2300500	4/2/1973	417	
USGS	2300500	4/3/1973	382	58
USGS	2300500	4/4/1973	1310	
USGS	2300500	4/5/1973	2680	
USGS	2300500	4/6/1973	2150	73
USGS	2300500	4/7/1973	1260	84
USGS	2300500	4/8/1973	794	80
USGS	2300500	4/9/1973	567	80
USGS	2300500	4/10/1973	425	
USGS	2300500	4/11/1973	302	86
USGS	2300500	4/12/1973	219	85
USGS	2300500	4/13/1973	167	95
USGS	2300500	4/14/1973	129	93
USGS	2300500	4/15/1973	104	103
USGS	2300500	4/16/1973	84	100
USGS	2300500	4/17/1973	72	100
USGS	2300500	4/18/1973	64	
USGS	2300500	4/19/1973	59	130
USGS	2300500	4/20/1973	55	155
USGS	2300500	4/21/1973	50	155
USGS	2300500	4/22/1973	44	150
USGS	2300500	4/23/1973	44	169
USGS	2300500	4/24/1973	40	150
USGS	2300500	4/25/1973	39	180

USGS	2300500	4/26/1973	40	153
USGS	2300500	4/27/1973	60	212
USGS	2300500	4/28/1973	59	130
USGS	2300500	4/29/1973	45	113
USGS	2300500	4/30/1973	38	109
USGS	2300500	5/1/1973	35	109
USGS	2300500	5/2/1973	32	158
USGS	2300500	5/3/1973	32	181
USGS	2300500	5/4/1973	31	181
USGS	2300500	5/5/1973	27	164
USGS	2300500	5/6/1973	26	168
USGS	2300500	5/7/1973	23	160
USGS	2300500	5/8/1973	23	153
USGS	2300500	5/9/1973	24	155
USGS	2300500	5/10/1973	23	157
USGS	2300500	5/11/1973	22	230
USGS	2300500	5/12/1973	23	145
USGS	2300500	5/13/1973	21	200
USGS	2300500	5/14/1973	21	157
USGS	2300500	5/15/1973	21	190
USGS	2300500	5/16/1973	19	240
USGS	2300500	5/17/1973	20	220
USGS	2300500	5/18/1973	18	183
USGS	2300500	5/19/1973	18	182
USGS	2300500	5/20/1973	19	208
USGS	2300500	5/21/1973	18	212
USGS	2300500	5/22/1973	17	233
USGS	2300500	5/23/1973	17	227
USGS	2300500	5/24/1973	18	339
USGS	2300500	5/25/1973	16	225
USGS	2300500	5/26/1973	14	231
USGS	2300500	5/27/1973	14	259
USGS	2300500	5/28/1973	14	284
USGS	2300500	5/29/1973	14	275
USGS	2300500	5/30/1973	14	200
USGS	2300500	5/31/1973	26	170
USGS	2300500	6/1/1973	42	192
USGS	2300500	6/2/1973	41	172
USGS	2300500	6/3/1973	38	165
USGS	2300500	6/4/1973	38	
USGS	2300500	6/5/1973	29	132
USGS	2300500	6/6/1973	24	132
USGS	2300500	6/7/1973	20	143
USGS	2300500	6/8/1973	18	140
USGS	2300500	6/9/1973	17	147
USGS	2300500	6/10/1973	16	127
USGS	2300500	6/11/1973	18	124
USGS	2300500	6/12/1973	20	175
USGS	2300500	6/13/1973	18	141
USGS	2300500	6/14/1973	32	189
USGS	2300500	6/15/1973	28	202
USGS	2300500	6/16/1973	23	140
USGS	2300500	6/17/1973	20	130
USGS	2300500	6/18/1973	17	127
USGS	2300500	6/19/1973	17	127

USGS	2300500	6/20/1973	16	128
USGS	2300500	6/21/1973	18	113
USGS	2300500	6/22/1973	22	
USGS	2300500	6/23/1973	42	142
USGS	2300500	6/24/1973	66	116
USGS	2300500	6/25/1973	80	138
USGS	2300500	6/26/1973	55	126
USGS	2300500	6/27/1973	39	123
USGS	2300500	6/28/1973	29	125
USGS	2300500	6/29/1973	25	
USGS	2300500	6/30/1973	23	119
USGS	2300500	7/1/1973	25	120
USGS	2300500	7/2/1973	105	128
USGS	2300500	7/3/1973	86	107
USGS	2300500	7/4/1973	107	100
USGS	2300500	7/5/1973	352	91
USGS	2300500	7/6/1973	366	105
USGS	2300500	7/7/1973	260	88
USGS	2300500	7/8/1973	128	92
USGS	2300500	7/9/1973	147	84
USGS	2300500	7/10/1973	264	81
USGS	2300500	7/11/1973	171	80
USGS	2300500	7/12/1973	213	92
USGS	2300500	7/13/1973	98	96
USGS	2300500	7/14/1973	69	95
USGS	2300500	7/15/1973	58	91
USGS	2300500	7/16/1973	51	90
USGS	2300500	7/17/1973	42	93
USGS	2300500	7/18/1973	40	95
USGS	2300500	7/19/1973	247	88
USGS	2300500	7/20/1973	1030	66
USGS	2300500	7/21/1973	1170	67
USGS	2300500	7/22/1973	1000	64
USGS	2300500	7/23/1973	576	
USGS	2300500	7/24/1973	352	
USGS	2300500	7/25/1973	223	77
USGS	2300500	7/26/1973	312	81
USGS	2300500	7/27/1973	278	80
USGS	2300500	7/28/1973	370	82
USGS	2300500	7/29/1973	188	79
USGS	2300500	7/30/1973	136	83
USGS	2300500	7/31/1973	326	89
USGS	2300500	8/1/1973	624	68
USGS	2300500	8/2/1973	930	76
USGS	2300500	8/3/1973	529	
USGS	2300500	8/4/1973	475	
USGS	2300500	8/5/1973	513	78
USGS	2300500	8/6/1973	468	71
USGS	2300500	8/7/1973	596	68
USGS	2300500	8/8/1973	432	76
USGS	2300500	8/9/1973	680	68
USGS	2300500	8/10/1973	552	
USGS	2300500	8/11/1973	391	
USGS	2300500	8/12/1973	282	74
USGS	2300500	8/13/1973	215	77

USGS	2300500	8/14/1973	174		80
USGS	2300500	8/15/1973	460		
USGS	2300500	8/16/1973	704		
USGS	2300500	8/17/1973	380		66
USGS	2300500	8/18/1973	223		73
USGS	2300500	8/19/1973	150		77
USGS	2300500	8/20/1973	228		
USGS	2300500	8/21/1973	576		
USGS	2300500	8/22/1973	414		
USGS	2300500	8/23/1973	255		75
USGS	2300500	8/24/1973	248		72
USGS	2300500	8/25/1973	215		72
USGS	2300500	8/26/1973	445		
USGS	2300500	8/27/1973	236		71
USGS	2300500	8/28/1973	200		70
USGS	2300500	8/29/1973	159		77
USGS	2300500	8/30/1973	115		85
USGS	2300500	8/31/1973	169		66
USGS	2300500	9/1/1973	566		67
USGS	2300500	9/2/1973	620		66
USGS	2300500	9/3/1973	636		63
USGS	2300500	9/4/1973	594		63
USGS	2300500	9/5/1973	662		59
USGS	2300500	9/6/1973	530		67
USGS	2300500	9/7/1973	383		69
USGS	2300500	9/8/1973	413		70
USGS	2300500	9/9/1973	523		70
USGS	2300500	9/10/1973	527		68
USGS	2300500	9/11/1973	572		73
USGS	2300500	9/12/1973	962		61
USGS	2300500	9/13/1973	1140		60
USGS	2300500	9/14/1973	1010		
USGS	2300500	9/15/1973	900		
USGS	2300500	9/16/1973	518		65
USGS	2300500	9/17/1973	289		
USGS	2300500	9/18/1973	196		84
USGS	2300500	9/19/1973	150		82
USGS	2300500	9/20/1973	143		87
USGS	2300500	9/21/1973	122		87
USGS	2300500	9/22/1973	131		88
USGS	2300500	9/23/1973	203		89
USGS	2300500	9/24/1973	414		72
USGS	2300500	9/25/1973	248		82
USGS	2300500	9/26/1973	167		86
USGS	2300500	9/27/1973	247		
USGS	2300500	9/28/1973	231		80
USGS	2300500	9/29/1973	175		88
USGS	2300500	9/30/1973	141		89
USGS	2300500	10/1/1973	108	3.0	91
USGS	2300500	10/2/1973	87	2.8	
USGS	2300500	10/3/1973	74	2.6	101
USGS	2300500	10/4/1973	64	2.5	104
USGS	2300500	10/5/1973	58	2.4	118
USGS	2300500	10/6/1973	52	2.3	116
USGS	2300500	10/7/1973	46	2.2	114

USGS	2300500	10/8/1973	42	2.2	110
USGS	2300500	10/9/1973	44	2.2	
USGS	2300500	10/10/1973	44	2.2	
USGS	2300500	10/11/1973	39	2.1	117
USGS	2300500	10/12/1973	37	2.1	135
USGS	2300500	10/13/1973	35	2.0	142
USGS	2300500	10/14/1973	33	2.0	141
USGS	2300500	10/15/1973	33	2.0	133
USGS	2300500	10/16/1973	32	2.1	160
USGS	2300500	10/17/1973	28	2.1	
USGS	2300500	10/18/1973	28	1.9	
USGS	2300500	10/19/1973	28	1.9	142
USGS	2300500	10/20/1973	26	1.8	140
USGS	2300500	10/21/1973	26	1.8	164
USGS	2300500	10/22/1973	25	1.8	140
USGS	2300500	10/23/1973	25	1.8	149
USGS	2300500	10/24/1973	24	1.8	172
USGS	2300500	10/25/1973	24	1.8	
USGS	2300500	10/26/1973	24	1.9	206
USGS	2300500	10/27/1973	25	1.9	204
USGS	2300500	10/28/1973	22	2.0	149
USGS	2300500	10/29/1973	21	2.0	153
USGS	2300500	10/30/1973	22	1.8	186
USGS	2300500	10/31/1973	23	1.8	232
USGS	2300500	11/1/1973	38	2.2	229
USGS	2300500	11/2/1973	35	2.0	
USGS	2300500	11/3/1973	36	2.0	141
USGS	2300500	11/4/1973	35	2.0	140
USGS	2300500	11/5/1973	32	1.9	136
USGS	2300500	11/6/1973	31	1.9	182
USGS	2300500	11/7/1973	29	1.9	152
USGS	2300500	11/8/1973	26	1.8	147
USGS	2300500	11/9/1973	26	1.8	152
USGS	2300500	11/10/1973	26	1.8	217
USGS	2300500	11/11/1973	24	1.8	211
USGS	2300500	11/12/1973	22	1.7	178
USGS	2300500	11/13/1973	22	1.8	183
USGS	2300500	11/14/1973	22	1.8	158
USGS	2300500	11/15/1973	22	1.9	147
USGS	2300500	11/16/1973	24	1.9	
USGS	2300500	11/17/1973	24	1.8	250
USGS	2300500	11/18/1973	25	1.8	240
USGS	2300500	11/19/1973	26	1.9	217
USGS	2300500	11/20/1973	27	1.8	241
USGS	2300500	11/21/1973	27	1.9	186
USGS	2300500	11/22/1973	26	1.8	187
USGS	2300500	11/23/1973	25	1.8	178
USGS	2300500	11/24/1973	24	1.8	176
USGS	2300500	11/25/1973	24	1.9	178
USGS	2300500	11/26/1973	22	1.9	174
USGS	2300500	11/27/1973	22	1.8	
USGS	2300500	11/28/1973	21	1.9	
USGS	2300500	11/29/1973	20	1.7	181
USGS	2300500	11/30/1973	20	1.7	193
USGS	2300500	12/1/1973	21	1.7	255

USGS	2300500	12/2/1973	21	1.7	252
USGS	2300500	12/3/1973	21	1.7	277
USGS	2300500	12/4/1973	22	1.7	256
USGS	2300500	12/5/1973	24	1.9	204
USGS	2300500	12/6/1973	21	1.8	
USGS	2300500	12/7/1973	22	1.7	304
USGS	2300500	12/8/1973	36	2.0	
USGS	2300500	12/9/1973	43	2.2	171
USGS	2300500	12/10/1973	37	2.1	135
USGS	2300500	12/11/1973	33	2.0	141
USGS	2300500	12/12/1973	30	1.9	
USGS	2300500	12/13/1973	26	1.9	142
USGS	2300500	12/14/1973	30	2.0	134
USGS	2300500	12/15/1973	35	2.0	134
USGS	2300500	12/16/1973	41	2.1	131
USGS	2300500	12/17/1973	45	2.2	125
USGS	2300500	12/18/1973	49	2.3	138
USGS	2300500	12/19/1973	44	2.2	141
USGS	2300500	12/20/1973	70	2.5	215
USGS	2300500	12/21/1973	96	2.9	149
USGS	2300500	12/22/1973	65	2.5	148
USGS	2300500	12/23/1973	52	2.3	142
USGS	2300500	12/24/1973	45	2.2	136
USGS	2300500	12/25/1973	40	2.1	132
USGS	2300500	12/26/1973	38	2.1	129
USGS	2300500	12/27/1973	36	2.1	128
USGS	2300500	12/28/1973	45	2.3	136
USGS	2300500	12/29/1973	58	2.4	126
USGS	2300500	12/30/1973	54	2.4	128
USGS	2300500	12/31/1973	45	2.2	123
USGS	2300500	1/1/1974	40	2.2	123
USGS	2300500	1/2/1974	36	2.1	121
USGS	2300500	1/3/1974	33	2.0	121
USGS	2300500	1/4/1974	31	2.0	
USGS	2300500	1/5/1974	30	2.0	122
USGS	2300500	1/6/1974	30	2.0	130
USGS	2300500	1/7/1974	29	2.0	133
USGS	2300500	1/8/1974	28	2.0	130
USGS	2300500	1/9/1974	26	2.0	149
USGS	2300500	1/10/1974	25	2.0	140
USGS	2300500	1/11/1974	24	1.9	145
USGS	2300500	1/12/1974	23	1.9	145
USGS	2300500	1/13/1974	22	1.9	139
USGS	2300500	1/14/1974	26	2.0	136
USGS	2300500	1/15/1974	24	1.9	133
USGS	2300500	1/16/1974	25	1.9	172
USGS	2300500	1/17/1974	24	1.9	180
USGS	2300500	1/18/1974	25	1.9	168
USGS	2300500	1/19/1974	24	1.9	170
USGS	2300500	1/20/1974	23	1.9	156
USGS	2300500	1/21/1974	23	1.9	140
USGS	2300500	1/22/1974	22	1.9	
USGS	2300500	1/23/1974	23	1.9	200
USGS	2300500	1/24/1974	23	1.9	212
USGS	2300500	1/25/1974	21	1.9	228

USGS	2300500	1/26/1974	23	1.9	231
USGS	2300500	1/27/1974	21	1.9	240
USGS	2300500	1/28/1974	18	1.8	207
USGS	2300500	1/29/1974	19	1.8	230
USGS	2300500	1/30/1974	20	1.9	238
USGS	2300500	1/31/1974	21	1.9	260
USGS	2300500	2/1/1974	20	1.8	
USGS	2300500	2/2/1974	19	1.8	
USGS	2300500	2/3/1974	18	1.8	
USGS	2300500	2/4/1974	18	1.8	
USGS	2300500	2/5/1974	16	1.8	198
USGS	2300500	2/6/1974	17	1.8	237
USGS	2300500	2/7/1974	18	1.9	259
USGS	2300500	2/8/1974	20	1.9	
USGS	2300500	2/9/1974	20	1.8	
USGS	2300500	2/10/1974	19	1.8	187
USGS	2300500	2/11/1974	18	1.8	208
USGS	2300500	2/12/1974	19	1.8	
USGS	2300500	2/13/1974	19	1.8	
USGS	2300500	2/14/1974	19	1.8	
USGS	2300500	2/15/1974	18	1.8	249
USGS	2300500	2/16/1974	29	2.0	466
USGS	2300500	2/17/1974	36	2.1	
USGS	2300500	2/18/1974	39	2.1	
USGS	2300500	2/19/1974	35	2.1	136
USGS	2300500	2/20/1974	38	2.1	141
USGS	2300500	2/21/1974	33	2.0	154
USGS	2300500	2/22/1974	31	1.9	
USGS	2300500	2/23/1974	28	1.9	
USGS	2300500	2/24/1974	26	1.8	154
USGS	2300500	2/25/1974	25	1.8	187
USGS	2300500	2/26/1974	24	1.8	191
USGS	2300500	2/27/1974	25	1.8	241
USGS	2300500	2/28/1974	25	1.8	
USGS	2300500	3/1/1974	27	1.8	266
USGS	2300500	3/2/1974	28	1.8	291
USGS	2300500	3/3/1974	25	1.8	
USGS	2300500	3/4/1974	25	1.8	
USGS	2300500	3/5/1974	25	1.8	
USGS	2300500	3/6/1974	25	1.8	
USGS	2300500	3/7/1974	24	1.8	271
USGS	2300500	3/8/1974	25	1.8	292
USGS	2300500	3/9/1974	23	1.8	
USGS	2300500	3/10/1974	22	1.7	
USGS	2300500	3/11/1974	21	1.7	
USGS	2300500	3/12/1974	21	1.7	
USGS	2300500	3/13/1974	21	1.7	
USGS	2300500	3/14/1974	21	1.7	
USGS	2300500	3/15/1974	19	1.7	
USGS	2300500	3/16/1974	20	1.7	
USGS	2300500	3/17/1974	20	1.7	
USGS	2300500	3/18/1974	19	1.7	
USGS	2300500	3/19/1974	18	1.7	
USGS	2300500	3/20/1974	20	1.7	
USGS	2300500	3/21/1974	20	1.7	

USGS	2300500	3/22/1974	20	1.7	
USGS	2300500	3/23/1974	19	1.7	
USGS	2300500	3/24/1974	20	1.7	225
USGS	2300500	3/25/1974	20	1.7	
USGS	2300500	3/26/1974	22	1.8	
USGS	2300500	3/27/1974	20	1.7	
USGS	2300500	3/28/1974	18	1.7	
USGS	2300500	3/29/1974	19	1.8	262
USGS	2300500	3/30/1974	20	1.8	
USGS	2300500	3/31/1974	16	1.6	
USGS	2300500	4/1/1974	14	1.6	
USGS	2300500	4/2/1974	15	1.6	
USGS	2300500	4/3/1974	15	1.6	
USGS	2300500	4/4/1974	17	1.7	
USGS	2300500	4/5/1974	20	1.8	
USGS	2300500	4/6/1974	18	1.7	
USGS	2300500	4/7/1974	17	1.7	
USGS	2300500	4/8/1974	16	1.7	
USGS	2300500	4/9/1974	14	1.6	
USGS	2300500	4/10/1974	14	1.6	
USGS	2300500	4/11/1974	13	1.6	
USGS	2300500	4/12/1974	14	1.6	
USGS	2300500	4/13/1974	14	1.6	
USGS	2300500	4/14/1974	13	1.6	
USGS	2300500	4/15/1974	13	1.6	
USGS	2300500	4/16/1974	12	1.5	
USGS	2300500	4/17/1974	12	1.6	
USGS	2300500	4/18/1974	13	1.6	
USGS	2300500	4/19/1974	12	1.6	
USGS	2300500	4/20/1974	12	1.5	
USGS	2300500	4/21/1974	11	1.5	
USGS	2300500	4/22/1974	12	1.6	
USGS	2300500	4/23/1974	11	1.6	
USGS	2300500	4/24/1974	11	1.6	
USGS	2300500	4/25/1974	10	1.5	
USGS	2300500	4/26/1974	9	1.5	
USGS	2300500	4/27/1974	11	1.5	
USGS	2300500	4/28/1974	11	1.5	
USGS	2300500	4/29/1974	11	1.5	
USGS	2300500	4/30/1974	10	1.5	
USGS	2300500	5/1/1974	10	1.5	
USGS	2300500	5/2/1974	10	1.5	
USGS	2300500	5/3/1974	11	1.5	
USGS	2300500	5/4/1974	11	1.6	
USGS	2300500	5/5/1974	11	1.6	
USGS	2300500	5/6/1974	13	1.7	
USGS	2300500	5/7/1974	11	1.6	
USGS	2300500	5/8/1974	11	1.6	
USGS	2300500	5/9/1974	11	1.6	
USGS	2300500	5/10/1974	11	1.6	
USGS	2300500	5/11/1974	12	1.6	
USGS	2300500	5/12/1974	18	1.7	
USGS	2300500	5/13/1974	10	1.5	
USGS	2300500	5/14/1974	9	1.5	
USGS	2300500	5/15/1974	13	1.6	

USGS	2300500	5/16/1974	29	1.9	
USGS	2300500	5/17/1974	104	3.0	
USGS	2300500	5/18/1974	78	2.6	
USGS	2300500	5/19/1974	32	2.0	
USGS	2300500	5/20/1974	27	1.9	
USGS	2300500	5/21/1974	22	1.8	
USGS	2300500	5/22/1974	21	1.9	
USGS	2300500	5/23/1974	20	2.0	
USGS	2300500	5/24/1974	18	1.8	
USGS	2300500	5/25/1974	17	1.7	
USGS	2300500	5/26/1974	16	1.7	
USGS	2300500	5/27/1974	16	1.7	
USGS	2300500	5/28/1974	13	1.6	
USGS	2300500	5/29/1974	12	1.6	170
USGS	2300500	5/30/1974	12	1.6	187
USGS	2300500	5/31/1974	11	1.6	162
USGS	2300500	6/1/1974	12	1.6	179
USGS	2300500	6/2/1974	11	1.6	179
USGS	2300500	6/3/1974	12	1.6	182
USGS	2300500	6/4/1974	17	1.7	182
USGS	2300500	6/5/1974	18	1.7	
USGS	2300500	6/6/1974	17	1.7	128
USGS	2300500	6/7/1974	17	1.7	
USGS	2300500	6/8/1974	18	1.7	157
USGS	2300500	6/9/1974	28	2.0	132
USGS	2300500	6/10/1974	36	2.1	
USGS	2300500	6/11/1974	33	2.0	160
USGS	2300500	6/12/1974	32	2.0	
USGS	2300500	6/13/1974	27	1.9	150
USGS	2300500	6/14/1974	23	1.8	142
USGS	2300500	6/15/1974	22	1.8	145
USGS	2300500	6/16/1974	22	1.8	148
USGS	2300500	6/17/1974	22	1.8	137
USGS	2300500	6/18/1974	20	1.8	131
USGS	2300500	6/19/1974	21	1.8	
USGS	2300500	6/20/1974	22	1.8	123
USGS	2300500	6/21/1974	27	1.9	
USGS	2300500	6/22/1974	27	1.9	
USGS	2300500	6/23/1974	26	1.9	
USGS	2300500	6/24/1974	44	2.1	
USGS	2300500	6/25/1974	124	3.2	
USGS	2300500	6/26/1974	176	3.7	
USGS	2300500	6/27/1974	888	9.3	
USGS	2300500	6/28/1974	1400	11.1	
USGS	2300500	6/29/1974	1540	11.5	
USGS	2300500	6/30/1974	1180	10.4	
USGS	2300500	7/1/1974	1410	11.1	
USGS	2300500	7/2/1974	1580	11.6	
USGS	2300500	7/3/1974	1980	12.5	
USGS	2300500	7/4/1974	1670	11.8	
USGS	2300500	7/5/1974	1160	10.3	
USGS	2300500	7/6/1974	849	9.1	
USGS	2300500	7/7/1974	532	7.2	
USGS	2300500	7/8/1974	421	6.3	
USGS	2300500	7/9/1974	323	5.4	

USGS	2300500	7/10/1974	427	6.4
USGS	2300500	7/11/1974	384	6.0
USGS	2300500	7/12/1974	156	3.7
USGS	2300500	7/13/1974	88	2.9
USGS	2300500	7/14/1974	59	2.5
USGS	2300500	7/15/1974	53	2.4
USGS	2300500	7/16/1974	47	2.3
USGS	2300500	7/17/1974	38	2.2
USGS	2300500	7/18/1974	300	4.2
USGS	2300500	7/19/1974	804	8.8
USGS	2300500	7/20/1974	713	8.4
USGS	2300500	7/21/1974	624	7.8
USGS	2300500	7/22/1974	255	4.7
USGS	2300500	7/23/1974	194	4.1
USGS	2300500	7/24/1974	319	5.4
USGS	2300500	7/25/1974	370	5.8
USGS	2300500	7/26/1974	360	5.7
USGS	2300500	7/27/1974	238	4.6
USGS	2300500	7/28/1974	398	6.1
USGS	2300500	7/29/1974	597	7.5
USGS	2300500	7/30/1974	1210	10.5
USGS	2300500	7/31/1974	1270	10.7
USGS	2300500	8/1/1974	922	9.4
USGS	2300500	8/2/1974	668	8.1
USGS	2300500	8/3/1974	851	9.2
USGS	2300500	8/4/1974	775	8.7
USGS	2300500	8/5/1974	510	7.0
USGS	2300500	8/6/1974	807	8.8
USGS	2300500	8/7/1974	856	9.1
USGS	2300500	8/8/1974	416	6.3
USGS	2300500	8/9/1974	359	5.8
USGS	2300500	8/10/1974	227	4.5
USGS	2300500	8/11/1974	572	7.5
USGS	2300500	8/12/1974	372	5.7
USGS	2300500	8/13/1974	255	4.6
USGS	2300500	8/14/1974	295	5.1
USGS	2300500	8/15/1974	230	4.4
USGS	2300500	8/16/1974	192	4.0
USGS	2300500	8/17/1974	156	3.6
USGS	2300500	8/18/1974	120	3.1
USGS	2300500	8/19/1974	101	2.9
USGS	2300500	8/20/1974	90	2.7
USGS	2300500	8/21/1974	79	2.6
USGS	2300500	8/22/1974	123	3.1
USGS	2300500	8/23/1974	147	3.4
USGS	2300500	8/24/1974	132	3.2
USGS	2300500	8/25/1974	103	2.9
USGS	2300500	8/26/1974	89	2.7
USGS	2300500	8/27/1974	82	2.6
USGS	2300500	8/28/1974	77	2.5
USGS	2300500	8/29/1974	88	2.7
USGS	2300500	8/30/1974	86	2.7
USGS	2300500	8/31/1974	55	2.2
USGS	2300500	9/1/1974	49	2.1
USGS	2300500	9/2/1974	45	2.1

USGS	2300500	9/3/1974	44	2.1	
USGS	2300500	9/4/1974	42	2.1	
USGS	2300500	9/5/1974	63	2.4	
USGS	2300500	9/6/1974	230	4.3	
USGS	2300500	9/7/1974	182	3.9	
USGS	2300500	9/8/1974	143	3.4	
USGS	2300500	9/9/1974	130	3.3	
USGS	2300500	9/10/1974	94	2.9	
USGS	2300500	9/11/1974	76	2.7	
USGS	2300500	9/12/1974	63	2.5	
USGS	2300500	9/13/1974	74	2.7	
USGS	2300500	9/14/1974	57	2.4	
USGS	2300500	9/15/1974	50	2.3	
USGS	2300500	9/16/1974	47	2.2	
USGS	2300500	9/17/1974	46	2.2	
USGS	2300500	9/18/1974	44	2.2	
USGS	2300500	9/19/1974	40	2.1	
USGS	2300500	9/20/1974	38	2.1	226
USGS	2300500	9/21/1974	35	2.0	190
USGS	2300500	9/22/1974	31	1.9	158
USGS	2300500	9/23/1974	29	1.9	130
USGS	2300500	9/24/1974	32	1.9	85
USGS	2300500	9/25/1974	73	2.6	
USGS	2300500	9/26/1974	67	2.5	102
USGS	2300500	9/27/1974	50	2.4	159
USGS	2300500	9/28/1974	44	2.2	110
USGS	2300500	9/29/1974	40	2.1	
USGS	2300500	9/30/1974	34	2.0	133
USGS	2300500	10/1/1974	32	1.9	122
USGS	2300500	10/2/1974	29	1.8	142
USGS	2300500	10/3/1974	27	1.8	207
USGS	2300500	10/4/1974	26	1.8	242
USGS	2300500	10/5/1974	25	1.8	
USGS	2300500	10/6/1974	25	1.8	252
USGS	2300500	10/7/1974	23	1.7	190
USGS	2300500	10/8/1974	22	1.8	172
USGS	2300500	10/9/1974	24	1.8	265
USGS	2300500	10/10/1974	25	1.8	
USGS	2300500	10/11/1974	23	1.7	
USGS	2300500	10/12/1974	23	1.7	260
USGS	2300500	10/13/1974	22	1.7	263
USGS	2300500	10/14/1974	21	1.7	197
USGS	2300500	10/15/1974	21	1.8	273
USGS	2300500	10/16/1974	23	1.9	306
USGS	2300500	10/17/1974	23	1.8	200
USGS	2300500	10/18/1974	24	1.8	
USGS	2300500	10/19/1974	22	1.8	
USGS	2300500	10/20/1974	20	1.7	242
USGS	2300500	10/21/1974	18	1.7	259
USGS	2300500	10/22/1974	20	1.7	
USGS	2300500	10/23/1974	20	1.7	321
USGS	2300500	10/24/1974	19	1.7	265
USGS	2300500	10/25/1974	19	1.7	285
USGS	2300500	10/26/1974	19	1.7	232
USGS	2300500	10/27/1974	19	1.7	

USGS	2300500	10/28/1974	18	1.7	172
USGS	2300500	10/29/1974	19	1.8	285
USGS	2300500	10/30/1974	20	1.7	247
USGS	2300500	10/31/1974	18	1.7	265
USGS	2300500	11/1/1974	18	1.7	
USGS	2300500	11/2/1974	19	1.7	
USGS	2300500	11/3/1974	19	1.7	
USGS	2300500	11/4/1974	18	1.7	
USGS	2300500	11/5/1974	18	1.7	
USGS	2300500	11/6/1974	18	1.7	342
USGS	2300500	11/7/1974	17	1.7	341
USGS	2300500	11/8/1974	18	1.7	335
USGS	2300500	11/9/1974	17	1.6	
USGS	2300500	11/10/1974	17	1.7	
USGS	2300500	11/11/1974	17	1.7	
USGS	2300500	11/12/1974	16	1.7	258
USGS	2300500	11/13/1974	16	1.6	296
USGS	2300500	11/14/1974	17	1.7	
USGS	2300500	11/15/1974	19	1.7	
USGS	2300500	11/16/1974	21	1.8	312
USGS	2300500	11/17/1974	20	1.8	
USGS	2300500	11/18/1974	19	1.7	
USGS	2300500	11/19/1974	19	1.7	
USGS	2300500	11/20/1974	17	1.7	274
USGS	2300500	11/21/1974	17	1.7	218
USGS	2300500	11/22/1974	16	1.7	
USGS	2300500	11/23/1974	15	1.6	271
USGS	2300500	11/24/1974	17	1.7	303
USGS	2300500	11/25/1974	18	1.7	340
USGS	2300500	11/26/1974	18	1.7	
USGS	2300500	11/27/1974	18	1.7	311
USGS	2300500	11/28/1974	17	1.7	271
USGS	2300500	11/29/1974	17	1.7	
USGS	2300500	11/30/1974	17	1.7	254
USGS	2300500	12/1/1974	19	1.9	
USGS	2300500	12/2/1974	19	1.8	337
USGS	2300500	12/3/1974	20	1.8	
USGS	2300500	12/4/1974	19	1.8	
USGS	2300500	12/5/1974	19	1.7	
USGS	2300500	12/6/1974	19	1.8	282
USGS	2300500	12/7/1974	18	1.8	
USGS	2300500	12/8/1974	18	1.8	198
USGS	2300500	12/9/1974	15	1.7	285
USGS	2300500	12/10/1974	17	1.7	
USGS	2300500	12/11/1974	18	1.7	277
USGS	2300500	12/12/1974	19	1.8	276
USGS	2300500	12/13/1974	21	1.9	
USGS	2300500	12/14/1974	21	1.8	295
USGS	2300500	12/15/1974	23	1.9	
USGS	2300500	12/16/1974	35	2.3	
USGS	2300500	12/17/1974	49	2.4	374
USGS	2300500	12/18/1974	42	2.3	233
USGS	2300500	12/19/1974	34	2.1	220
USGS	2300500	12/20/1974	40	2.2	
USGS	2300500	12/21/1974	42	2.2	177

USGS	2300500	12/22/1974	39	2.1	
USGS	2300500	12/23/1974	35	2.1	200
USGS	2300500	12/24/1974	32	2.0	
USGS	2300500	12/25/1974	30	2.0	
USGS	2300500	12/26/1974	28	2.0	161
USGS	2300500	12/27/1974	27	2.0	152
USGS	2300500	12/28/1974	27	2.0	157
USGS	2300500	12/29/1974	27	2.0	
USGS	2300500	12/30/1974	26	1.9	157
USGS	2300500	12/31/1974	25	1.9	165
USGS	2300500	1/1/1975	24	1.9	153
USGS	2300500	1/2/1975	23	1.9	215
USGS	2300500	1/3/1975	23	1.9	163
USGS	2300500	1/4/1975	23	1.9	
USGS	2300500	1/5/1975	23	1.9	152
USGS	2300500	1/6/1975	23	1.9	185
USGS	2300500	1/7/1975	24	1.9	203
USGS	2300500	1/8/1975	23	1.9	195
USGS	2300500	1/9/1975	24	1.9	223
USGS	2300500	1/10/1975	25	1.9	237
USGS	2300500	1/11/1975	24	2.0	229
USGS	2300500	1/12/1975	23	1.9	258
USGS	2300500	1/13/1975	26	2.0	
USGS	2300500	1/14/1975	23	1.9	186
USGS	2300500	1/15/1975	24	1.9	205
USGS	2300500	1/16/1975	24	1.9	
USGS	2300500	1/17/1975	23	1.9	241
USGS	2300500	1/18/1975	25	2.0	270
USGS	2300500	1/19/1975	26	2.0	265
USGS	2300500	1/20/1975	25	2.0	305
USGS	2300500	1/21/1975	22	1.9	242
USGS	2300500	1/22/1975	23	1.9	222
USGS	2300500	1/23/1975	23	1.9	258
USGS	2300500	1/24/1975	24	1.9	230
USGS	2300500	1/25/1975	25	2.0	234
USGS	2300500	1/26/1975	30	2.1	
USGS	2300500	1/27/1975	35	2.2	212
USGS	2300500	1/28/1975	31	2.1	172
USGS	2300500	1/29/1975	29	2.1	
USGS	2300500	1/30/1975	29	2.0	228
USGS	2300500	1/31/1975	29	2.0	270
USGS	2300500	2/1/1975	29	2.0	
USGS	2300500	2/2/1975	28	2.0	
USGS	2300500	2/3/1975	29	2.1	
USGS	2300500	2/4/1975	30	2.1	
USGS	2300500	2/5/1975	28	2.0	
USGS	2300500	2/6/1975	29	2.1	
USGS	2300500	2/7/1975	46	2.4	
USGS	2300500	2/8/1975	51	2.4	
USGS	2300500	2/9/1975	41	2.3	
USGS	2300500	2/10/1975	34	2.2	
USGS	2300500	2/11/1975	31	2.1	
USGS	2300500	2/12/1975	31	2.1	
USGS	2300500	2/13/1975	30	2.1	
USGS	2300500	2/14/1975	29	2.1	

USGS	2300500	2/15/1975	29	2.1
USGS	2300500	2/16/1975	29	2.1
USGS	2300500	2/17/1975	29	2.1
USGS	2300500	2/18/1975	27	2.1
USGS	2300500	2/19/1975	29	2.1
USGS	2300500	2/20/1975	26	2.0
USGS	2300500	2/21/1975	25	2.0
USGS	2300500	2/22/1975	26	2.0
USGS	2300500	2/23/1975	25	2.0
USGS	2300500	2/24/1975	25	2.1
USGS	2300500	2/25/1975	23	2.0
USGS	2300500	2/26/1975	23	2.0
USGS	2300500	2/27/1975	23	2.0
USGS	2300500	2/28/1975	22	1.9
USGS	2300500	3/1/1975	24	2.0
USGS	2300500	3/2/1975	23	2.0
USGS	2300500	3/3/1975	22	2.0
USGS	2300500	3/4/1975	22	2.0
USGS	2300500	3/5/1975	26	2.1
USGS	2300500	3/6/1975	25	2.1
USGS	2300500	3/7/1975	26	2.0
USGS	2300500	3/8/1975	23	2.0
USGS	2300500	3/9/1975	21	1.9
USGS	2300500	3/10/1975	20	1.9
USGS	2300500	3/11/1975	20	1.9
USGS	2300500	3/12/1975	20	1.9
USGS	2300500	3/13/1975	19	1.9
USGS	2300500	3/14/1975	19	1.9
USGS	2300500	3/15/1975	16	1.8
USGS	2300500	3/16/1975	15	1.8
USGS	2300500	3/17/1975	15	1.8
USGS	2300500	3/18/1975	14	1.8
USGS	2300500	3/19/1975	16	1.9
USGS	2300500	3/20/1975	15	1.8
USGS	2300500	3/21/1975	17	1.9
USGS	2300500	3/22/1975	18	1.9
USGS	2300500	3/23/1975	19	1.9
USGS	2300500	3/24/1975	14	1.8
USGS	2300500	3/25/1975	14	1.8
USGS	2300500	3/26/1975	13	1.8
USGS	2300500	3/27/1975	14	1.8
USGS	2300500	3/28/1975	14	1.8
USGS	2300500	3/29/1975	15	1.9
USGS	2300500	3/30/1975	15	1.9
USGS	2300500	3/31/1975	14	1.8
USGS	2300500	4/1/1975	12	1.8
USGS	2300500	4/2/1975	13	1.8
USGS	2300500	4/3/1975	12	1.8
USGS	2300500	4/4/1975	12	1.7
USGS	2300500	4/5/1975	12	1.7
USGS	2300500	4/6/1975	12	1.8
USGS	2300500	4/7/1975	12	1.7
USGS	2300500	4/8/1975	12	1.7
USGS	2300500	4/9/1975	12	1.7
USGS	2300500	4/10/1975	12	1.8

USGS	2300500	4/11/1975	12	1.8
USGS	2300500	4/12/1975	12	1.8
USGS	2300500	4/13/1975	11	1.7
USGS	2300500	4/14/1975	11	1.7
USGS	2300500	4/15/1975	11	1.7
USGS	2300500	4/16/1975	11	1.7
USGS	2300500	4/17/1975	11	1.7
USGS	2300500	4/18/1975	11	1.8
USGS	2300500	4/19/1975	10	1.7
USGS	2300500	4/20/1975	10	1.7
USGS	2300500	4/21/1975	10	1.7
USGS	2300500	4/22/1975	10	1.7
USGS	2300500	4/23/1975	10	1.7
USGS	2300500	4/24/1975	10	1.7
USGS	2300500	4/25/1975	11	1.7
USGS	2300500	4/26/1975	11	1.7
USGS	2300500	4/27/1975	11	1.7
USGS	2300500	4/28/1975	10	1.8
USGS	2300500	4/29/1975	10	1.8
USGS	2300500	4/30/1975	10	1.7
USGS	2300500	5/1/1975	14	1.8
USGS	2300500	5/2/1975	11	1.7
USGS	2300500	5/3/1975	10	1.7
USGS	2300500	5/4/1975	13	1.8
USGS	2300500	5/5/1975	12	1.8
USGS	2300500	5/6/1975	10	1.7
USGS	2300500	5/7/1975	10	1.7
USGS	2300500	5/8/1975	10	1.7
USGS	2300500	5/9/1975	10	1.7
USGS	2300500	5/10/1975	41	2.4
USGS	2300500	5/11/1975	53	2.7
USGS	2300500	5/12/1975	32	2.4
USGS	2300500	5/13/1975	25	2.2
USGS	2300500	5/14/1975	21	2.1
USGS	2300500	5/15/1975	19	2.1
USGS	2300500	5/16/1975	21	2.2
USGS	2300500	5/17/1975	30	2.4
USGS	2300500	5/18/1975	20	2.0
USGS	2300500	5/19/1975	18	1.9
USGS	2300500	5/20/1975	16	1.9
USGS	2300500	5/21/1975	15	1.9
USGS	2300500	5/22/1975	15	1.8
USGS	2300500	5/23/1975	14	1.8
USGS	2300500	5/24/1975	12	1.8
USGS	2300500	5/25/1975	11	1.8
USGS	2300500	5/26/1975	11	1.8
USGS	2300500	5/27/1975	11	1.8
USGS	2300500	5/28/1975	20	2.2
USGS	2300500	5/29/1975	69	3.0
USGS	2300500	5/30/1975	64	2.9
USGS	2300500	5/31/1975	45	2.7
USGS	2300500	6/1/1975	82	3.1
USGS	2300500	6/2/1975	113	3.6
USGS	2300500	6/3/1975	91	3.4
USGS	2300500	6/4/1975	85	3.3

USGS	2300500	6/5/1975	52	2.7	
USGS	2300500	6/6/1975	40	2.5	
USGS	2300500	6/7/1975	35	2.4	
USGS	2300500	6/8/1975	241	4.7	
USGS	2300500	6/9/1975	180	4.4	
USGS	2300500	6/10/1975	85	3.3	
USGS	2300500	6/11/1975	68	3.0	
USGS	2300500	6/12/1975	57	2.8	
USGS	2300500	6/13/1975	47	2.6	
USGS	2300500	6/14/1975	66	3.0	
USGS	2300500	6/15/1975	64	2.9	
USGS	2300500	6/16/1975	54	2.7	
USGS	2300500	6/17/1975	44	2.5	
USGS	2300500	6/18/1975	44	2.5	182
USGS	2300500	6/19/1975	52	2.7	
USGS	2300500	6/20/1975	168	4.2	
USGS	2300500	6/21/1975	118	3.8	215
USGS	2300500	6/22/1975	390	6.3	184
USGS	2300500	6/23/1975	369	6.1	179
USGS	2300500	6/24/1975	213	4.7	
USGS	2300500	6/25/1975	138	3.9	195
USGS	2300500	6/26/1975	79	3.2	193
USGS	2300500	6/27/1975	59	2.8	195
USGS	2300500	6/28/1975	48	2.6	
USGS	2300500	6/29/1975	41	2.5	
USGS	2300500	6/30/1975	38	2.4	190
USGS	2300500	7/1/1975	49	2.6	
USGS	2300500	7/2/1975	60	2.9	
USGS	2300500	7/3/1975	52	2.7	
USGS	2300500	7/4/1975	43	2.5	
USGS	2300500	7/5/1975	38	2.4	
USGS	2300500	7/6/1975	36	2.4	
USGS	2300500	7/7/1975	36	2.4	
USGS	2300500	7/8/1975	38	2.4	
USGS	2300500	7/9/1975	39	2.5	
USGS	2300500	7/10/1975	50	2.7	
USGS	2300500	7/11/1975	55	2.7	
USGS	2300500	7/12/1975	89	3.3	
USGS	2300500	7/13/1975	273	5.1	
USGS	2300500	7/14/1975	521	7.2	
USGS	2300500	7/15/1975	382	6.2	
USGS	2300500	7/16/1975	476	6.9	
USGS	2300500	7/17/1975	311	5.6	
USGS	2300500	7/18/1975	230	4.9	
USGS	2300500	7/19/1975	652	8.0	
USGS	2300500	7/20/1975	924	9.5	
USGS	2300500	7/21/1975	705	8.5	
USGS	2300500	7/22/1975	710	8.5	
USGS	2300500	7/23/1975	381	6.1	
USGS	2300500	7/24/1975	687	8.2	
USGS	2300500	7/25/1975	1420	11.2	
USGS	2300500	7/26/1975	961	9.7	
USGS	2300500	7/27/1975	744	8.7	
USGS	2300500	7/28/1975	519	7.3	
USGS	2300500	7/29/1975	283	5.3	

USGS	2300500	7/30/1975	200	4.6	
USGS	2300500	7/31/1975	97	3.4	
USGS	2300500	8/1/1975	134	3.9	
USGS	2300500	8/2/1975	279	5.3	
USGS	2300500	8/3/1975	181	4.4	
USGS	2300500	8/4/1975	151	4.1	
USGS	2300500	8/5/1975	118	3.8	
USGS	2300500	8/6/1975	99	3.5	
USGS	2300500	8/7/1975	170	4.3	
USGS	2300500	8/8/1975	361	6.0	
USGS	2300500	8/9/1975	496	7.1	
USGS	2300500	8/10/1975	489	7.0	
USGS	2300500	8/11/1975	365	6.0	
USGS	2300500	8/12/1975	172	4.3	
USGS	2300500	8/13/1975	121	3.8	
USGS	2300500	8/14/1975	95	3.5	
USGS	2300500	8/15/1975	106	3.6	
USGS	2300500	8/16/1975	240	4.9	
USGS	2300500	8/17/1975	206	4.6	
USGS	2300500	8/18/1975	169	4.3	
USGS	2300500	8/19/1975	115	3.7	
USGS	2300500	8/20/1975	95	3.4	
USGS	2300500	8/21/1975	94	3.5	
USGS	2300500	8/22/1975	100	3.5	
USGS	2300500	8/23/1975	89	3.3	
USGS	2300500	8/24/1975	77	3.2	
USGS	2300500	8/25/1975	76	3.1	
USGS	2300500	8/26/1975	71	3.1	
USGS	2300500	8/27/1975	67	3.0	
USGS	2300500	8/28/1975	64	3.0	
USGS	2300500	8/29/1975	59	2.9	144
USGS	2300500	8/30/1975	57	2.8	134
USGS	2300500	8/31/1975	176	4.2	122
USGS	2300500	9/1/1975	169	4.3	99
USGS	2300500	9/2/1975	91	3.4	118
USGS	2300500	9/3/1975	69	3.0	126
USGS	2300500	9/4/1975	145	4.0	131
USGS	2300500	9/5/1975	222	4.8	80
USGS	2300500	9/6/1975	256	5.1	
USGS	2300500	9/7/1975	132	3.9	77
USGS	2300500	9/8/1975	195	4.5	83
USGS	2300500	9/9/1975	400	6.3	63
USGS	2300500	9/10/1975	496	7.1	57
USGS	2300500	9/11/1975	642	8.1	57
USGS	2300500	9/12/1975	601	7.6	57
USGS	2300500	9/13/1975	269	5.1	68
USGS	2300500	9/14/1975	151	4.1	69
USGS	2300500	9/15/1975	133	3.8	80
USGS	2300500	9/16/1975	122	3.8	84
USGS	2300500	9/17/1975	109	3.6	88
USGS	2300500	9/18/1975	106	3.5	87
USGS	2300500	9/19/1975	192	4.4	79
USGS	2300500	9/20/1975	176	4.2	88
USGS	2300500	9/21/1975	124	3.7	88
USGS	2300500	9/22/1975	99	3.5	89

USGS	2300500	9/23/1975	132	3.8	100
USGS	2300500	9/24/1975	363	5.8	73
USGS	2300500	9/25/1975	388	6.0	83
USGS	2300500	9/26/1975	148	4.0	90
USGS	2300500	9/27/1975	103	3.5	94
USGS	2300500	9/28/1975	86	3.3	98
USGS	2300500	9/29/1975	82	3.2	100
USGS	2300500	9/30/1975	88	3.3	104
USGS	2300500	10/1/1975	60	2.9	108
USGS	2300500	10/2/1975	46	2.7	112
USGS	2300500	10/3/1975	96	3.2	103
USGS	2300500	10/4/1975	368	5.8	81
USGS	2300500	10/5/1975	85	3.1	118
USGS	2300500	10/6/1975	79	2.9	130
USGS	2300500	10/7/1975	164	4.1	101
USGS	2300500	10/8/1975	92	3.3	109
USGS	2300500	10/9/1975	70	2.9	113
USGS	2300500	10/10/1975	55	2.7	113
USGS	2300500	10/11/1975	60	2.7	103
USGS	2300500	10/12/1975	52	2.6	102
USGS	2300500	10/13/1975	39	2.4	111
USGS	2300500	10/14/1975	38	2.3	120
USGS	2300500	10/15/1975	35	2.3	137
USGS	2300500	10/16/1975	34	2.3	140
USGS	2300500	10/17/1975	46	2.5	156
USGS	2300500	10/18/1975	61	2.8	127
USGS	2300500	10/19/1975	62	2.7	126
USGS	2300500	10/20/1975	45	2.5	114
USGS	2300500	10/21/1975	37	2.3	136
USGS	2300500	10/22/1975	36	2.3	136
USGS	2300500	10/23/1975	36	2.4	153
USGS	2300500	10/24/1975	34	2.3	137
USGS	2300500	10/25/1975	34	2.3	171
USGS	2300500	10/26/1975	34	2.3	185
USGS	2300500	10/27/1975	35	2.3	178
USGS	2300500	10/28/1975	39	2.3	184
USGS	2300500	10/29/1975	430	6.5	87
USGS	2300500	10/30/1975	682	8.2	68
USGS	2300500	10/31/1975	724	8.5	69
USGS	2300500	11/1/1975	504	7.0	78
USGS	2300500	11/2/1975	291	5.2	82
USGS	2300500	11/3/1975	197	4.3	93
USGS	2300500	11/4/1975	154	3.8	101
USGS	2300500	11/5/1975	118	3.5	118
USGS	2300500	11/6/1975	86	3.1	140
USGS	2300500	11/7/1975	84	3.0	144
USGS	2300500	11/8/1975	84	3.0	126
USGS	2300500	11/9/1975	84	3.0	122
USGS	2300500	11/10/1975	85	3.0	114
USGS	2300500	11/11/1975	76	2.8	
USGS	2300500	11/12/1975	66	2.7	133
USGS	2300500	11/13/1975	71	2.7	134
USGS	2300500	11/14/1975	59	2.6	133
USGS	2300500	11/15/1975	55	2.5	142
USGS	2300500	11/16/1975	54	2.5	163

USGS	2300500	11/17/1975	53	2.5	194
USGS	2300500	11/18/1975	49	2.4	192
USGS	2300500	11/19/1975	49	2.4	188
USGS	2300500	11/20/1975	47	2.4	202
USGS	2300500	11/21/1975	46	2.4	180
USGS	2300500	11/22/1975	44	2.3	160
USGS	2300500	11/23/1975	42	2.3	160
USGS	2300500	11/24/1975	40	2.2	172
USGS	2300500	11/25/1975	39	2.2	175
USGS	2300500	11/26/1975	38	2.2	160
USGS	2300500	11/27/1975	39	2.2	158
USGS	2300500	11/28/1975	39	2.2	182
USGS	2300500	11/29/1975	39	2.2	182
USGS	2300500	11/30/1975	39	2.2	194
USGS	2300500	12/1/1975	37	2.2	174
USGS	2300500	12/2/1975	38	2.2	190
USGS	2300500	12/3/1975	37	2.2	182
USGS	2300500	12/4/1975	35	2.2	173
USGS	2300500	12/5/1975	35	2.1	177
USGS	2300500	12/6/1975	37	2.2	215
USGS	2300500	12/7/1975	36	2.2	223
USGS	2300500	12/8/1975	37	2.2	
USGS	2300500	12/9/1975	38	2.2	
USGS	2300500	12/10/1975	37	2.2	
USGS	2300500	12/11/1975	36	2.2	
USGS	2300500	12/12/1975	35	2.1	
USGS	2300500	12/13/1975	36	2.2	
USGS	2300500	12/14/1975	37	2.2	
USGS	2300500	12/15/1975	36	2.2	
USGS	2300500	12/16/1975	34	2.1	
USGS	2300500	12/17/1975	34	2.2	
USGS	2300500	12/18/1975	34	2.2	
USGS	2300500	12/19/1975	34	2.1	
USGS	2300500	12/20/1975	34	2.2	
USGS	2300500	12/21/1975	37	2.2	
USGS	2300500	12/22/1975	37	2.2	217
USGS	2300500	12/23/1975	36	2.2	220
USGS	2300500	12/24/1975	36	2.2	251
USGS	2300500	12/25/1975	36	2.2	
USGS	2300500	12/26/1975	38	2.3	
USGS	2300500	12/27/1975	41	2.3	154
USGS	2300500	12/28/1975	40	2.3	155
USGS	2300500	12/29/1975	37	2.2	150
USGS	2300500	12/30/1975	36	2.2	149
USGS	2300500	12/31/1975	35	2.2	151
USGS	2300500	1/1/1976	35	2.2	178
USGS	2300500	1/2/1976	34	2.2	143
USGS	2300500	1/3/1976	34	2.2	158
USGS	2300500	1/4/1976	32	2.1	160
USGS	2300500	1/5/1976	31	2.1	147
USGS	2300500	1/6/1976	31	2.1	158
USGS	2300500	1/7/1976	32	2.1	145
USGS	2300500	1/8/1976	33	2.2	
USGS	2300500	1/9/1976	33	2.2	156
USGS	2300500	1/10/1976	37	2.2	158

USGS	2300500	1/11/1976	35	2.2	176
USGS	2300500	1/12/1976	34	2.2	157
USGS	2300500	1/13/1976	33	2.2	166
USGS	2300500	1/14/1976	31	2.1	141
USGS	2300500	1/15/1976	32	2.1	184
USGS	2300500	1/16/1976	32	2.2	180
USGS	2300500	1/17/1976	33	2.2	212
USGS	2300500	1/18/1976	31	2.1	197
USGS	2300500	1/19/1976	30	2.1	200
USGS	2300500	1/20/1976	31	2.1	217
USGS	2300500	1/21/1976	31	2.2	197
USGS	2300500	1/22/1976	32	2.2	226
USGS	2300500	1/23/1976	32	2.2	244
USGS	2300500	1/24/1976	32	2.2	268
USGS	2300500	1/25/1976	30	2.1	193
USGS	2300500	1/26/1976	30	2.1	197
USGS	2300500	1/27/1976	34	2.2	193
USGS	2300500	1/28/1976	46	2.4	
USGS	2300500	1/29/1976	41	2.4	204
USGS	2300500	1/30/1976	38	2.3	196
USGS	2300500	1/31/1976	37	2.3	224
USGS	2300500	2/1/1976	36	2.3	275
USGS	2300500	2/2/1976	39	2.3	272
USGS	2300500	2/3/1976	38	2.3	186
USGS	2300500	2/4/1976	34	2.3	188
USGS	2300500	2/5/1976	32	2.2	216
USGS	2300500	2/6/1976	33	2.3	247
USGS	2300500	2/7/1976	36	2.3	291
USGS	2300500	2/8/1976	37	2.3	266
USGS	2300500	2/9/1976	32	2.3	286
USGS	2300500	2/10/1976	34	2.3	291
USGS	2300500	2/11/1976	34	2.3	291
USGS	2300500	2/12/1976	34	2.3	293
USGS	2300500	2/13/1976	34	2.3	318
USGS	2300500	2/14/1976	33	2.3	268
USGS	2300500	2/15/1976	30	2.2	267
USGS	2300500	2/16/1976	28	2.2	232
USGS	2300500	2/17/1976	27	2.2	194
USGS	2300500	2/18/1976	27	2.2	230
USGS	2300500	2/19/1976	28	2.2	284
USGS	2300500	2/20/1976	29	2.2	262
USGS	2300500	2/21/1976	30	2.3	252
USGS	2300500	2/22/1976	30	2.3	258
USGS	2300500	2/23/1976	28	2.2	252
USGS	2300500	2/24/1976	29	2.3	262
USGS	2300500	2/25/1976	29	2.3	281
USGS	2300500	2/26/1976	29	2.3	224
USGS	2300500	2/27/1976	28	2.3	279
USGS	2300500	2/28/1976	28	2.3	275
USGS	2300500	2/29/1976	27	2.3	275
USGS	2300500	3/1/1976	27	2.3	275
USGS	2300500	3/2/1976	27	2.3	263
USGS	2300500	3/3/1976	28	2.3	248
USGS	2300500	3/4/1976	28	2.4	245
USGS	2300500	3/5/1976	33	2.5	305

USGS	2300500	3/6/1976	43	2.7	200
USGS	2300500	3/7/1976	50	2.8	202
USGS	2300500	3/8/1976	37	2.5	
USGS	2300500	3/9/1976	32	2.6	185
USGS	2300500	3/10/1976	39	2.6	225
USGS	2300500	3/11/1976	34	2.5	245
USGS	2300500	3/12/1976	34	2.5	200
USGS	2300500	3/13/1976	35	2.6	266
USGS	2300500	3/14/1976	34	2.6	265
USGS	2300500	3/15/1976	33	2.5	282
USGS	2300500	3/16/1976	32	2.5	306
USGS	2300500	3/17/1976	28	2.4	235
USGS	2300500	3/18/1976	25	2.4	332
USGS	2300500	3/19/1976	24	2.4	256
USGS	2300500	3/20/1976	25	2.4	
USGS	2300500	3/21/1976	26	2.4	262
USGS	2300500	3/22/1976	23	2.4	300
USGS	2300500	3/23/1976	22	2.4	300
USGS	2300500	3/24/1976	19	2.3	298
USGS	2300500	3/25/1976	19	2.3	235
USGS	2300500	3/26/1976	19	2.3	287
USGS	2300500	3/27/1976	22	2.4	360
USGS	2300500	3/28/1976	23	2.4	352
USGS	2300500	3/29/1976	20	2.4	362
USGS	2300500	3/30/1976	16	2.3	316
USGS	2300500	3/31/1976	16	2.3	275
USGS	2300500	4/1/1976	15	2.3	320
USGS	2300500	4/2/1976	16	2.4	318
USGS	2300500	4/3/1976	16	2.3	295
USGS	2300500	4/4/1976	15	2.3	297
USGS	2300500	4/5/1976	16	2.4	338
USGS	2300500	4/6/1976	30	2.7	620
USGS	2300500	4/7/1976	38	2.9	780
USGS	2300500	4/8/1976	78	3.4	435
USGS	2300500	4/9/1976	55	3.1	325
USGS	2300500	4/10/1976	64	3.2	
USGS	2300500	4/11/1976	47	3.0	195
USGS	2300500	4/12/1976	36	2.8	190
USGS	2300500	4/13/1976	29	2.7	210
USGS	2300500	4/14/1976	27	2.6	255
USGS	2300500	4/15/1976	24	2.6	260
USGS	2300500	4/16/1976	26	2.6	280
USGS	2300500	4/17/1976	26	2.6	335
USGS	2300500	4/18/1976	26	2.6	340
USGS	2300500	4/19/1976	24	2.6	335
USGS	2300500	4/20/1976	22	2.5	325
USGS	2300500	4/21/1976	21	2.5	320
USGS	2300500	4/22/1976	17	2.4	340
USGS	2300500	4/23/1976	19	2.4	340
USGS	2300500	4/24/1976	17	2.4	330
USGS	2300500	4/25/1976	17	2.4	380
USGS	2300500	4/26/1976	17	2.4	320
USGS	2300500	4/27/1976	13	2.3	380
USGS	2300500	4/28/1976	11	2.3	330
USGS	2300500	4/29/1976	10	2.2	360

USGS	2300500	4/30/1976	10	2.2	370
USGS	2300500	5/1/1976	10	2.2	380
USGS	2300500	5/2/1976	10	2.2	380
USGS	2300500	5/3/1976	10	2.3	220
USGS	2300500	5/4/1976	10	2.2	215
USGS	2300500	5/5/1976	11	2.2	237
USGS	2300500	5/6/1976	11	2.2	
USGS	2300500	5/7/1976	26	2.6	486
USGS	2300500	5/8/1976	14	2.3	321
USGS	2300500	5/9/1976	12	2.2	320
USGS	2300500	5/10/1976	9	2.1	321
USGS	2300500	5/11/1976	9	2.2	312
USGS	2300500	5/12/1976	8	2.1	
USGS	2300500	5/13/1976	12	2.2	377
USGS	2300500	5/14/1976	9	2.2	377
USGS	2300500	5/15/1976	141	4.1	485
USGS	2300500	5/16/1976	429	6.6	
USGS	2300500	5/17/1976	290	5.5	206
USGS	2300500	5/18/1976	42	2.9	206
USGS	2300500	5/19/1976	12	2.3	220
USGS	2300500	5/20/1976	8	2.1	221
USGS	2300500	5/21/1976	7	2.0	233
USGS	2300500	5/22/1976	8	2.1	315
USGS	2300500	5/23/1976	17	2.4	315
USGS	2300500	5/24/1976	30	2.7	268
USGS	2300500	5/25/1976	15	2.4	200
USGS	2300500	5/26/1976	9	2.2	185
USGS	2300500	5/27/1976	6	2.0	228
USGS	2300500	5/28/1976	5	2.1	228
USGS	2300500	5/29/1976	8	2.2	192
USGS	2300500	5/30/1976	8	2.2	185
USGS	2300500	5/31/1976	6	2.1	190
USGS	2300500	6/1/1976	9	2.2	250
USGS	2300500	6/2/1976	32	2.7	245
USGS	2300500	6/3/1976	222	4.9	130
USGS	2300500	6/4/1976	59	3.3	127
USGS	2300500	6/5/1976	172	4.4	127
USGS	2300500	6/6/1976	238	5.1	128
USGS	2300500	6/7/1976	208	4.8	
USGS	2300500	6/8/1976	73	3.3	
USGS	2300500	6/9/1976	23	2.5	
USGS	2300500	6/10/1976	51	3.0	
USGS	2300500	6/11/1976	92	3.7	110
USGS	2300500	6/12/1976	56	3.2	110
USGS	2300500	6/13/1976	22	2.6	
USGS	2300500	6/14/1976	15	2.4	
USGS	2300500	6/15/1976	9	2.2	153
USGS	2300500	6/16/1976	8	2.2	153
USGS	2300500	6/17/1976	7	2.1	152
USGS	2300500	6/18/1976	8	2.1	160
USGS	2300500	6/19/1976	27	2.8	146
USGS	2300500	6/20/1976	68	3.4	103
USGS	2300500	6/21/1976	331	5.9	100
USGS	2300500	6/22/1976	529	7.3	87
USGS	2300500	6/23/1976	406	6.4	94

USGS	2300500	6/24/1976	163	4.3	106
USGS	2300500	6/25/1976	98	3.7	110
USGS	2300500	6/26/1976	60	3.2	140
USGS	2300500	6/27/1976	43	3.0	136
USGS	2300500	6/28/1976	35	2.9	140
USGS	2300500	6/29/1976	31	2.9	132
USGS	2300500	6/30/1976	41	3.0	145
USGS	2300500	7/1/1976	28	2.7	146
USGS	2300500	7/2/1976	26	2.7	128
USGS	2300500	7/3/1976	24	2.6	128
USGS	2300500	7/4/1976	28	2.8	119
USGS	2300500	7/5/1976	43	3.0	119
USGS	2300500	7/6/1976	30	2.7	130
USGS	2300500	7/7/1976	41	3.0	130
USGS	2300500	7/8/1976	35	2.9	148
USGS	2300500	7/9/1976	26	2.7	147
USGS	2300500	7/10/1976	141	3.7	144
USGS	2300500	7/11/1976	260	5.2	144
USGS	2300500	7/12/1976	57	3.2	
USGS	2300500	7/13/1976	23	2.6	
USGS	2300500	7/14/1976	12	2.4	
USGS	2300500	7/15/1976	13	2.4	
USGS	2300500	7/16/1976	6	2.1	
USGS	2300500	7/17/1976	8	2.4	
USGS	2300500	7/18/1976	22	2.7	117
USGS	2300500	7/19/1976	18	2.5	117
USGS	2300500	7/20/1976	8	2.3	124
USGS	2300500	7/21/1976	9	2.4	147
USGS	2300500	7/22/1976	18	2.5	145
USGS	2300500	7/23/1976	15	2.4	150
USGS	2300500	7/24/1976	21	2.6	124
USGS	2300500	7/25/1976	26	2.7	119
USGS	2300500	7/26/1976	45	3.0	170
USGS	2300500	7/27/1976	15	2.5	170
USGS	2300500	7/28/1976	22	2.6	124
USGS	2300500	7/29/1976	30	2.8	143
USGS	2300500	7/30/1976	28	2.8	144
USGS	2300500	7/31/1976	24	2.7	130
USGS	2300500	8/1/1976	47	3.1	94
USGS	2300500	8/2/1976	71	3.4	98
USGS	2300500	8/3/1976	141	4.1	105
USGS	2300500	8/4/1976	184	4.6	103
USGS	2300500	8/5/1976	111	3.9	141
USGS	2300500	8/6/1976	107	3.8	141
USGS	2300500	8/7/1976	86	3.6	142
USGS	2300500	8/8/1976	60	3.3	141
USGS	2300500	8/9/1976	46	3.1	136
USGS	2300500	8/10/1976	41	3.0	136
USGS	2300500	8/11/1976	39	3.0	164
USGS	2300500	8/12/1976	38	3.0	163
USGS	2300500	8/13/1976	49	3.1	118
USGS	2300500	8/14/1976	141	4.2	120
USGS	2300500	8/15/1976	172	4.5	119
USGS	2300500	8/16/1976	474	7.0	
USGS	2300500	8/17/1976	403	6.4	

USGS	2300500	8/18/1976	310	5.7	114
USGS	2300500	8/19/1976	142	4.3	120
USGS	2300500	8/20/1976	94	3.7	115
USGS	2300500	8/21/1976	67	3.4	150
USGS	2300500	8/22/1976	49	3.2	115
USGS	2300500	8/23/1976	42	3.1	150
USGS	2300500	8/24/1976	36	3.0	
USGS	2300500	8/25/1976	32	2.9	
USGS	2300500	8/26/1976	33	2.9	120
USGS	2300500	8/27/1976	33	2.9	
USGS	2300500	8/28/1976	31	2.9	165
USGS	2300500	8/29/1976	30	2.8	195
USGS	2300500	8/30/1976	30	2.8	
USGS	2300500	8/31/1976	28	2.8	190
USGS	2300500	9/1/1976	25	2.8	190
USGS	2300500	9/2/1976	24	2.7	
USGS	2300500	9/3/1976	22	2.7	
USGS	2300500	9/4/1976	33	2.9	250
USGS	2300500	9/5/1976	78	3.5	250
USGS	2300500	9/6/1976	90	3.7	
USGS	2300500	9/7/1976	73	3.5	
USGS	2300500	9/8/1976	78	3.6	
USGS	2300500	9/9/1976	116	4.0	
USGS	2300500	9/10/1976	41	3.1	
USGS	2300500	9/11/1976	26	2.8	155
USGS	2300500	9/12/1976	22	2.7	150
USGS	2300500	9/13/1976	22	2.7	
USGS	2300500	9/14/1976	30	2.9	
USGS	2300500	9/15/1976	28	2.8	175
USGS	2300500	9/16/1976	31	2.9	125
USGS	2300500	9/17/1976	26	2.8	175
USGS	2300500	9/18/1976	33	2.9	130
USGS	2300500	9/19/1976	34	3.0	235
USGS	2300500	9/20/1976	22	2.8	175
USGS	2300500	9/21/1976	20	2.7	165
USGS	2300500	9/22/1976	63	3.3	
USGS	2300500	9/23/1976	42	3.1	
USGS	2300500	9/24/1976	30	2.9	165
USGS	2300500	9/25/1976	28	2.9	165
USGS	2300500	9/26/1976	28	2.9	195
USGS	2300500	9/27/1976	25	2.8	200
USGS	2300500	9/28/1976	25	2.8	200
USGS	2300500	9/29/1976	25	2.8	200
USGS	2300500	9/30/1976	32	3.0	
USGS	2300500	10/1/1976	30	2.9	
USGS	2300500	10/2/1976	15	2.5	
USGS	2300500	10/3/1976	11	2.4	
USGS	2300500	10/4/1976	8	2.4	
USGS	2300500	10/5/1976	7	2.3	
USGS	2300500	10/6/1976	12	2.5	210
USGS	2300500	10/7/1976	26	2.8	205
USGS	2300500	10/8/1976	22	2.8	210
USGS	2300500	10/9/1976	24	2.9	240
USGS	2300500	10/10/1976	25	2.9	240
USGS	2300500	10/11/1976	26	3.0	230

USGS	2300500	10/12/1976	24	2.8	220
USGS	2300500	10/13/1976	20	2.7	315
USGS	2300500	10/14/1976	20	2.8	325
USGS	2300500	10/15/1976	21	2.8	315
USGS	2300500	10/16/1976	21	2.8	230
USGS	2300500	10/17/1976	18	2.8	215
USGS	2300500	10/18/1976	17	2.7	
USGS	2300500	10/19/1976	14	2.6	
USGS	2300500	10/20/1976	14	2.6	
USGS	2300500	10/21/1976	15	2.7	
USGS	2300500	10/22/1976	14	2.6	
USGS	2300500	10/23/1976	18	2.6	
USGS	2300500	10/24/1976	20	2.7	220
USGS	2300500	10/25/1976	20	2.7	195
USGS	2300500	10/26/1976	19	2.7	
USGS	2300500	10/27/1976	17	2.6	195
USGS	2300500	10/28/1976	15	2.5	355
USGS	2300500	10/29/1976	15	2.5	315
USGS	2300500	10/30/1976	15	2.5	300
USGS	2300500	10/31/1976	17	2.6	265
USGS	2300500	11/1/1976	15	2.5	195
USGS	2300500	11/2/1976	14	2.5	315
USGS	2300500	11/3/1976	52	3.2	360
USGS	2300500	11/4/1976	70	3.4	210
USGS	2300500	11/5/1976	70	3.3	210
USGS	2300500	11/6/1976	48	3.0	
USGS	2300500	11/7/1976	38	2.8	260
USGS	2300500	11/8/1976	30	2.6	265
USGS	2300500	11/9/1976	25	2.6	
USGS	2300500	11/10/1976	26	2.6	
USGS	2300500	11/11/1976	26	2.6	
USGS	2300500	11/12/1976	26	2.6	
USGS	2300500	11/13/1976	24	2.5	325
USGS	2300500	11/14/1976	20	2.4	
USGS	2300500	11/15/1976	18	2.4	
USGS	2300500	11/16/1976	17	2.4	
USGS	2300500	11/17/1976	16	2.4	
USGS	2300500	11/18/1976	18	2.4	
USGS	2300500	11/19/1976	20	2.5	
USGS	2300500	11/20/1976	21	2.5	
USGS	2300500	11/21/1976	21	2.5	
USGS	2300500	11/22/1976	14	2.4	
USGS	2300500	11/23/1976	13	2.3	251
USGS	2300500	11/24/1976	16	2.4	294
USGS	2300500	11/25/1976	17	2.4	243
USGS	2300500	11/26/1976	14	2.3	244
USGS	2300500	11/27/1976	14	2.3	236
USGS	2300500	11/28/1976	14	2.3	220
USGS	2300500	11/29/1976	17	2.4	240
USGS	2300500	11/30/1976	30	2.7	179
USGS	2300500	12/1/1976	44	3.0	
USGS	2300500	12/2/1976	46	2.9	
USGS	2300500	12/3/1976	38	2.8	165
USGS	2300500	12/4/1976	14	2.3	194
USGS	2300500	12/5/1976	8	2.2	196

USGS	2300500	12/6/1976	24	2.6	215
USGS	2300500	12/7/1976	4	2.1	212
USGS	2300500	12/8/1976	3	2.1	211
USGS	2300500	12/9/1976	2	2.0	239
USGS	2300500	12/10/1976	1	2.0	239
USGS	2300500	12/11/1976	1	1.9	216
USGS	2300500	12/12/1976	10	2.3	165
USGS	2300500	12/13/1976	14	2.3	176
USGS	2300500	12/14/1976	1	1.9	175
USGS	2300500	12/15/1976	1	1.9	174
USGS	2300500	12/16/1976	1	2.0	174
USGS	2300500	12/17/1976	1	1.9	
USGS	2300500	12/18/1976	1	1.8	190
USGS	2300500	12/19/1976	1	1.9	232
USGS	2300500	12/20/1976	1	1.9	235
USGS	2300500	12/21/1976	1	2.1	341
USGS	2300500	12/22/1976	2	2.0	341
USGS	2300500	12/23/1976	21	2.5	276
USGS	2300500	12/24/1976	33	2.7	276
USGS	2300500	12/25/1976	38	2.8	
USGS	2300500	12/26/1976	46	3.0	
USGS	2300500	12/27/1976	38	2.8	
USGS	2300500	12/28/1976	34	2.8	
USGS	2300500	12/29/1976	7	2.1	
USGS	2300500	12/30/1976	2	2.0	
USGS	2300500	12/31/1976	5	2.1	
USGS	2300500	1/1/1977	14	2.3	234
USGS	2300500	1/2/1977	17	2.4	234
USGS	2300500	1/3/1977	32	2.7	159
USGS	2300500	1/4/1977	44	2.9	162
USGS	2300500	1/5/1977	39	2.8	200
USGS	2300500	1/6/1977	31	2.7	196
USGS	2300500	1/7/1977	24	2.6	142
USGS	2300500	1/8/1977	17	2.4	146
USGS	2300500	1/9/1977	12	2.3	144
USGS	2300500	1/10/1977	20	2.4	152
USGS	2300500	1/11/1977	15	2.3	157
USGS	2300500	1/12/1977	12	2.3	222
USGS	2300500	1/13/1977	29	2.6	215
USGS	2300500	1/14/1977	15	2.3	219
USGS	2300500	1/15/1977	20	2.4	216
USGS	2300500	1/16/1977	28	2.5	212
USGS	2300500	1/17/1977	45	2.9	206
USGS	2300500	1/18/1977	15	2.3	205
USGS	2300500	1/19/1977	22	2.5	218
USGS	2300500	1/20/1977	18	2.4	214
USGS	2300500	1/21/1977	7	2.1	231
USGS	2300500	1/22/1977	7	2.1	231
USGS	2300500	1/23/1977	17	2.4	229
USGS	2300500	1/24/1977	10	2.2	226
USGS	2300500	1/25/1977	3	2.0	206
USGS	2300500	1/26/1977	7	2.1	202
USGS	2300500	1/27/1977	22	2.5	160
USGS	2300500	1/28/1977	26	2.6	161
USGS	2300500	1/29/1977	30	2.6	161

USGS	2300500	1/30/1977	26	2.6	162
USGS	2300500	1/31/1977	26	2.6	162
USGS	2300500	2/1/1977	30	2.6	159
USGS	2300500	2/2/1977	28	2.6	162
USGS	2300500	2/3/1977	22	2.5	218
USGS	2300500	2/4/1977	72	3.1	226
USGS	2300500	2/5/1977	68	2.9	166
USGS	2300500	2/6/1977	53	2.7	165
USGS	2300500	2/7/1977	39	2.4	221
USGS	2300500	2/8/1977	30	2.3	223
USGS	2300500	2/9/1977	25	2.2	234
USGS	2300500	2/10/1977	37	2.4	236
USGS	2300500	2/11/1977	26	2.2	225
USGS	2300500	2/12/1977	18	2.0	227
USGS	2300500	2/13/1977	18	2.0	226
USGS	2300500	2/14/1977	18	2.0	226
USGS	2300500	2/15/1977	14	2.0	226
USGS	2300500	2/16/1977	15	2.0	224
USGS	2300500	2/17/1977	13	2.0	306
USGS	2300500	2/18/1977	19	2.1	311
USGS	2300500	2/19/1977	10	1.9	322
USGS	2300500	2/20/1977	10	2.0	322
USGS	2300500	2/21/1977	10	2.0	312
USGS	2300500	2/22/1977	24	2.3	310
USGS	2300500	2/23/1977	5	1.9	272
USGS	2300500	2/24/1977	78	3.1	274
USGS	2300500	2/25/1977	100	3.5	154
USGS	2300500	2/26/1977	97	3.5	158
USGS	2300500	2/27/1977	78	3.2	178
USGS	2300500	2/28/1977	65	3.1	178
USGS	2300500	3/1/1977	44	2.7	225
USGS	2300500	3/2/1977	33	2.5	219
USGS	2300500	3/3/1977	27	2.4	218
USGS	2300500	3/4/1977	27	2.4	194
USGS	2300500	3/5/1977	23	2.3	195
USGS	2300500	3/6/1977	21	2.3	193
USGS	2300500	3/7/1977	20	2.3	231
USGS	2300500	3/8/1977	15	2.2	231
USGS	2300500	3/9/1977	11	2.1	336
USGS	2300500	3/10/1977	13	2.2	
USGS	2300500	3/11/1977	31	2.5	335
USGS	2300500	3/12/1977	27	2.5	334
USGS	2300500	3/13/1977	18	2.3	399
USGS	2300500	3/14/1977	18	2.3	
USGS	2300500	3/15/1977	18	2.3	392
USGS	2300500	3/16/1977	17	2.3	343
USGS	2300500	3/17/1977	16	2.2	346
USGS	2300500	3/18/1977	16	2.3	346
USGS	2300500	3/19/1977	18	2.3	294
USGS	2300500	3/20/1977	16	2.3	296
USGS	2300500	3/21/1977	12	2.2	272
USGS	2300500	3/22/1977	11	2.1	274
USGS	2300500	3/23/1977	12	2.2	272
USGS	2300500	3/24/1977	12	2.2	314
USGS	2300500	3/25/1977	16	2.3	312

USGS	2300500	3/26/1977	11	2.2	307
USGS	2300500	3/27/1977	10	2.1	314
USGS	2300500	3/28/1977	11	2.2	313
USGS	2300500	3/29/1977	14	2.2	327
USGS	2300500	3/30/1977	13	2.2	326
USGS	2300500	3/31/1977	13	2.2	353
USGS	2300500	4/1/1977	8	2.1	344
USGS	2300500	4/2/1977	8	2.1	350
USGS	2300500	4/3/1977	7	2.1	350
USGS	2300500	4/4/1977	6	2.1	350
USGS	2300500	4/5/1977	6	2.1	378
USGS	2300500	4/6/1977	6	2.1	377
USGS	2300500	4/7/1977	16	2.3	378
USGS	2300500	4/8/1977	20	2.5	387
USGS	2300500	4/9/1977	20	2.5	376
USGS	2300500	4/10/1977	25	2.6	378
USGS	2300500	4/11/1977	20	2.5	362
USGS	2300500	4/12/1977	16	2.4	422
USGS	2300500	4/13/1977	20	2.5	422
USGS	2300500	4/14/1977	20	2.5	362
USGS	2300500	4/15/1977	22	2.6	355
USGS	2300500	4/16/1977	21	2.5	370
USGS	2300500	4/17/1977	17	2.5	374
USGS	2300500	4/18/1977	17	2.4	391
USGS	2300500	4/19/1977	14	2.4	391
USGS	2300500	4/20/1977	9	2.3	393
USGS	2300500	4/21/1977	8	2.2	374
USGS	2300500	4/22/1977	12	2.3	376
USGS	2300500	4/23/1977	11	2.3	366
USGS	2300500	4/24/1977	17	2.5	368
USGS	2300500	4/25/1977	14	2.4	372
USGS	2300500	4/26/1977	10	2.3	372
USGS	2300500	4/27/1977	13	2.4	373
USGS	2300500	4/28/1977	8	2.3	345
USGS	2300500	4/29/1977	7	2.3	345
USGS	2300500	4/30/1977	11	2.3	347
USGS	2300500	5/1/1977	10	2.3	360
USGS	2300500	5/2/1977	8	2.3	361
USGS	2300500	5/3/1977	7	2.2	382
USGS	2300500	5/4/1977	8	2.3	382
USGS	2300500	5/5/1977	9	2.3	334
USGS	2300500	5/6/1977	7	2.2	336
USGS	2300500	5/7/1977	8	2.3	410
USGS	2300500	5/8/1977	10	2.3	410
USGS	2300500	5/9/1977	12	2.4	409
USGS	2300500	5/10/1977	8	2.3	436
USGS	2300500	5/11/1977	4	2.2	400
USGS	2300500	5/12/1977	4	2.2	470
USGS	2300500	5/13/1977	5	2.2	368
USGS	2300500	5/14/1977	9	2.3	368
USGS	2300500	5/15/1977	9	2.3	367
USGS	2300500	5/16/1977	8	2.3	367
USGS	2300500	5/17/1977	4	2.2	393
USGS	2300500	5/18/1977	4	2.2	390
USGS	2300500	5/19/1977	5	2.3	388

USGS	2300500	5/20/1977	4	2.2	413
USGS	2300500	5/21/1977	3	2.2	372
USGS	2300500	5/22/1977	3	2.2	417
USGS	2300500	5/23/1977	4	2.2	399
USGS	2300500	5/24/1977	4	2.2	402
USGS	2300500	5/25/1977	4	2.2	400
USGS	2300500	5/26/1977	5	2.3	393
USGS	2300500	5/27/1977	5	2.2	570
USGS	2300500	5/28/1977	2	2.1	570
USGS	2300500	5/29/1977	3	2.2	570
USGS	2300500	5/30/1977	6	2.3	215
USGS	2300500	5/31/1977	14	2.5	
USGS	2300500	6/1/1977	14	2.5	
USGS	2300500	6/2/1977	9	2.5	
USGS	2300500	6/3/1977	27	2.8	
USGS	2300500	6/4/1977	8	2.4	
USGS	2300500	6/5/1977	5	2.3	
USGS	2300500	6/6/1977	5	2.3	
USGS	2300500	6/7/1977	5	2.3	
USGS	2300500	6/8/1977	4	2.3	218
USGS	2300500	6/9/1977	4	2.3	212
USGS	2300500	6/10/1977	8	2.4	210
USGS	2300500	6/11/1977	10	2.4	193
USGS	2300500	6/12/1977	7	2.3	
USGS	2300500	6/13/1977	4	2.2	196
USGS	2300500	6/14/1977	2	2.2	193
USGS	2300500	6/15/1977	2	2.2	174
USGS	2300500	6/16/1977	24	2.9	195
USGS	2300500	6/17/1977	55	3.3	
USGS	2300500	6/18/1977	44	3.2	
USGS	2300500	6/19/1977	134	4.2	
USGS	2300500	6/20/1977	106	3.9	154
USGS	2300500	6/21/1977	21	2.7	180
USGS	2300500	6/22/1977	5	2.4	173
USGS	2300500	6/23/1977	7	2.4	170
USGS	2300500	6/24/1977	2	2.2	169
USGS	2300500	6/25/1977	1	2.1	160
USGS	2300500	6/26/1977	1	2.1	
USGS	2300500	6/27/1977	4	2.3	
USGS	2300500	6/28/1977	8	2.4	146
USGS	2300500	6/29/1977	13	2.5	
USGS	2300500	6/30/1977	14	2.6	
USGS	2300500	7/1/1977	15	2.6	148
USGS	2300500	7/2/1977	13	2.5	154
USGS	2300500	7/3/1977	12	2.5	153
USGS	2300500	7/4/1977	18	2.7	177
USGS	2300500	7/5/1977	78	3.8	182
USGS	2300500	7/6/1977	206	4.9	185
USGS	2300500	7/7/1977	209	4.9	160
USGS	2300500	7/8/1977	118	4.1	160
USGS	2300500	7/9/1977	71	3.5	158
USGS	2300500	7/10/1977	52	3.2	159
USGS	2300500	7/11/1977	34	3.0	
USGS	2300500	7/12/1977	20	2.7	
USGS	2300500	7/13/1977	12	2.5	

USGS	2300500	7/14/1977	45	3.2	
USGS	2300500	7/15/1977	50	3.2	
USGS	2300500	7/16/1977	34	3.0	
USGS	2300500	7/17/1977	30	2.9	
USGS	2300500	7/18/1977	68	3.5	
USGS	2300500	7/19/1977	394	6.4	
USGS	2300500	7/20/1977	381	6.3	
USGS	2300500	7/21/1977	379	6.3	
USGS	2300500	7/22/1977	297	5.6	
USGS	2300500	7/23/1977	214	4.9	
USGS	2300500	7/24/1977	318	5.8	
USGS	2300500	7/25/1977	344	6.0	
USGS	2300500	7/26/1977	201	4.8	149
USGS	2300500	7/27/1977	142	4.3	148
USGS	2300500	7/28/1977	104	3.9	
USGS	2300500	7/29/1977	194	4.8	
USGS	2300500	7/30/1977	96	3.8	
USGS	2300500	7/31/1977	76	3.6	
USGS	2300500	8/1/1977	171	4.6	175
USGS	2300500	8/2/1977	177	4.6	180
USGS	2300500	8/3/1977	135	4.2	174
USGS	2300500	8/4/1977	178	4.6	166
USGS	2300500	8/5/1977	149	4.3	
USGS	2300500	8/6/1977	114	4.0	
USGS	2300500	8/7/1977	101	3.8	164
USGS	2300500	8/8/1977	92	3.7	165
USGS	2300500	8/9/1977	95	3.8	168
USGS	2300500	8/10/1977	119	4.1	
USGS	2300500	8/11/1977	171	4.5	124
USGS	2300500	8/12/1977	562	7.6	
USGS	2300500	8/13/1977	699	8.3	124
USGS	2300500	8/14/1977	699	8.4	125
USGS	2300500	8/15/1977	733	8.6	123
USGS	2300500	8/16/1977	577	7.7	132
USGS	2300500	8/17/1977	284	5.5	137
USGS	2300500	8/18/1977	167	4.5	138
USGS	2300500	8/19/1977	122	4.1	200
USGS	2300500	8/20/1977	102	3.9	201
USGS	2300500	8/21/1977	91	3.7	202
USGS	2300500	8/22/1977	158	4.5	
USGS	2300500	8/23/1977	301	5.7	200
USGS	2300500	8/24/1977	306	5.7	150
USGS	2300500	8/25/1977	592	7.7	150
USGS	2300500	8/26/1977	480	7.0	150
USGS	2300500	8/27/1977	212	5.0	150
USGS	2300500	8/28/1977	148	4.3	148
USGS	2300500	8/29/1977	89	3.7	148
USGS	2300500	8/30/1977	151	4.4	153
USGS	2300500	8/31/1977	169	4.6	138
USGS	2300500	9/1/1977	134	4.2	137
USGS	2300500	9/2/1977	137	4.2	136
USGS	2300500	9/3/1977	454	6.8	170
USGS	2300500	9/4/1977	451	6.8	168
USGS	2300500	9/5/1977	875	9.2	168
USGS	2300500	9/6/1977	968	9.6	119

USGS	2300500	9/7/1977	832	9.0	119
USGS	2300500	9/8/1977	595	7.7	168
USGS	2300500	9/9/1977	369	6.2	114
USGS	2300500	9/10/1977	284	5.6	
USGS	2300500	9/11/1977	198	4.8	112
USGS	2300500	9/12/1977	127	4.1	113
USGS	2300500	9/13/1977	102	3.9	
USGS	2300500	9/14/1977	119	4.3	112
USGS	2300500	9/15/1977	167	4.5	79
USGS	2300500	9/16/1977	97	3.8	79
USGS	2300500	9/17/1977	80	3.6	
USGS	2300500	9/18/1977	173	4.6	78
USGS	2300500	9/19/1977	848	9.2	78
USGS	2300500	9/20/1977	775	8.8	78
USGS	2300500	9/21/1977	516	7.2	78
USGS	2300500	9/22/1977	638	8.0	91
USGS	2300500	9/23/1977	1250	10.6	91
USGS	2300500	9/24/1977	767	8.7	
USGS	2300500	9/25/1977	546	7.4	92
USGS	2300500	9/26/1977	361	5.9	79
USGS	2300500	9/27/1977	255	4.9	78
USGS	2300500	9/28/1977	651	8.2	76
USGS	2300500	9/29/1977	727	8.5	82
USGS	2300500	9/30/1977	441	6.6	92
USGS	2300500	10/1/1977	277	5.1	
USGS	2300500	10/2/1977	196	4.3	
USGS	2300500	10/3/1977	127	3.6	
USGS	2300500	10/4/1977	67	2.7	
USGS	2300500	10/5/1977	54	2.6	
USGS	2300500	10/6/1977	63	2.7	
USGS	2300500	10/7/1977	57	2.6	
USGS	2300500	10/8/1977	54	2.6	
USGS	2300500	10/9/1977	52	2.6	
USGS	2300500	10/10/1977	46	2.5	
USGS	2300500	10/11/1977	42	2.4	
USGS	2300500	10/12/1977	56	2.6	225
USGS	2300500	10/13/1977	108	3.3	
USGS	2300500	10/14/1977	70	2.9	
USGS	2300500	10/15/1977	64	2.7	
USGS	2300500	10/16/1977	54	2.6	
USGS	2300500	10/17/1977	42	2.4	
USGS	2300500	10/18/1977	38	2.3	236
USGS	2300500	10/19/1977	34	2.2	
USGS	2300500	10/20/1977	37	2.3	
USGS	2300500	10/21/1977	35	2.2	
USGS	2300500	10/22/1977	34	2.2	
USGS	2300500	10/23/1977	32	2.1	
USGS	2300500	10/24/1977	31	2.1	182
USGS	2300500	10/25/1977	32	2.1	
USGS	2300500	10/26/1977	32	2.2	
USGS	2300500	10/27/1977	34	2.2	
USGS	2300500	10/28/1977	32	2.2	
USGS	2300500	10/29/1977	30	2.1	
USGS	2300500	10/30/1977	30	2.1	245
USGS	2300500	10/31/1977	28	2.1	

USGS	2300500	11/1/1977	28	2.1	244
USGS	2300500	11/2/1977	30	2.1	
USGS	2300500	11/3/1977	32	2.2	
USGS	2300500	11/4/1977	33	2.2	
USGS	2300500	11/5/1977	37	2.3	
USGS	2300500	11/6/1977	38	2.3	
USGS	2300500	11/7/1977	38	2.3	195
USGS	2300500	11/8/1977	36	2.3	
USGS	2300500	11/9/1977	34	2.2	
USGS	2300500	11/10/1977	32	2.2	
USGS	2300500	11/11/1977	30	2.1	300
USGS	2300500	11/12/1977	29	2.1	
USGS	2300500	11/13/1977	29	2.1	
USGS	2300500	11/14/1977	28	2.1	
USGS	2300500	11/15/1977	28	2.1	
USGS	2300500	11/16/1977	28	2.1	
USGS	2300500	11/17/1977	28	2.1	
USGS	2300500	11/18/1977	26	2.0	
USGS	2300500	11/19/1977	24	2.0	
USGS	2300500	11/20/1977	25	2.0	
USGS	2300500	11/21/1977	26	2.0	
USGS	2300500	11/22/1977	24	2.0	
USGS	2300500	11/23/1977	50	2.4	
USGS	2300500	11/24/1977	110	3.4	
USGS	2300500	11/25/1977	132	3.7	
USGS	2300500	11/26/1977	129	3.6	
USGS	2300500	11/27/1977	100	3.2	
USGS	2300500	11/28/1977	71	2.8	245
USGS	2300500	11/29/1977	62	2.7	
USGS	2300500	11/30/1977	56	2.6	
USGS	2300500	12/1/1977	54	2.6	
USGS	2300500	12/2/1977	52	2.5	
USGS	2300500	12/3/1977	51	2.5	
USGS	2300500	12/4/1977	55	2.5	
USGS	2300500	12/5/1977	53	2.5	
USGS	2300500	12/6/1977	54	2.6	
USGS	2300500	12/7/1977	52	2.5	
USGS	2300500	12/8/1977	52	2.5	
USGS	2300500	12/9/1977	74	2.8	
USGS	2300500	12/10/1977	118	3.5	
USGS	2300500	12/11/1977	110	3.4	
USGS	2300500	12/12/1977	87	3.1	
USGS	2300500	12/13/1977	74	2.9	
USGS	2300500	12/14/1977	68	2.8	
USGS	2300500	12/15/1977	67	2.8	
USGS	2300500	12/16/1977	165	3.9	
USGS	2300500	12/17/1977	208	4.5	
USGS	2300500	12/18/1977	213	4.5	
USGS	2300500	12/19/1977	174	4.1	
USGS	2300500	12/20/1977	138	3.7	
USGS	2300500	12/21/1977	115	3.4	
USGS	2300500	12/22/1977	118	3.4	
USGS	2300500	12/23/1977	104	3.3	
USGS	2300500	12/24/1977	101	3.2	
USGS	2300500	12/25/1977	94	3.1	

USGS	2300500	12/26/1977	115	3.4	
USGS	2300500	12/27/1977	111	3.4	
USGS	2300500	12/28/1977	114	3.4	
USGS	2300500	12/29/1977	100	3.2	
USGS	2300500	12/30/1977	85	3.0	
USGS	2300500	12/31/1977	81	3.0	
USGS	2300500	1/1/1978	80	2.9	
USGS	2300500	1/2/1978	76	2.9	
USGS	2300500	1/3/1978	71	2.8	
USGS	2300500	1/4/1978	65	2.7	
USGS	2300500	1/5/1978	60	2.6	
USGS	2300500	1/6/1978	58	2.6	141
USGS	2300500	1/7/1978	56	2.6	
USGS	2300500	1/8/1978	56	2.6	
USGS	2300500	1/9/1978	90	3.1	
USGS	2300500	1/10/1978	86	3.0	
USGS	2300500	1/11/1978	75	2.9	
USGS	2300500	1/12/1978	66	2.7	
USGS	2300500	1/13/1978	88	3.0	
USGS	2300500	1/14/1978	149	3.8	
USGS	2300500	1/15/1978	128	3.6	
USGS	2300500	1/16/1978	109	3.3	
USGS	2300500	1/17/1978	114	3.4	
USGS	2300500	1/18/1978	176	4.1	118
USGS	2300500	1/19/1978	214	4.4	
USGS	2300500	1/20/1978	533	7.3	
USGS	2300500	1/21/1978	676	8.2	
USGS	2300500	1/22/1978	640	8.0	
USGS	2300500	1/23/1978	369	5.8	
USGS	2300500	1/24/1978	226	4.5	
USGS	2300500	1/25/1978	175	3.9	
USGS	2300500	1/26/1978	155	3.7	118
USGS	2300500	1/27/1978	127	3.4	
USGS	2300500	1/28/1978	127	3.4	
USGS	2300500	1/29/1978	113	3.2	
USGS	2300500	1/30/1978	94	2.9	
USGS	2300500	1/31/1978	84	2.8	
USGS	2300500	2/1/1978	78	2.7	
USGS	2300500	2/2/1978	76	2.7	165
USGS	2300500	2/3/1978	80	2.7	
USGS	2300500	2/4/1978	85	2.8	
USGS	2300500	2/5/1978	79	2.7	
USGS	2300500	2/6/1978	69	2.6	
USGS	2300500	2/7/1978	66	2.6	
USGS	2300500	2/8/1978	67	2.6	
USGS	2300500	2/9/1978	109	3.2	
USGS	2300500	2/10/1978	115	3.2	
USGS	2300500	2/11/1978	111	3.2	
USGS	2300500	2/12/1978	97	3.0	
USGS	2300500	2/13/1978	82	2.8	
USGS	2300500	2/14/1978	76	2.7	
USGS	2300500	2/15/1978	70	2.6	
USGS	2300500	2/16/1978	191	3.9	
USGS	2300500	2/17/1978	402	6.1	150
USGS	2300500	2/18/1978	905	8.8	

USGS	2300500	2/19/1978	1430	11.2	
USGS	2300500	2/20/1978	1510	11.4	
USGS	2300500	2/21/1978	1070	9.8	
USGS	2300500	2/22/1978	603	7.4	
USGS	2300500	2/23/1978	393	5.7	
USGS	2300500	2/24/1978	304	4.8	
USGS	2300500	2/25/1978	259	4.4	
USGS	2300500	2/26/1978	216	3.9	
USGS	2300500	2/27/1978	188	3.6	
USGS	2300500	2/28/1978	171	3.4	
USGS	2300500	3/1/1978	157	3.3	
USGS	2300500	3/2/1978	137	3.0	
USGS	2300500	3/3/1978	237	4.0	
USGS	2300500	3/4/1978	498	6.5	
USGS	2300500	3/5/1978	380	5.5	
USGS	2300500	3/6/1978	276	4.5	
USGS	2300500	3/7/1978	225	4.0	
USGS	2300500	3/8/1978	199	3.7	119
USGS	2300500	3/9/1978	431	5.9	
USGS	2300500	3/10/1978	437	6.0	
USGS	2300500	3/11/1978	338	5.1	
USGS	2300500	3/12/1978	273	4.5	
USGS	2300500	3/13/1978	221	4.0	
USGS	2300500	3/14/1978	186	3.6	310
USGS	2300500	3/15/1978	169	3.4	134
USGS	2300500	3/16/1978	152	3.2	
USGS	2300500	3/17/1978	135	3.1	
USGS	2300500	3/18/1978	119	2.9	
USGS	2300500	3/19/1978	111	2.8	
USGS	2300500	3/20/1978	107	2.8	
USGS	2300500	3/21/1978	104	2.8	
USGS	2300500	3/22/1978	101	2.7	
USGS	2300500	3/23/1978	96	2.7	
USGS	2300500	3/24/1978	92	2.7	374
USGS	2300500	3/25/1978	90	2.6	
USGS	2300500	3/26/1978	84	2.6	
USGS	2300500	3/27/1978	78	2.5	
USGS	2300500	3/28/1978	72	2.5	230
USGS	2300500	3/29/1978	70	2.4	
USGS	2300500	3/30/1978	67	2.4	
USGS	2300500	3/31/1978	64	2.4	
USGS	2300500	4/1/1978	63	2.4	
USGS	2300500	4/2/1978	61	2.4	
USGS	2300500	4/3/1978	58	2.4	
USGS	2300500	4/4/1978	57	2.4	
USGS	2300500	4/5/1978	56	2.4	
USGS	2300500	4/6/1978	54	2.4	
USGS	2300500	4/7/1978	53	2.4	
USGS	2300500	4/8/1978	51	2.4	
USGS	2300500	4/9/1978	47	2.3	
USGS	2300500	4/10/1978	44	2.3	
USGS	2300500	4/11/1978	44	2.3	
USGS	2300500	4/12/1978	44	2.3	
USGS	2300500	4/13/1978	44	2.3	
USGS	2300500	4/14/1978	41	2.3	

USGS	2300500	4/15/1978	39	2.3	
USGS	2300500	4/16/1978	37	2.3	
USGS	2300500	4/17/1978	35	2.3	
USGS	2300500	4/18/1978	34	2.2	
USGS	2300500	4/19/1978	32	2.2	
USGS	2300500	4/20/1978	30	2.2	
USGS	2300500	4/21/1978	28	2.2	
USGS	2300500	4/22/1978	26	2.2	
USGS	2300500	4/23/1978	26	2.2	
USGS	2300500	4/24/1978	24	2.2	
USGS	2300500	4/25/1978	21	2.2	
USGS	2300500	4/26/1978	23	2.2	
USGS	2300500	4/27/1978	21	2.2	
USGS	2300500	4/28/1978	22	2.2	
USGS	2300500	4/29/1978	21	2.2	
USGS	2300500	4/30/1978	20	2.2	
USGS	2300500	5/1/1978	22	2.2	
USGS	2300500	5/2/1978	23	2.2	
USGS	2300500	5/3/1978	22	2.2	
USGS	2300500	5/4/1978	147	3.9	
USGS	2300500	5/5/1978	379	6.2	
USGS	2300500	5/6/1978	351	5.9	
USGS	2300500	5/7/1978	259	5.1	263
USGS	2300500	5/8/1978	175	4.3	
USGS	2300500	5/9/1978	125	3.8	
USGS	2300500	5/10/1978	99	3.5	
USGS	2300500	5/11/1978	73	3.2	
USGS	2300500	5/12/1978	60	3.0	
USGS	2300500	5/13/1978	56	2.9	
USGS	2300500	5/14/1978	48	2.8	
USGS	2300500	5/15/1978	42	2.7	
USGS	2300500	5/16/1978	39	2.6	170
USGS	2300500	5/17/1978	37	2.5	
USGS	2300500	5/18/1978	37	2.5	
USGS	2300500	5/19/1978	48	2.8	
USGS	2300500	5/20/1978	73	3.2	
USGS	2300500	5/21/1978	60	3.0	
USGS	2300500	5/22/1978	44	2.7	320
USGS	2300500	5/23/1978	38	2.6	
USGS	2300500	5/24/1978	36	2.5	
USGS	2300500	5/25/1978	36	2.5	
USGS	2300500	5/26/1978	38	2.6	
USGS	2300500	5/27/1978	48	2.8	
USGS	2300500	5/28/1978	37	2.5	154
USGS	2300500	5/29/1978	32	2.4	
USGS	2300500	5/30/1978	29	2.4	
USGS	2300500	5/31/1978	28	2.3	
USGS	2300500	6/1/1978	28	2.3	
USGS	2300500	6/2/1978	44	2.7	
USGS	2300500	6/3/1978	38	2.6	
USGS	2300500	6/4/1978	56	3.0	
USGS	2300500	6/5/1978	67	3.1	154
USGS	2300500	6/6/1978	73	3.2	
USGS	2300500	6/7/1978	63	3.1	
USGS	2300500	6/8/1978	80	3.3	

USGS	2300500	6/9/1978	158	4.2	
USGS	2300500	6/10/1978	385	6.2	
USGS	2300500	6/11/1978	208	4.7	
USGS	2300500	6/12/1978	122	3.8	
USGS	2300500	6/13/1978	76	3.2	
USGS	2300500	6/14/1978	58	3.0	
USGS	2300500	6/15/1978	51	2.8	
USGS	2300500	6/16/1978	45	2.7	
USGS	2300500	6/17/1978	39	2.6	146
USGS	2300500	6/18/1978	34	2.5	
USGS	2300500	6/19/1978	32	2.4	
USGS	2300500	6/20/1978	32	2.5	
USGS	2300500	6/21/1978	32	2.5	
USGS	2300500	6/22/1978	39	2.6	
USGS	2300500	6/23/1978	230	4.8	
USGS	2300500	6/24/1978	226	4.9	
USGS	2300500	6/25/1978	133	3.9	140
USGS	2300500	6/26/1978	144	4.0	
USGS	2300500	6/27/1978	163	4.2	
USGS	2300500	6/28/1978	257	5.1	
USGS	2300500	6/29/1978	94	3.5	137
USGS	2300500	6/30/1978	65	3.1	
USGS	2300500	7/1/1978	61	3.0	
USGS	2300500	7/2/1978	78	3.3	
USGS	2300500	7/3/1978	110	3.7	
USGS	2300500	7/4/1978	184	4.4	
USGS	2300500	7/5/1978	108	3.7	
USGS	2300500	7/6/1978	101	3.6	
USGS	2300500	7/7/1978	122	3.8	95
USGS	2300500	7/8/1978	122	3.8	
USGS	2300500	7/9/1978	228	4.8	
USGS	2300500	7/10/1978	628	7.9	
USGS	2300500	7/11/1978	569	7.5	
USGS	2300500	7/12/1978	433	6.6	
USGS	2300500	7/13/1978	302	5.5	
USGS	2300500	7/14/1978	302	5.5	88
USGS	2300500	7/15/1978	265	5.2	
USGS	2300500	7/16/1978	247	5.0	
USGS	2300500	7/17/1978	322	5.7	
USGS	2300500	7/18/1978	1030	9.8	
USGS	2300500	7/19/1978	1090	10.0	
USGS	2300500	7/20/1978	604	7.7	
USGS	2300500	7/21/1978	431	6.4	85
USGS	2300500	7/22/1978	369	5.9	
USGS	2300500	7/23/1978	260	4.9	
USGS	2300500	7/24/1978	192	4.2	
USGS	2300500	7/25/1978	192	4.1	101
USGS	2300500	7/26/1978	675	8.0	
USGS	2300500	7/27/1978	989	9.7	
USGS	2300500	7/28/1978	1070	10.0	
USGS	2300500	7/29/1978	871	9.2	
USGS	2300500	7/30/1978	497	7.0	
USGS	2300500	7/31/1978	415	6.3	86
USGS	2300500	8/1/1978	408	6.2	
USGS	2300500	8/2/1978	725	8.5	

USGS	2300500	8/3/1978	1080	10.0	
USGS	2300500	8/4/1978	1720	11.8	
USGS	2300500	8/5/1978	2070	12.7	
USGS	2300500	8/6/1978	1630	11.6	
USGS	2300500	8/7/1978	884	9.2	67
USGS	2300500	8/8/1978	445	6.5	
USGS	2300500	8/9/1978	320	5.4	
USGS	2300500	8/10/1978	372	5.9	
USGS	2300500	8/11/1978	821	9.0	
USGS	2300500	8/12/1978	1790	12.1	
USGS	2300500	8/13/1978	1920	12.4	
USGS	2300500	8/14/1978	1560	11.5	58
USGS	2300500	8/15/1978	1110	10.1	
USGS	2300500	8/16/1978	623	7.8	
USGS	2300500	8/17/1978	330	5.5	
USGS	2300500	8/18/1978	370	5.9	
USGS	2300500	8/19/1978	746	8.6	
USGS	2300500	8/20/1978	692	8.3	
USGS	2300500	8/21/1978	360	5.8	
USGS	2300500	8/22/1978	212	4.4	85
USGS	2300500	8/23/1978	156	3.8	
USGS	2300500	8/24/1978	121	3.4	
USGS	2300500	8/25/1978	103	3.1	
USGS	2300500	8/26/1978	112	3.3	
USGS	2300500	8/27/1978	78	2.8	
USGS	2300500	8/28/1978	63	2.6	
USGS	2300500	8/29/1978	64	2.6	127
USGS	2300500	8/30/1978	104	3.2	
USGS	2300500	8/31/1978	92	3.0	
USGS	2300500	9/1/1978	60	2.5	
USGS	2300500	9/2/1978	52	2.4	
USGS	2300500	9/3/1978	47	2.3	
USGS	2300500	9/4/1978	46	2.3	141
USGS	2300500	9/5/1978	44	2.3	
USGS	2300500	9/6/1978	49	2.3	
USGS	2300500	9/7/1978	56	2.5	
USGS	2300500	9/8/1978	58	2.5	
USGS	2300500	9/9/1978	54	2.4	
USGS	2300500	9/10/1978	46	2.3	
USGS	2300500	9/11/1978	40	2.2	
USGS	2300500	9/12/1978	37	2.2	
USGS	2300500	9/13/1978	36	2.1	
USGS	2300500	9/14/1978	40	2.2	230
USGS	2300500	9/15/1978	41	2.2	
USGS	2300500	9/16/1978	37	2.1	
USGS	2300500	9/17/1978	34	2.1	
USGS	2300500	9/18/1978	31	2.0	
USGS	2300500	9/19/1978	31	2.0	
USGS	2300500	9/20/1978	31	2.0	180
USGS	2300500	9/21/1978	29	2.0	
USGS	2300500	9/22/1978	28	1.9	
USGS	2300500	9/23/1978	28	1.9	
USGS	2300500	9/24/1978	78	2.8	
USGS	2300500	9/25/1978	106	3.1	
USGS	2300500	9/26/1978	247	4.7	

USGS	2300500	9/27/1978	182	4.1	
USGS	2300500	9/28/1978	106	3.2	
USGS	2300500	9/29/1978	81	2.8	
USGS	2300500	9/30/1978	81	2.9	129
USGS	2300500	10/1/1978	85	2.9	
USGS	2300500	10/2/1978	88	2.9	
USGS	2300500	10/3/1978	74	2.7	
USGS	2300500	10/4/1978	73	2.7	
USGS	2300500	10/5/1978	132	3.5	
USGS	2300500	10/6/1978	119	3.3	
USGS	2300500	10/7/1978	80	2.8	
USGS	2300500	10/8/1978	60	2.5	
USGS	2300500	10/9/1978	53	2.4	
USGS	2300500	10/10/1978	47	2.3	
USGS	2300500	10/11/1978	45	2.3	
USGS	2300500	10/12/1978	46	2.3	155
USGS	2300500	10/13/1978	61	2.5	
USGS	2300500	10/14/1978	61	2.5	
USGS	2300500	10/15/1978	61	2.5	
USGS	2300500	10/16/1978	56	2.5	145
USGS	2300500	10/17/1978	45	2.3	
USGS	2300500	10/18/1978	38	2.2	
USGS	2300500	10/19/1978	33	2.1	
USGS	2300500	10/20/1978	35	2.1	
USGS	2300500	10/21/1978	39	2.2	
USGS	2300500	10/22/1978	36	2.1	170
USGS	2300500	10/23/1978	33	2.1	
USGS	2300500	10/24/1978	32	2.1	
USGS	2300500	10/25/1978	30	2.1	
USGS	2300500	10/26/1978	29	2.0	
USGS	2300500	10/27/1978	28	2.0	174
USGS	2300500	10/28/1978	31	2.1	
USGS	2300500	10/29/1978	33	2.1	
USGS	2300500	10/30/1978	30	2.1	
USGS	2300500	10/31/1978	28	2.1	
USGS	2300500	11/1/1978	28	2.1	
USGS	2300500	11/2/1978	28	2.1	
USGS	2300500	11/3/1978	27	2.1	
USGS	2300500	11/4/1978	26	2.0	
USGS	2300500	11/5/1978	25	2.0	
USGS	2300500	11/6/1978	24	2.0	
USGS	2300500	11/7/1978	23	2.0	
USGS	2300500	11/8/1978	26	2.1	199
USGS	2300500	11/9/1978	28	2.1	
USGS	2300500	11/10/1978	28	2.1	
USGS	2300500	11/11/1978	28	2.1	
USGS	2300500	11/12/1978	27	2.1	
USGS	2300500	11/13/1978	22	2.0	
USGS	2300500	11/14/1978	23	2.0	
USGS	2300500	11/15/1978	24	2.0	
USGS	2300500	11/16/1978	24	2.0	
USGS	2300500	11/17/1978	23	2.0	
USGS	2300500	11/18/1978	22	2.0	225
USGS	2300500	11/19/1978	23	2.0	
USGS	2300500	11/20/1978	24	2.0	

USGS	2300500	11/21/1978	23	2.0	
USGS	2300500	11/22/1978	22	2.0	
USGS	2300500	11/23/1978	23	2.0	218
USGS	2300500	11/24/1978	24	2.1	
USGS	2300500	11/25/1978	26	2.1	
USGS	2300500	11/26/1978	24	2.1	
USGS	2300500	11/27/1978	23	2.0	
USGS	2300500	11/28/1978	21	2.0	
USGS	2300500	11/29/1978	22	2.0	
USGS	2300500	11/30/1978	22	2.0	207
USGS	2300500	12/1/1978	36	2.3	
USGS	2300500	12/2/1978	42	2.4	
USGS	2300500	12/3/1978	43	2.4	
USGS	2300500	12/4/1978	35	2.3	
USGS	2300500	12/5/1978	32	2.2	
USGS	2300500	12/6/1978	30	2.2	
USGS	2300500	12/7/1978	29	2.1	
USGS	2300500	12/8/1978	27	2.1	
USGS	2300500	12/9/1978	27	2.1	
USGS	2300500	12/10/1978	26	2.1	262
USGS	2300500	12/11/1978	25	2.1	
USGS	2300500	12/12/1978	26	2.1	
USGS	2300500	12/13/1978	27	2.1	
USGS	2300500	12/14/1978	27	2.1	
USGS	2300500	12/15/1978	26	2.1	
USGS	2300500	12/16/1978	27	2.1	
USGS	2300500	12/17/1978	27	2.1	263
USGS	2300500	12/18/1978	25	2.1	
USGS	2300500	12/19/1978	25	2.1	
USGS	2300500	12/20/1978	25	2.1	
USGS	2300500	12/21/1978	26	2.1	
USGS	2300500	12/22/1978	26	2.1	
USGS	2300500	12/23/1978	25	2.1	
USGS	2300500	12/24/1978	35	2.2	256
USGS	2300500	12/25/1978	54	2.6	
USGS	2300500	12/26/1978	52	2.6	
USGS	2300500	12/27/1978	41	2.4	
USGS	2300500	12/28/1978	81	3.0	
USGS	2300500	12/29/1978	92	3.2	
USGS	2300500	12/30/1978	78	3.0	
USGS	2300500	12/31/1978	56	2.6	176
USGS	2300500	1/1/1979	41	2.4	
USGS	2300500	1/2/1979	92	3.1	
USGS	2300500	1/3/1979	163	4.0	
USGS	2300500	1/4/1979	114	3.4	
USGS	2300500	1/5/1979	72	2.9	
USGS	2300500	1/6/1979	59	2.7	
USGS	2300500	1/7/1979	52	2.6	
USGS	2300500	1/8/1979	50	2.5	
USGS	2300500	1/9/1979	51	2.5	
USGS	2300500	1/10/1979	47	2.5	
USGS	2300500	1/11/1979	43	2.4	
USGS	2300500	1/12/1979	360	5.4	
USGS	2300500	1/13/1979	1040	9.9	
USGS	2300500	1/14/1979	951	9.5	

USGS	2300500	1/15/1979	602	7.7
USGS	2300500	1/16/1979	270	4.9
USGS	2300500	1/17/1979	146	3.7
USGS	2300500	1/18/1979	111	3.3
USGS	2300500	1/19/1979	92	3.1
USGS	2300500	1/20/1979	90	3.0
USGS	2300500	1/21/1979	175	3.9
USGS	2300500	1/22/1979	193	4.1
USGS	2300500	1/23/1979	150	3.7
USGS	2300500	1/24/1979	390	5.6
USGS	2300500	1/25/1979	406	6.2
USGS	2300500	1/26/1979	336	5.5
USGS	2300500	1/27/1979	260	4.8
USGS	2300500	1/28/1979	208	4.3
USGS	2300500	1/29/1979	154	3.7
USGS	2300500	1/30/1979	137	3.6
USGS	2300500	1/31/1979	121	3.4
USGS	2300500	2/1/1979	107	3.2
USGS	2300500	2/2/1979	96	3.1
USGS	2300500	2/3/1979	87	3.0
USGS	2300500	2/4/1979	80	2.9
USGS	2300500	2/5/1979	76	2.8
USGS	2300500	2/6/1979	63	2.7
USGS	2300500	2/7/1979	52	2.5
USGS	2300500	2/8/1979	61	2.7
USGS	2300500	2/9/1979	60	2.6
USGS	2300500	2/10/1979	55	2.6
USGS	2300500	2/11/1979	56	2.6
USGS	2300500	2/12/1979	48	2.5
USGS	2300500	2/13/1979	45	2.4
USGS	2300500	2/14/1979	43	2.4
USGS	2300500	2/15/1979	42	2.4
USGS	2300500	2/16/1979	46	2.4
USGS	2300500	2/17/1979	62	2.7
USGS	2300500	2/18/1979	63	2.7
USGS	2300500	2/19/1979	52	2.5
USGS	2300500	2/20/1979	40	2.3
USGS	2300500	2/21/1979	41	2.3
USGS	2300500	2/22/1979	42	2.4
USGS	2300500	2/23/1979	57	2.6
USGS	2300500	2/24/1979	113	3.3
USGS	2300500	2/25/1979	156	3.7
USGS	2300500	2/26/1979	182	4.0
USGS	2300500	2/27/1979	122	3.4
USGS	2300500	2/28/1979	95	3.1
USGS	2300500	3/1/1979	85	3.0
USGS	2300500	3/2/1979	80	2.9
USGS	2300500	3/3/1979	75	2.8
USGS	2300500	3/4/1979	71	2.8
USGS	2300500	3/5/1979	73	2.8
USGS	2300500	3/6/1979	200	4.2
USGS	2300500	3/7/1979	472	6.8
USGS	2300500	3/8/1979	354	5.7
USGS	2300500	3/9/1979	298	5.2
USGS	2300500	3/10/1979	231	4.5

USGS	2300500	3/11/1979	183	4.0	
USGS	2300500	3/12/1979	142	3.6	
USGS	2300500	3/13/1979	115	3.3	
USGS	2300500	3/14/1979	102	3.2	
USGS	2300500	3/15/1979	91	3.1	
USGS	2300500	3/16/1979	82	2.9	
USGS	2300500	3/17/1979	76	2.9	
USGS	2300500	3/18/1979	72	2.8	
USGS	2300500	3/19/1979	67	2.8	
USGS	2300500	3/20/1979	59	2.7	
USGS	2300500	3/21/1979	46	2.5	
USGS	2300500	3/22/1979	43	2.5	
USGS	2300500	3/23/1979	41	2.5	
USGS	2300500	3/24/1979	44	2.5	
USGS	2300500	3/25/1979	34	2.4	
USGS	2300500	3/26/1979	35	2.4	
USGS	2300500	3/27/1979	40	2.5	
USGS	2300500	3/28/1979	39	2.5	
USGS	2300500	3/29/1979	38	2.5	
USGS	2300500	3/30/1979	39	2.5	
USGS	2300500	3/31/1979	27	2.4	
USGS	2300500	4/1/1979	21	2.3	
USGS	2300500	4/2/1979	26	2.4	
USGS	2300500	4/3/1979	27	2.4	
USGS	2300500	4/4/1979	29	2.4	
USGS	2300500	4/5/1979	28	2.4	
USGS	2300500	4/6/1979	27	2.4	
USGS	2300500	4/7/1979	26	2.4	
USGS	2300500	4/8/1979	25	2.4	287
USGS	2300500	4/9/1979	26	2.5	
USGS	2300500	4/10/1979	27	2.5	
USGS	2300500	4/11/1979	27	2.5	
USGS	2300500	4/12/1979	26	2.5	
USGS	2300500	4/13/1979	23	2.5	
USGS	2300500	4/14/1979	24	2.5	
USGS	2300500	4/15/1979	24	2.5	374
USGS	2300500	4/16/1979	20	2.5	
USGS	2300500	4/17/1979	17	2.4	
USGS	2300500	4/18/1979	17	2.4	
USGS	2300500	4/19/1979	18	2.5	
USGS	2300500	4/20/1979	18	2.5	
USGS	2300500	4/21/1979	18	2.5	
USGS	2300500	4/22/1979	19	2.5	329
USGS	2300500	4/23/1979	18	2.5	
USGS	2300500	4/24/1979	18	2.5	
USGS	2300500	4/25/1979	28	2.7	
USGS	2300500	4/26/1979	26	2.7	
USGS	2300500	4/27/1979	18	2.5	
USGS	2300500	4/28/1979	25	2.7	
USGS	2300500	4/29/1979	22	2.6	309
USGS	2300500	4/30/1979	20	2.6	
USGS	2300500	5/1/1979	16	2.6	
USGS	2300500	5/2/1979	21	2.6	
USGS	2300500	5/3/1979	21	2.6	
USGS	2300500	5/4/1979	20	2.6	

USGS	2300500	5/5/1979	20	2.6	342
USGS	2300500	5/6/1979	18	2.6	
USGS	2300500	5/7/1979	33	2.8	
USGS	2300500	5/8/1979	65	3.1	
USGS	2300500	5/9/1979	155	4.3	345
USGS	2300500	5/10/1979	104	3.7	
USGS	2300500	5/11/1979	109	3.6	
USGS	2300500	5/12/1979	365	6.0	
USGS	2300500	5/13/1979	390	6.2	
USGS	2300500	5/14/1979	232	5.1	
USGS	2300500	5/15/1979	247	5.2	
USGS	2300500	5/16/1979	218	4.9	
USGS	2300500	5/17/1979	77	3.3	
USGS	2300500	5/18/1979	68	3.2	155
USGS	2300500	5/19/1979	65	3.1	
USGS	2300500	5/20/1979	58	3.0	
USGS	2300500	5/21/1979	35	2.6	
USGS	2300500	5/22/1979	35	2.6	
USGS	2300500	5/23/1979	18	2.3	
USGS	2300500	5/24/1979	20	2.3	
USGS	2300500	5/25/1979	32	2.5	
USGS	2300500	5/26/1979	23	2.4	
USGS	2300500	5/27/1979	16	2.2	
USGS	2300500	5/28/1979	14	2.2	242
USGS	2300500	5/29/1979	21	2.3	
USGS	2300500	5/30/1979	30	2.5	
USGS	2300500	5/31/1979	60	3.0	
USGS	2300500	6/1/1979	70	3.2	131
USGS	2300500	6/2/1979	83	3.4	
USGS	2300500	6/3/1979	86	3.4	
USGS	2300500	6/4/1979	86	3.4	
USGS	2300500	6/5/1979	46	2.8	
USGS	2300500	6/6/1979	32	2.6	
USGS	2300500	6/7/1979	21	2.4	
USGS	2300500	6/8/1979	17	2.3	
USGS	2300500	6/9/1979	26	2.4	159
USGS	2300500	6/10/1979	22	2.4	
USGS	2300500	6/11/1979	21	2.3	
USGS	2300500	6/12/1979	18	2.3	
USGS	2300500	6/13/1979	22	2.4	
USGS	2300500	6/14/1979	27	2.5	
USGS	2300500	6/15/1979	26	2.4	
USGS	2300500	6/16/1979	21	2.4	
USGS	2300500	6/17/1979	19	2.3	152
USGS	2300500	6/18/1979	16	2.2	
USGS	2300500	6/19/1979	13	2.2	
USGS	2300500	6/20/1979	12	2.1	
USGS	2300500	6/21/1979	10	2.1	
USGS	2300500	6/22/1979	20	2.3	
USGS	2300500	6/23/1979	43	2.8	
USGS	2300500	6/24/1979	35	2.6	146
USGS	2300500	6/25/1979	29	2.5	
USGS	2300500	6/26/1979	24	2.4	
USGS	2300500	6/27/1979	23	2.4	
USGS	2300500	6/28/1979	24	2.4	

USGS	2300500	6/29/1979	36	2.6	
USGS	2300500	6/30/1979	54	2.9	
USGS	2300500	7/1/1979	57	3.0	
USGS	2300500	7/2/1979	32	2.6	
USGS	2300500	7/3/1979	24	2.4	
USGS	2300500	7/4/1979	24	2.4	
USGS	2300500	7/5/1979	30	2.5	183
USGS	2300500	7/6/1979	22	2.4	
USGS	2300500	7/7/1979	24	2.4	
USGS	2300500	7/8/1979	101	3.6	
USGS	2300500	7/9/1979	65	3.1	
USGS	2300500	7/10/1979	27	2.5	
USGS	2300500	7/11/1979	76	3.3	
USGS	2300500	7/12/1979	47	2.8	144
USGS	2300500	7/13/1979	52	2.9	
USGS	2300500	7/14/1979	115	3.8	
USGS	2300500	7/15/1979	73	3.2	
USGS	2300500	7/16/1979	53	2.9	
USGS	2300500	7/17/1979	55	3.0	137
USGS	2300500	7/18/1979	78	3.3	
USGS	2300500	7/19/1979	135	4.0	
USGS	2300500	7/20/1979	96	3.5	
USGS	2300500	7/21/1979	46	2.8	
USGS	2300500	7/22/1979	53	2.9	
USGS	2300500	7/23/1979	53	2.9	
USGS	2300500	7/24/1979	53	2.9	
USGS	2300500	7/25/1979	71	3.2	
USGS	2300500	7/26/1979	60	3.0	141
USGS	2300500	7/27/1979	50	2.9	
USGS	2300500	7/28/1979	42	2.7	
USGS	2300500	7/29/1979	28	2.5	
USGS	2300500	7/30/1979	21	2.3	
USGS	2300500	7/31/1979	16	2.2	142
USGS	2300500	8/1/1979	25	2.4	
USGS	2300500	8/2/1979	32	2.6	
USGS	2300500	8/3/1979	27	2.5	
USGS	2300500	8/4/1979	24	2.4	
USGS	2300500	8/5/1979	24	2.4	
USGS	2300500	8/6/1979	25	2.4	
USGS	2300500	8/7/1979	30	2.5	
USGS	2300500	8/8/1979	42	2.7	
USGS	2300500	8/9/1979	52	2.9	
USGS	2300500	8/10/1979	41	2.7	
USGS	2300500	8/11/1979	58	3.0	
USGS	2300500	8/12/1979	152	4.2	
USGS	2300500	8/13/1979	224	5.0	
USGS	2300500	8/14/1979	209	4.9	
USGS	2300500	8/15/1979	169	4.4	
USGS	2300500	8/16/1979	139	4.1	
USGS	2300500	8/17/1979	200	4.8	
USGS	2300500	8/18/1979	156	4.3	
USGS	2300500	8/19/1979	154	4.3	
USGS	2300500	8/20/1979	185	4.6	
USGS	2300500	8/21/1979	280	5.4	
USGS	2300500	8/22/1979	206	4.8	

USGS	2300500	8/23/1979	227	5.0
USGS	2300500	8/24/1979	523	7.2
USGS	2300500	8/25/1979	540	7.3
USGS	2300500	8/26/1979	686	8.2
USGS	2300500	8/27/1979	609	7.8
USGS	2300500	8/28/1979	338	5.6
USGS	2300500	8/29/1979	220	4.4
USGS	2300500	8/30/1979	368	5.8
USGS	2300500	8/31/1979	413	6.2
USGS	2300500	9/1/1979	272	5.0
USGS	2300500	9/2/1979	140	3.5
USGS	2300500	9/3/1979	134	3.5
USGS	2300500	9/4/1979	150	3.7
USGS	2300500	9/5/1979	125	3.4
USGS	2300500	9/6/1979	166	3.8
USGS	2300500	9/7/1979	303	5.2
USGS	2300500	9/8/1979	286	5.1
USGS	2300500	9/9/1979	197	4.2
USGS	2300500	9/10/1979	164	3.8
USGS	2300500	9/11/1979	137	3.5
USGS	2300500	9/12/1979	171	3.9
USGS	2300500	9/13/1979	511	7.1
USGS	2300500	9/14/1979	1170	10.3
USGS	2300500	9/15/1979	1810	12.1
USGS	2300500	9/16/1979	2180	12.9
USGS	2300500	9/17/1979	1580	11.6
USGS	2300500	9/18/1979	941	9.5
USGS	2300500	9/19/1979	497	7.0
USGS	2300500	9/20/1979	318	5.4
USGS	2300500	9/21/1979	292	5.1
USGS	2300500	9/22/1979	1560	11.5
USGS	2300500	9/23/1979	5030	16.2
USGS	2300500	9/24/1979	3250	14.5
USGS	2300500	9/25/1979	2140	12.8
USGS	2300500	9/26/1979	1780	12.1
USGS	2300500	9/27/1979	1740	12.0
USGS	2300500	9/28/1979	1590	11.6
USGS	2300500	9/29/1979	1330	10.9
USGS	2300500	9/30/1979	1580	11.6
USGS	2300500	10/1/1979	1730	12.0
USGS	2300500	10/2/1979	1540	11.5
USGS	2300500	10/3/1979	1140	10.2
USGS	2300500	10/4/1979	586	7.6
USGS	2300500	10/5/1979	342	5.6
USGS	2300500	10/6/1979	253	4.7
USGS	2300500	10/7/1979	201	4.1
USGS	2300500	10/8/1979	167	3.7
USGS	2300500	10/9/1979	139	3.4
USGS	2300500	10/10/1979	126	3.2
USGS	2300500	10/11/1979	115	3.1
USGS	2300500	10/12/1979	102	2.9
USGS	2300500	10/13/1979	97	2.8
USGS	2300500	10/14/1979	92	2.7
USGS	2300500	10/15/1979	84	2.6
USGS	2300500	10/16/1979	84	2.6

USGS	2300500	10/17/1979	177	3.8	
USGS	2300500	10/18/1979	172	3.8	
USGS	2300500	10/19/1979	160	3.6	
USGS	2300500	10/20/1979	128	3.2	176
USGS	2300500	10/21/1979	106	2.9	
USGS	2300500	10/22/1979	90	2.7	
USGS	2300500	10/23/1979	83	2.6	
USGS	2300500	10/24/1979	76	2.5	
USGS	2300500	10/25/1979	71	2.4	
USGS	2300500	10/26/1979	66	2.3	175
USGS	2300500	10/27/1979	60	2.2	
USGS	2300500	10/28/1979	57	2.1	
USGS	2300500	10/29/1979	56	2.1	
USGS	2300500	10/30/1979	55	2.1	
USGS	2300500	10/31/1979	53	2.1	134
USGS	2300500	11/1/1979	52	2.0	
USGS	2300500	11/2/1979	59	2.2	
USGS	2300500	11/3/1979	105	2.9	
USGS	2300500	11/4/1979	158	3.6	
USGS	2300500	11/5/1979	118	3.1	
USGS	2300500	11/6/1979	86	2.6	
USGS	2300500	11/7/1979	75	2.5	130
USGS	2300500	11/8/1979	66	2.3	
USGS	2300500	11/9/1979	60	2.2	
USGS	2300500	11/10/1979	53	2.1	
USGS	2300500	11/11/1979	64	2.3	
USGS	2300500	11/12/1979	55	2.1	
USGS	2300500	11/13/1979	58	2.2	218
USGS	2300500	11/14/1979	55	2.2	
USGS	2300500	11/15/1979	53	2.1	
USGS	2300500	11/16/1979	51	2.1	
USGS	2300500	11/17/1979	53	2.1	
USGS	2300500	11/18/1979	51	2.1	
USGS	2300500	11/19/1979	50	2.1	221
USGS	2300500	11/20/1979	48	2.1	
USGS	2300500	11/21/1979	48	2.0	
USGS	2300500	11/22/1979	48	2.1	
USGS	2300500	11/23/1979	46	2.0	
USGS	2300500	11/24/1979	44	2.0	
USGS	2300500	11/25/1979	47	2.0	
USGS	2300500	11/26/1979	47	2.1	
USGS	2300500	11/27/1979	45	2.0	
USGS	2300500	11/28/1979	50	2.1	
USGS	2300500	11/29/1979	49	2.1	
USGS	2300500	11/30/1979	49	2.1	227
USGS	2300500	12/1/1979	49	2.1	
USGS	2300500	12/2/1979	50	2.1	
USGS	2300500	12/3/1979	47	2.1	
USGS	2300500	12/4/1979	45	2.0	
USGS	2300500	12/5/1979	45	2.0	
USGS	2300500	12/6/1979	49	2.1	225
USGS	2300500	12/7/1979	81	2.6	
USGS	2300500	12/8/1979	78	2.6	
USGS	2300500	12/9/1979	69	2.5	
USGS	2300500	12/10/1979	58	2.3	

USGS	2300500	12/11/1979	52	2.2	
USGS	2300500	12/12/1979	61	2.3	
USGS	2300500	12/13/1979	58	2.3	155
USGS	2300500	12/14/1979	57	2.3	
USGS	2300500	12/15/1979	56	2.3	
USGS	2300500	12/16/1979	66	2.4	
USGS	2300500	12/17/1979	87	2.8	
USGS	2300500	12/18/1979	77	2.6	
USGS	2300500	12/19/1979	65	2.4	
USGS	2300500	12/20/1979	56	2.3	
USGS	2300500	12/21/1979	51	2.2	
USGS	2300500	12/22/1979	48	2.2	
USGS	2300500	12/23/1979	60	2.4	
USGS	2300500	12/24/1979	58	2.3	156
USGS	2300500	12/25/1979	54	2.3	
USGS	2300500	12/26/1979	52	2.2	
USGS	2300500	12/27/1979	50	2.2	
USGS	2300500	12/28/1979	51	2.2	
USGS	2300500	12/29/1979	53	2.3	
USGS	2300500	12/30/1979	52	2.2	
USGS	2300500	12/31/1979	51	2.3	146
USGS	2300500	1/1/1980	50	2.2	
USGS	2300500	1/2/1980	45	2.1	
USGS	2300500	1/3/1980	44	2.1	
USGS	2300500	1/4/1980	46	2.2	
USGS	2300500	1/5/1980	54	2.3	
USGS	2300500	1/6/1980	50	2.2	
USGS	2300500	1/7/1980	54	2.3	149
USGS	2300500	1/8/1980	52	2.3	
USGS	2300500	1/9/1980	50	2.2	
USGS	2300500	1/10/1980	48	2.2	
USGS	2300500	1/11/1980	48	2.2	
USGS	2300500	1/12/1980	51	2.3	
USGS	2300500	1/13/1980	86	2.8	
USGS	2300500	1/14/1980	96	2.9	134
USGS	2300500	1/15/1980	90	2.9	
USGS	2300500	1/16/1980	75	2.6	
USGS	2300500	1/17/1980	67	2.5	
USGS	2300500	1/18/1980	76	2.7	
USGS	2300500	1/19/1980	70	2.6	
USGS	2300500	1/20/1980	65	2.5	186
USGS	2300500	1/21/1980	57	2.4	
USGS	2300500	1/22/1980	46	2.2	
USGS	2300500	1/23/1980	62	2.5	
USGS	2300500	1/24/1980	56	2.3	
USGS	2300500	1/25/1980	64	2.5	
USGS	2300500	1/26/1980	64	2.5	
USGS	2300500	1/27/1980	214	4.4	
USGS	2300500	1/28/1980	235	4.6	
USGS	2300500	1/29/1980	184	4.0	
USGS	2300500	1/30/1980	136	3.5	122
USGS	2300500	1/31/1980	108	3.1	
USGS	2300500	2/1/1980	94	2.9	
USGS	2300500	2/2/1980	84	2.8	
USGS	2300500	2/3/1980	76	2.7	

USGS	2300500	2/4/1980	69	2.6	
USGS	2300500	2/5/1980	63	2.5	
USGS	2300500	2/6/1980	63	2.5	
USGS	2300500	2/7/1980	60	2.4	
USGS	2300500	2/8/1980	60	2.4	
USGS	2300500	2/9/1980	57	2.4	
USGS	2300500	2/10/1980	108	3.1	
USGS	2300500	2/11/1980	141	3.5	
USGS	2300500	2/12/1980	111	3.2	
USGS	2300500	2/13/1980	84	2.8	
USGS	2300500	2/14/1980	77	2.7	
USGS	2300500	2/15/1980	86	2.8	
USGS	2300500	2/16/1980	197	4.2	229
USGS	2300500	2/17/1980	241	4.6	
USGS	2300500	2/18/1980	168	3.9	
USGS	2300500	2/19/1980	153	3.7	
USGS	2300500	2/20/1980	150	3.7	
USGS	2300500	2/21/1980	131	3.4	
USGS	2300500	2/22/1980	112	3.2	324
USGS	2300500	2/23/1980	97	3.0	
USGS	2300500	2/24/1980	90	2.9	
USGS	2300500	2/25/1980	82	2.7	
USGS	2300500	2/26/1980	74	2.6	
USGS	2300500	2/27/1980	65	2.5	
USGS	2300500	2/28/1980	66	2.5	
USGS	2300500	2/29/1980	67	2.5	
USGS	2300500	3/1/1980	83	2.7	
USGS	2300500	3/2/1980	225	4.5	
USGS	2300500	3/3/1980	197	4.2	198
USGS	2300500	3/4/1980	183	4.0	
USGS	2300500	3/5/1980	127	3.3	
USGS	2300500	3/6/1980	102	3.0	
USGS	2300500	3/7/1980	93	2.9	
USGS	2300500	3/8/1980	88	2.8	
USGS	2300500	3/9/1980	81	2.7	
USGS	2300500	3/10/1980	70	2.6	194
USGS	2300500	3/11/1980	65	2.5	
USGS	2300500	3/12/1980	63	2.4	
USGS	2300500	3/13/1980	65	2.5	
USGS	2300500	3/14/1980	60	2.4	
USGS	2300500	3/15/1980	60	2.4	
USGS	2300500	3/16/1980	60	2.4	
USGS	2300500	3/17/1980	60	2.4	144
USGS	2300500	3/18/1980	60	2.4	
USGS	2300500	3/19/1980	58	2.4	
USGS	2300500	3/20/1980	59	2.4	
USGS	2300500	3/21/1980	57	2.4	
USGS	2300500	3/22/1980	53	2.3	
USGS	2300500	3/23/1980	49	2.2	
USGS	2300500	3/24/1980	48	2.2	
USGS	2300500	3/25/1980	48	2.2	
USGS	2300500	3/26/1980	47	2.2	
USGS	2300500	3/27/1980	50	2.3	321
USGS	2300500	3/28/1980	49	2.2	
USGS	2300500	3/29/1980	48	2.2	

USGS	2300500	3/30/1980	59	2.4	
USGS	2300500	3/31/1980	65	2.5	
USGS	2300500	4/1/1980	106	3.0	
USGS	2300500	4/2/1980	238	4.6	
USGS	2300500	4/3/1980	260	4.8	
USGS	2300500	4/4/1980	231	4.5	
USGS	2300500	4/5/1980	170	3.9	
USGS	2300500	4/6/1980	124	3.3	129
USGS	2300500	4/7/1980	100	3.0	
USGS	2300500	4/8/1980	113	3.2	
USGS	2300500	4/9/1980	129	3.4	
USGS	2300500	4/10/1980	132	3.4	
USGS	2300500	4/11/1980	105	3.1	
USGS	2300500	4/12/1980	94	2.9	
USGS	2300500	4/13/1980	78	2.7	
USGS	2300500	4/14/1980	166	3.8	
USGS	2300500	4/15/1980	282	5.0	
USGS	2300500	4/16/1980	259	4.8	96
USGS	2300500	4/17/1980	208	4.3	
USGS	2300500	4/18/1980	148	3.6	
USGS	2300500	4/19/1980	115	3.3	
USGS	2300500	4/20/1980	87	2.9	
USGS	2300500	4/21/1980	68	2.6	
USGS	2300500	4/22/1980	54	2.4	
USGS	2300500	4/23/1980	48	2.3	
USGS	2300500	4/24/1980	44	2.3	
USGS	2300500	4/25/1980	42	2.2	
USGS	2300500	4/26/1980	42	2.2	322
USGS	2300500	4/27/1980	40	2.2	
USGS	2300500	4/28/1980	37	2.2	
USGS	2300500	4/29/1980	36	2.1	
USGS	2300500	4/30/1980	34	2.1	
USGS	2300500	5/1/1980	34	2.1	
USGS	2300500	5/2/1980	35	2.1	
USGS	2300500	5/3/1980	34	2.1	417
USGS	2300500	5/4/1980	34	2.1	
USGS	2300500	5/5/1980	34	2.1	
USGS	2300500	5/6/1980	32	2.1	
USGS	2300500	5/7/1980	30	2.0	
USGS	2300500	5/8/1980	30	2.0	
USGS	2300500	5/9/1980	51	2.4	
USGS	2300500	5/10/1980	64	2.6	630
USGS	2300500	5/11/1980	51	2.4	
USGS	2300500	5/12/1980	40	2.2	
USGS	2300500	5/13/1980	34	2.1	
USGS	2300500	5/14/1980	32	2.1	
USGS	2300500	5/15/1980	31	2.1	
USGS	2300500	5/16/1980	34	2.1	
USGS	2300500	5/17/1980	35	2.2	
USGS	2300500	5/18/1980	36	2.2	
USGS	2300500	5/19/1980	32	2.1	
USGS	2300500	5/20/1980	32	2.1	
USGS	2300500	5/21/1980	38	2.2	
USGS	2300500	5/22/1980	156	3.8	
USGS	2300500	5/23/1980	166	3.9	

USGS	2300500	5/24/1980	145	3.6	
USGS	2300500	5/25/1980	199	4.2	
USGS	2300500	5/26/1980	481	6.7	
USGS	2300500	5/27/1980	719	8.4	
USGS	2300500	5/28/1980	750	8.6	88
USGS	2300500	5/29/1980	424	6.3	
USGS	2300500	5/30/1980	151	3.7	
USGS	2300500	5/31/1980	96	3.1	
USGS	2300500	6/1/1980	78	2.8	
USGS	2300500	6/2/1980	73	2.7	
USGS	2300500	6/3/1980	62	2.6	
USGS	2300500	6/4/1980	54	2.4	227
USGS	2300500	6/5/1980	47	2.3	
USGS	2300500	6/6/1980	44	2.3	
USGS	2300500	6/7/1980	39	2.2	
USGS	2300500	6/8/1980	34	2.1	
USGS	2300500	6/9/1980	32	2.1	
USGS	2300500	6/10/1980	33	2.1	228
USGS	2300500	6/11/1980	33	2.1	
USGS	2300500	6/12/1980	41	2.2	
USGS	2300500	6/13/1980	37	2.2	
USGS	2300500	6/14/1980	44	2.3	
USGS	2300500	6/15/1980	35	2.1	
USGS	2300500	6/16/1980	31	2.0	
USGS	2300500	6/17/1980	28	2.0	
USGS	2300500	6/18/1980	26	2.0	
USGS	2300500	6/19/1980	27	2.0	160
USGS	2300500	6/20/1980	26	2.0	
USGS	2300500	6/21/1980	293	4.6	
USGS	2300500	6/22/1980	760	8.7	
USGS	2300500	6/23/1980	628	7.9	
USGS	2300500	6/24/1980	199	4.2	
USGS	2300500	6/25/1980	109	3.2	
USGS	2300500	6/26/1980	77	2.8	131
USGS	2300500	6/27/1980	58	2.5	
USGS	2300500	6/28/1980	59	2.5	
USGS	2300500	6/29/1980	46	2.3	
USGS	2300500	6/30/1980	48	2.3	
USGS	2300500	7/1/1980	43	2.3	
USGS	2300500	7/2/1980	39	2.2	
USGS	2300500	7/3/1980	40	2.2	
USGS	2300500	7/4/1980	55	2.4	
USGS	2300500	7/5/1980	108	3.2	
USGS	2300500	7/6/1980	85	2.9	
USGS	2300500	7/7/1980	71	2.7	
USGS	2300500	7/8/1980	96	3.0	
USGS	2300500	7/9/1980	95	3.0	
USGS	2300500	7/10/1980	63	2.5	
USGS	2300500	7/11/1980	58	2.5	
USGS	2300500	7/12/1980	52	2.4	
USGS	2300500	7/13/1980	47	2.3	
USGS	2300500	7/14/1980	42	2.2	
USGS	2300500	7/15/1980	40	2.2	
USGS	2300500	7/16/1980	40	2.2	
USGS	2300500	7/17/1980	91	2.8	

USGS	2300500	7/18/1980	154	3.7	
USGS	2300500	7/19/1980	157	3.7	
USGS	2300500	7/20/1980	105	3.1	
USGS	2300500	7/21/1980	107	3.2	
USGS	2300500	7/22/1980	98	3.1	
USGS	2300500	7/23/1980	83	2.9	
USGS	2300500	7/24/1980	79	2.8	
USGS	2300500	7/25/1980	135	3.5	
USGS	2300500	7/26/1980	287	5.1	
USGS	2300500	7/27/1980	252	4.7	
USGS	2300500	7/28/1980	174	3.9	110
USGS	2300500	7/29/1980	128	3.4	
USGS	2300500	7/30/1980	102	3.1	
USGS	2300500	7/31/1980	82	2.8	
USGS	2300500	8/1/1980	76	2.8	
USGS	2300500	8/2/1980	65	2.6	
USGS	2300500	8/3/1980	56	2.5	
USGS	2300500	8/4/1980	48	2.3	
USGS	2300500	8/5/1980	44	2.3	
USGS	2300500	8/6/1980	41	2.2	
USGS	2300500	8/7/1980	38	2.2	
USGS	2300500	8/8/1980	39	2.2	
USGS	2300500	8/9/1980	56	2.4	
USGS	2300500	8/10/1980	115	3.3	
USGS	2300500	8/11/1980	80	2.8	
USGS	2300500	8/12/1980	130	3.4	
USGS	2300500	8/13/1980	213	4.3	
USGS	2300500	8/14/1980	171	3.9	
USGS	2300500	8/15/1980	124	3.4	
USGS	2300500	8/16/1980	130	3.5	
USGS	2300500	8/17/1980	140	3.6	
USGS	2300500	8/18/1980	114	3.2	
USGS	2300500	8/19/1980	150	3.7	
USGS	2300500	8/20/1980	169	3.9	
USGS	2300500	8/21/1980	172	3.9	
USGS	2300500	8/22/1980	153	3.7	
USGS	2300500	8/23/1980	180	4.0	
USGS	2300500	8/24/1980	184	4.0	
USGS	2300500	8/25/1980	241	4.6	
USGS	2300500	8/26/1980	175	3.9	
USGS	2300500	8/27/1980	127	3.4	
USGS	2300500	8/28/1980	124	3.4	
USGS	2300500	8/29/1980	109	3.2	
USGS	2300500	8/30/1980	116	3.3	
USGS	2300500	8/31/1980	152	3.7	
USGS	2300500	9/1/1980	140	3.5	
USGS	2300500	9/2/1980	242	4.6	
USGS	2300500	9/3/1980	325	5.4	
USGS	2300500	9/4/1980	734	8.5	
USGS	2300500	9/5/1980	560	7.4	
USGS	2300500	9/6/1980	387	6.0	
USGS	2300500	9/7/1980	310	5.3	
USGS	2300500	9/8/1980	306	5.3	100
USGS	2300500	9/9/1980	182	4.0	
USGS	2300500	9/10/1980	142	3.6	

USGS	2300500	9/11/1980	125	3.4	
USGS	2300500	9/12/1980	97	3.1	
USGS	2300500	9/13/1980	89	3.0	
USGS	2300500	9/14/1980	159	3.8	
USGS	2300500	9/15/1980	390	6.0	131
USGS	2300500	9/16/1980	514	7.1	
USGS	2300500	9/17/1980	498	6.9	
USGS	2300500	9/18/1980	523	7.2	
USGS	2300500	9/19/1980	396	6.1	
USGS	2300500	9/20/1980	271	5.0	
USGS	2300500	9/21/1980	187	4.1	
USGS	2300500	9/22/1980	139	3.6	
USGS	2300500	9/23/1980	114	3.3	
USGS	2300500	9/24/1980	97	3.1	92
USGS	2300500	9/25/1980	108	3.2	
USGS	2300500	9/26/1980	85	2.9	
USGS	2300500	9/27/1980	72	2.7	
USGS	2300500	9/28/1980	64	2.6	
USGS	2300500	9/29/1980	58	2.5	
USGS	2300500	9/30/1980	53	2.5	279
USGS	2300500	10/1/1980	83	2.8	341
USGS	2300500	10/2/1980	119	3.3	
USGS	2300500	10/3/1980	91	3.0	
USGS	2300500	10/4/1980	74	2.8	
USGS	2300500	10/5/1980	63	2.6	
USGS	2300500	10/6/1980	53	2.5	
USGS	2300500	10/7/1980	50	2.4	
USGS	2300500	10/8/1980	48	2.4	
USGS	2300500	10/9/1980	47	2.4	
USGS	2300500	10/10/1980	46	2.3	
USGS	2300500	10/11/1980	44	2.3	342
USGS	2300500	10/12/1980	43	2.3	
USGS	2300500	10/13/1980	40	2.2	
USGS	2300500	10/14/1980	37	2.2	
USGS	2300500	10/15/1980	37	2.2	
USGS	2300500	10/16/1980	37	2.2	
USGS	2300500	10/17/1980	38	2.2	
USGS	2300500	10/18/1980	39	2.2	
USGS	2300500	10/19/1980	38	2.2	
USGS	2300500	10/20/1980	36	2.2	316
USGS	2300500	10/21/1980	37	2.2	
USGS	2300500	10/22/1980	37	2.2	
USGS	2300500	10/23/1980	36	2.2	
USGS	2300500	10/24/1980	36	2.2	
USGS	2300500	10/25/1980	34	2.2	
USGS	2300500	10/26/1980	32	2.1	
USGS	2300500	10/27/1980	30	2.1	
USGS	2300500	10/28/1980	32	2.2	
USGS	2300500	10/29/1980	31	2.2	317
USGS	2300500	10/30/1980	30	2.1	
USGS	2300500	10/31/1980	29	2.1	
USGS	2300500	11/1/1980	30	2.1	
USGS	2300500	11/2/1980	29	2.1	
USGS	2300500	11/3/1980	27	2.1	
USGS	2300500	11/4/1980	27	2.1	

USGS	2300500	11/5/1980	26	2.1	
USGS	2300500	11/6/1980	26	2.1	239
USGS	2300500	11/7/1980	26	2.1	
USGS	2300500	11/8/1980	26	2.1	
USGS	2300500	11/9/1980	26	2.1	
USGS	2300500	11/10/1980	25	2.1	
USGS	2300500	11/11/1980	22	2.0	
USGS	2300500	11/12/1980	21	2.0	
USGS	2300500	11/13/1980	22	2.0	189
USGS	2300500	11/14/1980	22	2.0	
USGS	2300500	11/15/1980	34	2.2	
USGS	2300500	11/16/1980	29	2.2	
USGS	2300500	11/17/1980	37	2.3	
USGS	2300500	11/18/1980	50	2.5	
USGS	2300500	11/19/1980	41	2.4	238
USGS	2300500	11/20/1980	34	2.2	
USGS	2300500	11/21/1980	32	2.2	
USGS	2300500	11/22/1980	30	2.1	
USGS	2300500	11/23/1980	31	2.2	
USGS	2300500	11/24/1980	31	2.2	
USGS	2300500	11/25/1980	33	2.2	192
USGS	2300500	11/26/1980	29	2.1	
USGS	2300500	11/27/1980	32	2.2	
USGS	2300500	11/28/1980	121	3.5	
USGS	2300500	11/29/1980	164	3.9	
USGS	2300500	11/30/1980	110	3.3	
USGS	2300500	12/1/1980	72	2.8	
USGS	2300500	12/2/1980	60	2.6	
USGS	2300500	12/3/1980	54	2.5	
USGS	2300500	12/4/1980	48	2.4	
USGS	2300500	12/5/1980	44	2.3	
USGS	2300500	12/6/1980	42	2.3	
USGS	2300500	12/7/1980	39	2.2	
USGS	2300500	12/8/1980	36	2.2	
USGS	2300500	12/9/1980	35	2.2	
USGS	2300500	12/10/1980	34	2.1	
USGS	2300500	12/11/1980	34	2.1	
USGS	2300500	12/12/1980	33	2.1	
USGS	2300500	12/13/1980	33	2.1	
USGS	2300500	12/14/1980	32	2.1	
USGS	2300500	12/15/1980	32	2.1	
USGS	2300500	12/16/1980	34	2.1	
USGS	2300500	12/17/1980	45	2.3	
USGS	2300500	12/18/1980	46	2.3	
USGS	2300500	12/19/1980	40	2.2	
USGS	2300500	12/20/1980	38	2.2	
USGS	2300500	12/21/1980	35	2.1	
USGS	2300500	12/22/1980	32	2.1	
USGS	2300500	12/23/1980	38	2.2	
USGS	2300500	12/24/1980	42	2.3	
USGS	2300500	12/25/1980	39	2.3	
USGS	2300500	12/26/1980	37	2.2	
USGS	2300500	12/27/1980	35	2.1	
USGS	2300500	12/28/1980	34	2.1	
USGS	2300500	12/29/1980	34	2.1	

USGS	2300500	12/30/1980	37	2.2	
USGS	2300500	12/31/1980	36	2.2	
USGS	2300500	1/1/1981	35	2.1	
USGS	2300500	1/2/1981	37	2.1	
USGS	2300500	1/3/1981	38	2.2	
USGS	2300500	1/4/1981	38	2.1	
USGS	2300500	1/5/1981	39	2.2	
USGS	2300500	1/6/1981	39	2.2	
USGS	2300500	1/7/1981	41	2.2	
USGS	2300500	1/8/1981	41	2.2	
USGS	2300500	1/9/1981	39	2.1	
USGS	2300500	1/10/1981	40	2.1	
USGS	2300500	1/11/1981	40	2.1	
USGS	2300500	1/12/1981	39	2.1	
USGS	2300500	1/13/1981	43	2.2	
USGS	2300500	1/14/1981	48	2.3	
USGS	2300500	1/15/1981	50	2.3	
USGS	2300500	1/16/1981	46	2.2	
USGS	2300500	1/17/1981	43	2.2	
USGS	2300500	1/18/1981	41	2.2	
USGS	2300500	1/19/1981	44	2.2	
USGS	2300500	1/20/1981	44	2.2	
USGS	2300500	1/21/1981	54	2.4	
USGS	2300500	1/22/1981	49	2.3	
USGS	2300500	1/23/1981	46	2.2	
USGS	2300500	1/24/1981	49	2.3	
USGS	2300500	1/25/1981	53	2.3	
USGS	2300500	1/26/1981	48	2.3	
USGS	2300500	1/27/1981	47	2.3	
USGS	2300500	1/28/1981	48	2.3	
USGS	2300500	1/29/1981	48	2.3	316
USGS	2300500	1/30/1981	49	2.3	
USGS	2300500	1/31/1981	50	2.3	
USGS	2300500	2/1/1981	47	2.3	
USGS	2300500	2/2/1981	46	2.3	
USGS	2300500	2/3/1981	44	2.2	
USGS	2300500	2/4/1981	46	2.3	
USGS	2300500	2/5/1981	47	2.3	
USGS	2300500	2/6/1981	46	2.2	
USGS	2300500	2/7/1981	48	2.3	
USGS	2300500	2/8/1981	346	5.4	
USGS	2300500	2/9/1981	561	7.4	320
USGS	2300500	2/10/1981	360	5.8	
USGS	2300500	2/11/1981	226	4.5	
USGS	2300500	2/12/1981	205	4.3	
USGS	2300500	2/13/1981	159	3.8	
USGS	2300500	2/14/1981	134	3.5	
USGS	2300500	2/15/1981	109	3.2	
USGS	2300500	2/16/1981	90	3.0	215
USGS	2300500	2/17/1981	90	2.9	
USGS	2300500	2/18/1981	184	4.0	
USGS	2300500	2/19/1981	102	3.1	
USGS	2300500	2/20/1981	83	2.9	
USGS	2300500	2/21/1981	72	2.7	
USGS	2300500	2/22/1981	65	2.6	

USGS	2300500	2/23/1981	58	2.5	207
USGS	2300500	2/24/1981	58	2.5	
USGS	2300500	2/25/1981	58	2.5	
USGS	2300500	2/26/1981	60	2.5	
USGS	2300500	2/27/1981	57	2.5	
USGS	2300500	2/28/1981	58	2.5	
USGS	2300500	3/1/1981	54	2.4	
USGS	2300500	3/2/1981	53	2.4	
USGS	2300500	3/3/1981	47	2.3	
USGS	2300500	3/4/1981	48	2.4	
USGS	2300500	3/5/1981	49	2.4	
USGS	2300500	3/6/1981	47	2.3	
USGS	2300500	3/7/1981	45	2.3	
USGS	2300500	3/8/1981	46	2.3	
USGS	2300500	3/9/1981	44	2.3	311
USGS	2300500	3/10/1981	46	2.3	
USGS	2300500	3/11/1981	43	2.3	
USGS	2300500	3/12/1981	44	2.3	215
USGS	2300500	3/13/1981	46	2.4	
USGS	2300500	3/14/1981	46	2.4	
USGS	2300500	3/15/1981	42	2.3	
USGS	2300500	3/16/1981	43	2.3	
USGS	2300500	3/17/1981	43	2.3	
USGS	2300500	3/18/1981	41	2.3	217
USGS	2300500	3/19/1981	53	2.5	
USGS	2300500	3/20/1981	50	2.5	
USGS	2300500	3/21/1981	47	2.5	
USGS	2300500	3/22/1981	49	2.5	
USGS	2300500	3/23/1981	62	2.7	
USGS	2300500	3/24/1981	53	2.6	
USGS	2300500	3/25/1981	48	2.5	369
USGS	2300500	3/26/1981	45	2.4	
USGS	2300500	3/27/1981	44	2.4	
USGS	2300500	3/28/1981	43	2.4	
USGS	2300500	3/29/1981	40	2.4	
USGS	2300500	3/30/1981	38	2.3	
USGS	2300500	3/31/1981	39	2.4	366
USGS	2300500	4/1/1981	41	2.4	
USGS	2300500	4/2/1981	40	2.4	
USGS	2300500	4/3/1981	36	2.3	
USGS	2300500	4/4/1981	36	2.3	
USGS	2300500	4/5/1981	35	2.3	
USGS	2300500	4/6/1981	33	2.3	
USGS	2300500	4/7/1981	31	2.2	
USGS	2300500	4/8/1981	32	2.3	
USGS	2300500	4/9/1981	33	2.3	
USGS	2300500	4/10/1981	33	2.3	
USGS	2300500	4/11/1981	34	2.3	
USGS	2300500	4/12/1981	32	2.3	
USGS	2300500	4/13/1981	29	2.3	
USGS	2300500	4/14/1981	28	2.2	
USGS	2300500	4/15/1981	27	2.2	
USGS	2300500	4/16/1981	24	2.2	
USGS	2300500	4/17/1981	25	2.2	
USGS	2300500	4/18/1981	27	2.2	

USGS	2300500	4/19/1981	27	2.2	
USGS	2300500	4/20/1981	25	2.2	
USGS	2300500	4/21/1981	24	2.2	
USGS	2300500	4/22/1981	24	2.2	
USGS	2300500	4/23/1981	25	2.3	
USGS	2300500	4/24/1981	26	2.3	
USGS	2300500	4/25/1981	23	2.2	
USGS	2300500	4/26/1981	22	2.2	
USGS	2300500	4/27/1981	24	2.3	
USGS	2300500	4/28/1981	30	2.3	
USGS	2300500	4/29/1981	25	2.3	
USGS	2300500	4/30/1981	25	2.3	
USGS	2300500	5/1/1981	25	2.3	
USGS	2300500	5/2/1981	24	2.3	
USGS	2300500	5/3/1981	21	2.2	
USGS	2300500	5/4/1981	18	2.2	
USGS	2300500	5/5/1981	16	2.2	
USGS	2300500	5/6/1981	16	2.2	
USGS	2300500	5/7/1981	18	2.3	
USGS	2300500	5/8/1981	25	2.3	
USGS	2300500	5/9/1981	26	2.3	
USGS	2300500	5/10/1981	25	2.3	
USGS	2300500	5/11/1981	22	2.3	
USGS	2300500	5/12/1981	17	2.1	
USGS	2300500	5/13/1981	17	2.1	
USGS	2300500	5/14/1981	18	2.2	
USGS	2300500	5/15/1981	19	2.2	
USGS	2300500	5/16/1981	20	2.2	
USGS	2300500	5/17/1981	18	2.2	
USGS	2300500	5/18/1981	16	2.1	
USGS	2300500	5/19/1981	15	2.1	
USGS	2300500	5/20/1981	14	2.1	
USGS	2300500	5/21/1981	14	2.1	
USGS	2300500	5/22/1981	13	2.0	
USGS	2300500	5/23/1981	10	2.0	
USGS	2300500	5/24/1981	8	2.0	
USGS	2300500	5/25/1981	7	1.9	
USGS	2300500	5/26/1981	89	2.7	
USGS	2300500	5/27/1981	465	6.7	
USGS	2300500	5/28/1981	128	3.5	
USGS	2300500	5/29/1981	62	2.7	
USGS	2300500	5/30/1981	50	2.6	
USGS	2300500	5/31/1981	31	2.3	
USGS	2300500	6/1/1981	38	2.4	
USGS	2300500	6/2/1981	55	2.7	282
USGS	2300500	6/3/1981	61	2.7	
USGS	2300500	6/4/1981	57	2.7	
USGS	2300500	6/5/1981	36	2.4	
USGS	2300500	6/6/1981	54	2.6	
USGS	2300500	6/7/1981	56	2.7	
USGS	2300500	6/8/1981	65	2.8	
USGS	2300500	6/9/1981	65	2.8	
USGS	2300500	6/10/1981	58	2.7	
USGS	2300500	6/11/1981	50	2.5	
USGS	2300500	6/12/1981	44	2.5	

USGS	2300500	6/13/1981	44	2.5	
USGS	2300500	6/14/1981	32	2.3	
USGS	2300500	6/15/1981	24	2.1	
USGS	2300500	6/16/1981	20	2.0	
USGS	2300500	6/17/1981	19	2.0	
USGS	2300500	6/18/1981	20	2.1	
USGS	2300500	6/19/1981	34	2.3	
USGS	2300500	6/20/1981	23	2.2	
USGS	2300500	6/21/1981	25	2.2	
USGS	2300500	6/22/1981	32	2.3	
USGS	2300500	6/23/1981	49	2.6	
USGS	2300500	6/24/1981	50	2.6	
USGS	2300500	6/25/1981	84	3.0	
USGS	2300500	6/26/1981	100	3.2	
USGS	2300500	6/27/1981	304	5.3	
USGS	2300500	6/28/1981	207	4.3	
USGS	2300500	6/29/1981	108	3.3	185
USGS	2300500	6/30/1981	83	3.0	
USGS	2300500	7/1/1981	69	2.8	
USGS	2300500	7/2/1981	63	2.8	
USGS	2300500	7/3/1981	40	2.4	
USGS	2300500	7/4/1981	47	2.5	
USGS	2300500	7/5/1981	42	2.5	
USGS	2300500	7/6/1981	35	2.3	
USGS	2300500	7/7/1981	32	2.3	
USGS	2300500	7/8/1981	37	2.3	
USGS	2300500	7/9/1981	100	3.2	
USGS	2300500	7/10/1981	66	2.8	
USGS	2300500	7/11/1981	50	2.6	
USGS	2300500	7/12/1981	67	2.8	
USGS	2300500	7/13/1981	114	3.4	
USGS	2300500	7/14/1981	91	3.1	
USGS	2300500	7/15/1981	87	3.0	
USGS	2300500	7/16/1981	68	2.8	
USGS	2300500	7/17/1981	63	2.8	
USGS	2300500	7/18/1981	81	3.0	
USGS	2300500	7/19/1981	67	2.8	
USGS	2300500	7/20/1981	93	3.1	
USGS	2300500	7/21/1981	123	3.5	
USGS	2300500	7/22/1981	112	3.3	
USGS	2300500	7/23/1981	87	3.0	
USGS	2300500	7/24/1981	95	3.1	
USGS	2300500	7/25/1981	130	3.5	
USGS	2300500	7/26/1981	138	3.6	
USGS	2300500	7/27/1981	174	4.0	
USGS	2300500	7/28/1981	187	4.1	
USGS	2300500	7/29/1981	164	3.9	
USGS	2300500	7/30/1981	126	3.5	
USGS	2300500	7/31/1981	115	3.4	
USGS	2300500	8/1/1981	200	4.2	
USGS	2300500	8/2/1981	232	4.6	
USGS	2300500	8/3/1981	391	6.1	138
USGS	2300500	8/4/1981	362	5.8	
USGS	2300500	8/5/1981	523	7.3	
USGS	2300500	8/6/1981	506	7.1	

USGS	2300500	8/7/1981	518	7.0	
USGS	2300500	8/8/1981	616	8.0	
USGS	2300500	8/9/1981	341	5.6	
USGS	2300500	8/10/1981	200	4.2	
USGS	2300500	8/11/1981	148	3.7	
USGS	2300500	8/12/1981	146	3.7	
USGS	2300500	8/13/1981	171	3.9	155
USGS	2300500	8/14/1981	376	5.9	
USGS	2300500	8/15/1981	802	9.1	
USGS	2300500	8/16/1981	1140	10.6	
USGS	2300500	8/17/1981	635	8.0	
USGS	2300500	8/18/1981	223	4.5	
USGS	2300500	8/19/1981	155	3.8	
USGS	2300500	8/20/1981	272	4.7	130
USGS	2300500	8/21/1981	1900	12.6	
USGS	2300500	8/22/1981	2560	13.9	
USGS	2300500	8/23/1981	1900	12.7	
USGS	2300500	8/24/1981	1220	10.8	
USGS	2300500	8/25/1981	770	9.0	
USGS	2300500	8/26/1981	1100	10.5	116
USGS	2300500	8/27/1981	815	9.3	
USGS	2300500	8/28/1981	1050	10.9	
USGS	2300500	8/29/1981	1690	12.2	
USGS	2300500	8/30/1981	1670	12.1	
USGS	2300500	8/31/1981	1220	10.9	
USGS	2300500	9/1/1981	719	8.7	
USGS	2300500	9/2/1981	435	6.4	
USGS	2300500	9/3/1981	250	4.7	
USGS	2300500	9/4/1981	197	4.2	
USGS	2300500	9/5/1981	298	5.2	100
USGS	2300500	9/6/1981	628	8.1	
USGS	2300500	9/7/1981	2530	13.1	
USGS	2300500	9/8/1981	3630	15.2	
USGS	2300500	9/9/1981	1850	12.5	
USGS	2300500	9/10/1981	980	10.0	
USGS	2300500	9/11/1981	632	8.1	
USGS	2300500	9/12/1981	321	5.4	111
USGS	2300500	9/13/1981	205	4.3	
USGS	2300500	9/14/1981	155	3.7	
USGS	2300500	9/15/1981	142	3.6	
USGS	2300500	9/16/1981	145	3.6	
USGS	2300500	9/17/1981	191	4.1	
USGS	2300500	9/18/1981	202	4.3	
USGS	2300500	9/19/1981	340	5.6	
USGS	2300500	9/20/1981	191	4.1	112
USGS	2300500	9/21/1981	201	4.2	
USGS	2300500	9/22/1981	442	6.5	
USGS	2300500	9/23/1981	346	5.7	
USGS	2300500	9/24/1981	236	4.6	
USGS	2300500	9/25/1981	158	3.8	142
USGS	2300500	9/26/1981	131	3.5	
USGS	2300500	9/27/1981	116	3.3	
USGS	2300500	9/28/1981	108	3.2	
USGS	2300500	9/29/1981	100	3.0	
USGS	2300500	9/30/1981	90	2.9	

USGS	2300500	10/1/1981	85	2.8	
USGS	2300500	10/2/1981	77	2.7	
USGS	2300500	10/3/1981	75	2.7	
USGS	2300500	10/4/1981	73	2.6	
USGS	2300500	10/5/1981	72	2.6	
USGS	2300500	10/6/1981	64	2.5	
USGS	2300500	10/7/1981	61	2.5	
USGS	2300500	10/8/1981	59	2.4	
USGS	2300500	10/9/1981	55	2.4	
USGS	2300500	10/10/1981	54	2.4	
USGS	2300500	10/11/1981	54	2.4	
USGS	2300500	10/12/1981	54	2.4	230
USGS	2300500	10/13/1981	102	3.1	
USGS	2300500	10/14/1981	102	3.1	
USGS	2300500	10/15/1981	68	2.6	
USGS	2300500	10/16/1981	54	2.5	
USGS	2300500	10/17/1981	54	2.5	
USGS	2300500	10/18/1981	53	2.5	
USGS	2300500	10/19/1981	52	2.5	
USGS	2300500	10/20/1981	46	2.4	210
USGS	2300500	10/21/1981	44	2.3	
USGS	2300500	10/22/1981	43	2.3	
USGS	2300500	10/23/1981	43	2.3	
USGS	2300500	10/24/1981	43	2.3	
USGS	2300500	10/25/1981	43	2.3	
USGS	2300500	10/26/1981	44	2.3	230
USGS	2300500	10/27/1981	44	2.3	
USGS	2300500	10/28/1981	45	2.4	
USGS	2300500	10/29/1981	45	2.4	
USGS	2300500	10/30/1981	44	2.3	
USGS	2300500	10/31/1981	42	2.3	
USGS	2300500	11/1/1981	41	2.3	
USGS	2300500	11/2/1981	38	2.3	
USGS	2300500	11/3/1981	38	2.2	
USGS	2300500	11/4/1981	39	2.3	
USGS	2300500	11/5/1981	40	2.3	280
USGS	2300500	11/6/1981	40	2.3	
USGS	2300500	11/7/1981	39	2.3	
USGS	2300500	11/8/1981	38	2.2	
USGS	2300500	11/9/1981	39	2.2	
USGS	2300500	11/10/1981	46	2.4	
USGS	2300500	11/11/1981	53	2.5	
USGS	2300500	11/12/1981	47	2.4	
USGS	2300500	11/13/1981	42	2.3	
USGS	2300500	11/14/1981	39	2.3	200
USGS	2300500	11/15/1981	39	2.3	
USGS	2300500	11/16/1981	45	2.4	280
USGS	2300500	11/17/1981	54	2.5	
USGS	2300500	11/18/1981	42	2.3	
USGS	2300500	11/19/1981	39	2.3	
USGS	2300500	11/20/1981	38	2.2	
USGS	2300500	11/21/1981	37	2.2	
USGS	2300500	11/22/1981	38	2.2	
USGS	2300500	11/23/1981	38	2.2	245
USGS	2300500	11/24/1981	37	2.2	

USGS	2300500	11/25/1981	37	2.2	
USGS	2300500	11/26/1981	36	2.2	
USGS	2300500	11/27/1981	37	2.2	
USGS	2300500	11/28/1981	37	2.2	305
USGS	2300500	11/29/1981	36	2.2	
USGS	2300500	11/30/1981	35	2.2	
USGS	2300500	12/1/1981	34	2.2	
USGS	2300500	12/2/1981	40	2.3	
USGS	2300500	12/3/1981	51	2.5	
USGS	2300500	12/4/1981	53	2.5	
USGS	2300500	12/5/1981	51	2.5	105
USGS	2300500	12/6/1981	48	2.4	
USGS	2300500	12/7/1981	48	2.4	
USGS	2300500	12/8/1981	42	2.3	
USGS	2300500	12/9/1981	40	2.3	
USGS	2300500	12/10/1981	40	2.3	
USGS	2300500	12/11/1981	40	2.3	
USGS	2300500	12/12/1981	40	2.3	270
USGS	2300500	12/13/1981	39	2.3	
USGS	2300500	12/14/1981	38	2.3	
USGS	2300500	12/15/1981	46	2.4	
USGS	2300500	12/16/1981	45	2.4	
USGS	2300500	12/17/1981	46	2.4	
USGS	2300500	12/18/1981	43	2.3	
USGS	2300500	12/19/1981	41	2.3	
USGS	2300500	12/20/1981	42	2.3	245
USGS	2300500	12/21/1981	44	2.4	
USGS	2300500	12/22/1981	43	2.3	
USGS	2300500	12/23/1981	41	2.3	
USGS	2300500	12/24/1981	40	2.3	
USGS	2300500	12/25/1981	41	2.3	
USGS	2300500	12/26/1981	44	2.4	
USGS	2300500	12/27/1981	66	2.7	270
USGS	2300500	12/28/1981	72	2.8	
USGS	2300500	12/29/1981	63	2.6	
USGS	2300500	12/30/1981	54	2.5	
USGS	2300500	12/31/1981	50	2.4	
USGS	2300500	1/1/1982	48	2.4	
USGS	2300500	1/2/1982	47	2.4	
USGS	2300500	1/3/1982	47	2.4	195
USGS	2300500	1/4/1982	47	2.4	
USGS	2300500	1/5/1982	50	2.4	
USGS	2300500	1/6/1982	50	2.4	
USGS	2300500	1/7/1982	47	2.4	
USGS	2300500	1/8/1982	47	2.4	
USGS	2300500	1/9/1982	46	2.4	
USGS	2300500	1/10/1982	45	2.4	220
USGS	2300500	1/11/1982	44	2.3	
USGS	2300500	1/12/1982	45	2.4	
USGS	2300500	1/13/1982	50	2.5	
USGS	2300500	1/14/1982	90	3.0	
USGS	2300500	1/15/1982	93	3.1	
USGS	2300500	1/16/1982	79	2.9	
USGS	2300500	1/17/1982	69	2.7	
USGS	2300500	1/18/1982	62	2.6	200

USGS	2300500	1/19/1982	56	2.5	
USGS	2300500	1/20/1982	52	2.5	
USGS	2300500	1/21/1982	51	2.5	
USGS	2300500	1/22/1982	53	2.5	
USGS	2300500	1/23/1982	52	2.5	
USGS	2300500	1/24/1982	61	2.6	290
USGS	2300500	1/25/1982	71	2.8	
USGS	2300500	1/26/1982	61	2.6	
USGS	2300500	1/27/1982	55	2.5	
USGS	2300500	1/28/1982	52	2.5	
USGS	2300500	1/29/1982	51	2.5	
USGS	2300500	1/30/1982	51	2.5	
USGS	2300500	1/31/1982	49	2.4	
USGS	2300500	2/1/1982	48	2.4	
USGS	2300500	2/2/1982	48	2.4	
USGS	2300500	2/3/1982	48	2.4	275
USGS	2300500	2/4/1982	46	2.4	
USGS	2300500	2/5/1982	47	2.4	
USGS	2300500	2/6/1982	50	2.4	
USGS	2300500	2/7/1982	52	2.5	
USGS	2300500	2/8/1982	53	2.5	
USGS	2300500	2/9/1982	53	2.5	
USGS	2300500	2/10/1982	52	2.5	325
USGS	2300500	2/11/1982	52	2.5	
USGS	2300500	2/12/1982	55	2.5	
USGS	2300500	2/13/1982	54	2.5	
USGS	2300500	2/14/1982	53	2.5	
USGS	2300500	2/15/1982	59	2.6	
USGS	2300500	2/16/1982	289	5.1	
USGS	2300500	2/17/1982	293	5.2	
USGS	2300500	2/18/1982	258	4.8	275
USGS	2300500	2/19/1982	175	4.0	
USGS	2300500	2/20/1982	134	3.5	
USGS	2300500	2/21/1982	111	3.2	
USGS	2300500	2/22/1982	100	3.1	
USGS	2300500	2/23/1982	88	2.9	
USGS	2300500	2/24/1982	87	2.8	
USGS	2300500	2/25/1982	85	2.8	
USGS	2300500	2/26/1982	80	2.8	275
USGS	2300500	2/27/1982	77	2.7	
USGS	2300500	2/28/1982	73	2.7	
USGS	2300500	3/1/1982	70	2.6	
USGS	2300500	3/2/1982	72	2.6	
USGS	2300500	3/3/1982	74	2.7	
USGS	2300500	3/4/1982	80	2.8	
USGS	2300500	3/5/1982	147	3.6	
USGS	2300500	3/6/1982	548	7.3	205
USGS	2300500	3/7/1982	613	7.8	
USGS	2300500	3/8/1982	796	8.8	
USGS	2300500	3/9/1982	615	7.7	143
USGS	2300500	3/10/1982	250	4.7	
USGS	2300500	3/11/1982	153	3.7	
USGS	2300500	3/12/1982	128	3.4	
USGS	2300500	3/13/1982	116	3.2	
USGS	2300500	3/14/1982	110	3.2	

USGS	2300500	3/15/1982	105	3.1	
USGS	2300500	3/16/1982	100	3.0	
USGS	2300500	3/17/1982	97	3.0	
USGS	2300500	3/18/1982	91	2.9	
USGS	2300500	3/19/1982	97	3.0	
USGS	2300500	3/20/1982	91	2.9	305
USGS	2300500	3/21/1982	85	2.8	
USGS	2300500	3/22/1982	79	2.7	
USGS	2300500	3/23/1982	76	2.7	
USGS	2300500	3/24/1982	71	2.6	
USGS	2300500	3/25/1982	97	3.0	
USGS	2300500	3/26/1982	90	2.9	
USGS	2300500	3/27/1982	77	2.7	
USGS	2300500	3/28/1982	101	3.0	
USGS	2300500	3/29/1982	388	6.0	355
USGS	2300500	3/30/1982	329	5.5	
USGS	2300500	3/31/1982	215	4.4	
USGS	2300500	4/1/1982	162	3.8	
USGS	2300500	4/2/1982	130	3.4	
USGS	2300500	4/3/1982	114	3.2	
USGS	2300500	4/4/1982	105	3.1	
USGS	2300500	4/5/1982	101	3.0	236
USGS	2300500	4/6/1982	90	2.9	
USGS	2300500	4/7/1982	79	2.7	
USGS	2300500	4/8/1982	74	2.7	
USGS	2300500	4/9/1982	69	2.6	
USGS	2300500	4/10/1982	62	2.5	
USGS	2300500	4/11/1982	70	2.6	
USGS	2300500	4/12/1982	69	2.6	230
USGS	2300500	4/13/1982	65	2.5	
USGS	2300500	4/14/1982	66	2.5	
USGS	2300500	4/15/1982	65	2.5	
USGS	2300500	4/16/1982	63	2.5	
USGS	2300500	4/17/1982	62	2.5	
USGS	2300500	4/18/1982	59	2.4	
USGS	2300500	4/19/1982	54	2.4	380
USGS	2300500	4/20/1982	53	2.3	
USGS	2300500	4/21/1982	53	2.4	
USGS	2300500	4/22/1982	50	2.3	
USGS	2300500	4/23/1982	51	2.3	
USGS	2300500	4/24/1982	54	2.4	
USGS	2300500	4/25/1982	73	2.6	
USGS	2300500	4/26/1982	356	5.7	331
USGS	2300500	4/27/1982	298	5.2	
USGS	2300500	4/28/1982	146	3.6	
USGS	2300500	4/29/1982	108	3.2	
USGS	2300500	4/30/1982	101	3.1	
USGS	2300500	5/1/1982	91	2.9	
USGS	2300500	5/2/1982	82	2.8	
USGS	2300500	5/3/1982	77	2.7	
USGS	2300500	5/4/1982	72	2.6	345
USGS	2300500	5/5/1982	65	2.5	
USGS	2300500	5/6/1982	60	2.5	
USGS	2300500	5/7/1982	56	2.4	
USGS	2300500	5/8/1982	55	2.4	

USGS	2300500	5/9/1982	54	2.4	
USGS	2300500	5/10/1982	52	2.3	
USGS	2300500	5/11/1982	49	2.3	386
USGS	2300500	5/12/1982	47	2.2	
USGS	2300500	5/13/1982	46	2.2	
USGS	2300500	5/14/1982	46	2.2	
USGS	2300500	5/15/1982	46	2.2	
USGS	2300500	5/16/1982	46	2.2	
USGS	2300500	5/17/1982	46	2.2	
USGS	2300500	5/18/1982	45	2.2	455
USGS	2300500	5/19/1982	43	2.2	
USGS	2300500	5/20/1982	42	2.1	
USGS	2300500	5/21/1982	42	2.1	
USGS	2300500	5/22/1982	44	2.2	
USGS	2300500	5/23/1982	156	3.5	
USGS	2300500	5/24/1982	246	4.7	
USGS	2300500	5/25/1982	157	3.7	
USGS	2300500	5/26/1982	364	5.8	303
USGS	2300500	5/27/1982	333	5.5	
USGS	2300500	5/28/1982	216	4.4	
USGS	2300500	5/29/1982	173	3.9	
USGS	2300500	5/30/1982	340	5.5	
USGS	2300500	5/31/1982	714	8.4	
USGS	2300500	6/1/1982	564	7.4	
USGS	2300500	6/2/1982	750	8.6	117
USGS	2300500	6/3/1982	501	6.8	
USGS	2300500	6/4/1982	230	4.5	
USGS	2300500	6/5/1982	196	4.2	
USGS	2300500	6/6/1982	143	3.6	
USGS	2300500	6/7/1982	112	3.2	
USGS	2300500	6/8/1982	97	3.0	
USGS	2300500	6/9/1982	87	2.9	
USGS	2300500	6/10/1982	79	2.7	
USGS	2300500	6/11/1982	70	2.6	176
USGS	2300500	6/12/1982	69	2.6	
USGS	2300500	6/13/1982	146	3.6	
USGS	2300500	6/14/1982	118	3.3	
USGS	2300500	6/15/1982	89	2.9	
USGS	2300500	6/16/1982	302	5.2	112
USGS	2300500	6/17/1982	534	7.1	
USGS	2300500	6/18/1982	2490	13.1	
USGS	2300500	6/19/1982	4420	15.7	
USGS	2300500	6/20/1982	2600	13.5	
USGS	2300500	6/21/1982	1450	11.2	
USGS	2300500	6/22/1982	904	9.3	
USGS	2300500	6/23/1982	492	6.9	
USGS	2300500	6/24/1982	312	5.3	
USGS	2300500	6/25/1982	407	6.2	
USGS	2300500	6/26/1982	590	7.6	
USGS	2300500	6/27/1982	684	8.2	
USGS	2300500	6/28/1982	569	7.5	87
USGS	2300500	6/29/1982	363	5.8	
USGS	2300500	6/30/1982	241	4.6	
USGS	2300500	7/1/1982	184	4.1	
USGS	2300500	7/2/1982	146	3.6	

USGS	2300500	7/3/1982	109	3.2	
USGS	2300500	7/4/1982	96	3.0	
USGS	2300500	7/5/1982	185	4.0	
USGS	2300500	7/6/1982	377	5.9	84
USGS	2300500	7/7/1982	372	5.9	
USGS	2300500	7/8/1982	368	5.8	
USGS	2300500	7/9/1982	439	6.5	
USGS	2300500	7/10/1982	418	6.3	
USGS	2300500	7/11/1982	512	7.1	
USGS	2300500	7/12/1982	583	7.6	
USGS	2300500	7/13/1982	483	6.9	
USGS	2300500	7/14/1982	362	5.8	86
USGS	2300500	7/15/1982	253	4.8	
USGS	2300500	7/16/1982	217	4.4	
USGS	2300500	7/17/1982	206	4.3	
USGS	2300500	7/18/1982	214	4.3	
USGS	2300500	7/19/1982	356	5.7	
USGS	2300500	7/20/1982	305	5.3	
USGS	2300500	7/21/1982	463	6.7	
USGS	2300500	7/22/1982	438	6.4	
USGS	2300500	7/23/1982	471	6.6	113
USGS	2300500	7/24/1982	306	5.3	
USGS	2300500	7/25/1982	587	7.6	
USGS	2300500	7/26/1982	856	9.1	
USGS	2300500	7/27/1982	649	7.9	
USGS	2300500	7/28/1982	292	5.1	
USGS	2300500	7/29/1982	423	6.3	
USGS	2300500	7/30/1982	483	6.8	84
USGS	2300500	7/31/1982	642	7.9	
USGS	2300500	8/1/1982	693	8.3	
USGS	2300500	8/2/1982	476	6.8	
USGS	2300500	8/3/1982	428	6.4	
USGS	2300500	8/4/1982	366	5.8	
USGS	2300500	8/5/1982	241	4.7	
USGS	2300500	8/6/1982	222	4.5	
USGS	2300500	8/7/1982	220	4.4	
USGS	2300500	8/8/1982	352	5.7	
USGS	2300500	8/9/1982	365	5.8	
USGS	2300500	8/10/1982	452	6.6	
USGS	2300500	8/11/1982	349	5.7	
USGS	2300500	8/12/1982	416	6.3	88
USGS	2300500	8/13/1982	339	5.6	
USGS	2300500	8/14/1982	287	5.1	
USGS	2300500	8/15/1982	186	4.1	
USGS	2300500	8/16/1982	208	4.3	
USGS	2300500	8/17/1982	547	7.3	
USGS	2300500	8/18/1982	700	8.3	
USGS	2300500	8/19/1982	635	8.0	
USGS	2300500	8/20/1982	586	7.6	
USGS	2300500	8/21/1982	491	6.9	85
USGS	2300500	8/22/1982	329	5.5	
USGS	2300500	8/23/1982	225	4.5	
USGS	2300500	8/24/1982	172	3.9	
USGS	2300500	8/25/1982	140	3.6	
USGS	2300500	8/26/1982	111	3.2	140

USGS	2300500	8/27/1982	102	3.1	
USGS	2300500	8/28/1982	93	2.9	
USGS	2300500	8/29/1982	84	2.8	
USGS	2300500	8/30/1982	76	2.7	
USGS	2300500	8/31/1982	68	2.6	
USGS	2300500	9/1/1982	63	2.5	
USGS	2300500	9/2/1982	60	2.5	
USGS	2300500	9/3/1982	58	2.4	
USGS	2300500	9/4/1982	57	2.4	
USGS	2300500	9/5/1982	67	2.6	
USGS	2300500	9/6/1982	64	2.5	195
USGS	2300500	9/7/1982	167	3.6	
USGS	2300500	9/8/1982	741	8.5	
USGS	2300500	9/9/1982	596	7.6	
USGS	2300500	9/10/1982	315	5.3	
USGS	2300500	9/11/1982	218	4.4	
USGS	2300500	9/12/1982	162	3.8	
USGS	2300500	9/13/1982	128	3.4	
USGS	2300500	9/14/1982	134	3.5	165
USGS	2300500	9/15/1982	115	3.2	
USGS	2300500	9/16/1982	94	3.0	
USGS	2300500	9/17/1982	85	2.8	
USGS	2300500	9/18/1982	75	2.7	
USGS	2300500	9/19/1982	70	2.6	
USGS	2300500	9/20/1982	164	3.8	
USGS	2300500	9/21/1982	678	7.2	
USGS	2300500	9/22/1982	1770	12.0	80
USGS	2300500	9/23/1982	2410	13.3	
USGS	2300500	9/24/1982	1980	12.4	
USGS	2300500	9/25/1982	1180	10.3	
USGS	2300500	9/26/1982	1880	12.0	
USGS	2300500	9/27/1982	3540	14.8	
USGS	2300500	9/28/1982	2500	13.4	
USGS	2300500	9/29/1982	1400	11.0	
USGS	2300500	9/30/1982	710	8.3	

Agency	Gage number	Date	Flow (cfs)	Gage Ht.	Sp. Conductance
USGS	2300500	10/1/1967	404		62
USGS	2300500	10/2/1967	273		61
USGS	2300500	10/3/1967	194		62
USGS	2300500	10/4/1967	149		69
USGS	2300500	10/5/1967	118		70
USGS	2300500	10/6/1967	112		74
USGS	2300500	10/7/1967	185		81
USGS	2300500	10/8/1967	149		80
USGS	2300500	10/9/1967	181		81
USGS	2300500	10/10/1967	282		80
USGS	2300500	10/11/1967	201		82
USGS	2300500	10/12/1967	163		80
USGS	2300500	10/13/1967	133		82
USGS	2300500	10/14/1967	107		82
USGS	2300500	10/15/1967	88		81
USGS	2300500	10/16/1967	76		69
USGS	2300500	10/17/1967	67		71
USGS	2300500	10/18/1967	64		75
USGS	2300500	10/19/1967	61		62
USGS	2300500	10/20/1967	56		61
USGS	2300500	10/21/1967	52		62
USGS	2300500	10/22/1967	48		62
USGS	2300500	10/23/1967	44		61
USGS	2300500	10/24/1967	43		62
USGS	2300500	10/25/1967	42		68
USGS	2300500	10/26/1967	39		71
USGS	2300500	10/27/1967	38		69
USGS	2300500	10/28/1967	37		81
USGS	2300500	10/29/1967	36		80
USGS	2300500	10/30/1967	34		80
USGS	2300500	10/31/1967	32		80
USGS	2300500	11/1/1967	30		62
USGS	2300500	11/2/1967	39		52
USGS	2300500	11/3/1967	48		69
USGS	2300500	11/4/1967	45		69
USGS	2300500	11/5/1967	40		63
USGS	2300500	11/6/1967	37		68
USGS	2300500	11/7/1967	34		89
USGS	2300500	11/8/1967	31		80
USGS	2300500	11/9/1967	28		60
USGS	2300500	11/10/1967	28		60
USGS	2300500	11/11/1967	28		60
USGS	2300500	11/12/1967	27		60
USGS	2300500	11/13/1967	26		64
USGS	2300500	11/14/1967	26		82
USGS	2300500	11/15/1967	26		69
USGS	2300500	11/16/1967	25		61
USGS	2300500	11/17/1967	26		69
USGS	2300500	11/18/1967	25		63

USGS	2300500	11/19/1967	25	51
USGS	2300500	11/20/1967	24	59
USGS	2300500	11/21/1967	24	71
USGS	2300500	11/22/1967	24	59
USGS	2300500	11/23/1967	25	68
USGS	2300500	11/24/1967	25	71
USGS	2300500	11/25/1967	25	66
USGS	2300500	11/26/1967	25	77
USGS	2300500	11/27/1967	26	80
USGS	2300500	11/28/1967	26	64
USGS	2300500	11/29/1967	26	61
USGS	2300500	11/30/1967	26	55
USGS	2300500	12/1/1967	25	210
USGS	2300500	12/2/1967	24	210
USGS	2300500	12/3/1967	25	210
USGS	2300500	12/4/1967	23	210
USGS	2300500	12/5/1967	24	219
USGS	2300500	12/6/1967	23	75
USGS	2300500	12/7/1967	24	68
USGS	2300500	12/8/1967	24	68
USGS	2300500	12/9/1967	24	69
USGS	2300500	12/10/1967	27	69
USGS	2300500	12/11/1967	44	69
USGS	2300500	12/12/1967	93	71
USGS	2300500	12/13/1967	93	73
USGS	2300500	12/14/1967	72	71
USGS	2300500	12/15/1967	60	69
USGS	2300500	12/16/1967	52	69
USGS	2300500	12/17/1967	49	69
USGS	2300500	12/18/1967	46	69
USGS	2300500	12/19/1967	44	210
USGS	2300500	12/20/1967	41	210
USGS	2300500	12/21/1967	40	210
USGS	2300500	12/22/1967	38	225
USGS	2300500	12/23/1967	36	225
USGS	2300500	12/24/1967	33	225
USGS	2300500	12/25/1967	32	69
USGS	2300500	12/26/1967	32	73
USGS	2300500	12/27/1967	32	69
USGS	2300500	12/28/1967	34	69
USGS	2300500	12/29/1967	36	71
USGS	2300500	12/30/1967	37	74
USGS	2300500	12/31/1967	34	69
USGS	2300500	2/14/1968	23	127
USGS	2300500	2/15/1968	23	142
USGS	2300500	2/16/1968	26	160
USGS	2300500	2/17/1968	24	180
USGS	2300500	2/18/1968	24	160
USGS	2300500	2/19/1968	38	150
USGS	2300500	2/20/1968	56	110
USGS	2300500	2/21/1968	51	105
USGS	2300500	2/22/1968	42	93

USGS	2300500	2/23/1968	40	98
USGS	2300500	2/24/1968	63	135
USGS	2300500	2/25/1968	69	100
USGS	2300500	2/26/1968	57	100
USGS	2300500	2/27/1968	52	100
USGS	2300500	2/28/1968	50	99
USGS	2300500	2/29/1968	46	105
USGS	2300500	3/1/1968	47	94
USGS	2300500	3/2/1968	46	93
USGS	2300500	3/3/1968	42	93
USGS	2300500	3/4/1968	40	92
USGS	2300500	3/5/1968	38	100
USGS	2300500	3/6/1968	38	130
USGS	2300500	3/7/1968	54	150
USGS	2300500	3/8/1968	60	100
USGS	2300500	3/9/1968	52	94
USGS	2300500	3/10/1968	46	86
USGS	2300500	3/11/1968	40	96
USGS	2300500	3/12/1968	38	91
USGS	2300500	3/13/1968	53	91
USGS	2300500	3/14/1968	63	89
USGS	2300500	3/15/1968	55	92
USGS	2300500	3/16/1968	48	89
USGS	2300500	3/17/1968	42	96
USGS	2300500	3/18/1968	38	105
USGS	2300500	3/19/1968	35	130
USGS	2300500	3/20/1968	32	150
USGS	2300500	3/21/1968	30	150
USGS	2300500	3/22/1968	27	150
USGS	2300500	3/23/1968	24	120
USGS	2300500	3/24/1968	22	115
USGS	2300500	3/25/1968	21	120
USGS	2300500	3/26/1968	21	110
USGS	2300500	3/27/1968	22	130
USGS	2300500	3/28/1968	23	160
USGS	2300500	3/29/1968	20	160
USGS	2300500	3/30/1968	20	140
USGS	2300500	3/31/1968	21	140
USGS	2300500	4/1/1968	20	155
USGS	2300500	4/2/1968	20	141
USGS	2300500	4/3/1968	20	145
USGS	2300500	4/4/1968	20	150
USGS	2300500	4/5/1968	20	190
USGS	2300500	4/6/1968	18	160
USGS	2300500	4/7/1968	16	150
USGS	2300500	4/8/1968	15	149
USGS	2300500	4/9/1968	15	161
USGS	2300500	4/10/1968	16	161
USGS	2300500	4/11/1968	19	221
USGS	2300500	4/12/1968	18	239
USGS	2300500	4/13/1968	20	190
USGS	2300500	4/14/1968	17	110

USGS	2300500	4/15/1968	16	111
USGS	2300500	4/16/1968	14	100
USGS	2300500	4/17/1968	14	100
USGS	2300500	4/18/1968	14	119
USGS	2300500	4/19/1968	15	129
USGS	2300500	4/20/1968	15	149
USGS	2300500	4/21/1968	14	210
USGS	2300500	4/22/1968	12	199
USGS	2300500	4/23/1968	11	185
USGS	2300500	4/24/1968	11	151
USGS	2300500	4/25/1968	11	185
USGS	2300500	4/26/1968	11	230
USGS	2300500	4/27/1968	11	230
USGS	2300500	4/28/1968	11	230
USGS	2300500	4/29/1968	10	219
USGS	2300500	4/30/1968	9	195
USGS	2300500	5/1/1968	10	150
USGS	2300500	5/2/1968	10	182
USGS	2300500	5/3/1968	10	150
USGS	2300500	5/4/1968	11	190
USGS	2300500	5/5/1968	12	245
USGS	2300500	5/6/1968	10	245
USGS	2300500	5/7/1968	10	160
USGS	2300500	5/8/1968	10	125
USGS	2300500	5/9/1968	10	120
USGS	2300500	5/10/1968	10	150
USGS	2300500	5/11/1968	11	175
USGS	2300500	5/12/1968	12	210
USGS	2300500	5/13/1968	17	169
USGS	2300500	5/14/1968	126	170
USGS	2300500	5/15/1968	126	110
USGS	2300500	5/16/1968	65	140
USGS	2300500	5/17/1968	45	130
USGS	2300500	5/18/1968	33	130
USGS	2300500	5/19/1968	28	121
USGS	2300500	5/20/1968	44	112
USGS	2300500	5/21/1968	42	112
USGS	2300500	5/22/1968	29	102
USGS	2300500	5/23/1968	24	102
USGS	2300500	5/24/1968	61	110
USGS	2300500	5/25/1968	332	131
USGS	2300500	5/26/1968	317	110
USGS	2300500	5/27/1968	215	100
USGS	2300500	5/28/1968	141	109
USGS	2300500	5/29/1968	135	110
USGS	2300500	5/30/1968	102	100
USGS	2300500	5/31/1968	73	100
USGS	2300500	6/1/1968	61	110
USGS	2300500	6/2/1968	51	107
USGS	2300500	6/3/1968	46	104
USGS	2300500	6/4/1968	558	94
USGS	2300500	6/5/1968	1600	76

USGS	2300500	6/6/1968	1640	85
USGS	2300500	6/7/1968	1060	75
USGS	2300500	6/8/1968	461	79
USGS	2300500	6/9/1968	265	80
USGS	2300500	6/10/1968	182	74
USGS	2300500	6/11/1968	144	72
USGS	2300500	6/12/1968	115	88
USGS	2300500	6/13/1968	97	94
USGS	2300500	6/14/1968	91	88
USGS	2300500	6/15/1968	191	83
USGS	2300500	6/16/1968	235	68
USGS	2300500	6/17/1968	226	78
USGS	2300500	6/18/1968	349	96
USGS	2300500	6/19/1968	566	70
USGS	2300500	6/20/1968	538	89
USGS	2300500	6/21/1968	466	75
USGS	2300500	6/22/1968	424	80
USGS	2300500	6/23/1968	310	70
USGS	2300500	6/24/1968	378	56
USGS	2300500	6/25/1968	632	62
USGS	2300500	6/26/1968	245	63
USGS	2300500	6/27/1968	391	80
USGS	2300500	6/28/1968	1520	61
USGS	2300500	6/29/1968	1400	64
USGS	2300500	6/30/1968	1210	69
USGS	2300500	7/1/1968	744	63
USGS	2300500	7/2/1968	524	69
USGS	2300500	7/3/1968	704	68
USGS	2300500	7/4/1968	1320	64
USGS	2300500	7/5/1968	2110	52
USGS	2300500	7/6/1968	3570	42
USGS	2300500	7/7/1968	2400	48
USGS	2300500	7/8/1968	1760	50
USGS	2300500	7/9/1968	1780	52
USGS	2300500	7/10/1968	2900	42
USGS	2300500	7/11/1968	2220	40
USGS	2300500	7/12/1968	1320	49
USGS	2300500	7/13/1968	704	62
USGS	2300500	7/14/1968	529	56
USGS	2300500	7/15/1968	645	49
USGS	2300500	7/16/1968	1320	40
USGS	2300500	7/17/1968	1100	46
USGS	2300500	7/18/1968	1020	47
USGS	2300500	7/19/1968	855	50
USGS	2300500	7/20/1968	732	65
USGS	2300500	7/21/1968	734	55
USGS	2300500	7/22/1968	597	55
USGS	2300500	7/23/1968	352	57
USGS	2300500	7/24/1968	312	60
USGS	2300500	7/25/1968	213	69
USGS	2300500	7/26/1968	156	75
USGS	2300500	7/27/1968	119	73

USGS	2300500	7/28/1968	94	77
USGS	2300500	7/29/1968	77	80
USGS	2300500	7/30/1968	65	81
USGS	2300500	7/31/1968	57	100
USGS	2300500	8/1/1968	52	100
USGS	2300500	8/2/1968	48	68
USGS	2300500	8/3/1968	46	62
USGS	2300500	8/4/1968	46	105
USGS	2300500	8/5/1968	60	85
USGS	2300500	8/6/1968	62	72
USGS	2300500	8/7/1968	51	56
USGS	2300500	8/8/1968	45	93
USGS	2300500	8/9/1968	156	53
USGS	2300500	8/10/1968	78	75
USGS	2300500	8/11/1968	52	74
USGS	2300500	8/12/1968	47	89
USGS	2300500	8/13/1968	97	72
USGS	2300500	8/14/1968	158	99
USGS	2300500	8/15/1968	313	54
USGS	2300500	8/16/1968	138	94
USGS	2300500	8/17/1968	80	65
USGS	2300500	8/18/1968	116	54
USGS	2300500	8/19/1968	222	75
USGS	2300500	8/20/1968	129	78
USGS	2300500	8/21/1968	115	54
USGS	2300500	8/22/1968	97	31
USGS	2300500	8/23/1968	75	83
USGS	2300500	8/24/1968	77	64
USGS	2300500	8/25/1968	143	67
USGS	2300500	8/26/1968	210	42
USGS	2300500	8/27/1968	325	75
USGS	2300500	8/28/1968	2410	64
USGS	2300500	8/29/1968	2360	73
USGS	2300500	8/30/1968	1620	70
USGS	2300500	8/31/1968	919	65
USGS	2300500	9/1/1968	445	45
USGS	2300500	9/2/1968	302	66
USGS	2300500	9/3/1968	230	61
USGS	2300500	9/4/1968	173	64
USGS	2300500	9/5/1968	135	63
USGS	2300500	9/6/1968	156	56
USGS	2300500	9/7/1968	302	57
USGS	2300500	9/8/1968	406	57
USGS	2300500	9/9/1968	379	61
USGS	2300500	9/10/1968	261	48
USGS	2300500	9/11/1968	208	77
USGS	2300500	9/12/1968	254	53
USGS	2300500	9/13/1968	999	44
USGS	2300500	9/14/1968	1800	56
USGS	2300500	9/15/1968	1930	45
USGS	2300500	9/16/1968	1250	38
USGS	2300500	9/17/1968	571	52

USGS	2300500	9/18/1968	322	63
USGS	2300500	9/19/1968	227	67
USGS	2300500	9/20/1968	227	47
USGS	2300500	9/21/1968	195	57
USGS	2300500	9/22/1968	155	47
USGS	2300500	9/23/1968	128	52
USGS	2300500	9/24/1968	115	43
USGS	2300500	9/25/1968	100	64
USGS	2300500	9/26/1968	89	57
USGS	2300500	9/27/1968	84	56
USGS	2300500	9/28/1968	90	64
USGS	2300500	9/29/1968	81	65
USGS	2300500	9/30/1968	68	65
USGS	2300500	10/1/1968	58	74
USGS	2300500	10/2/1968	52	92
USGS	2300500	10/3/1968	49	82
USGS	2300500	10/4/1968	45	85
USGS	2300500	10/5/1968	41	80
USGS	2300500	10/6/1968	39	87
USGS	2300500	10/7/1968	38	80
USGS	2300500	10/8/1968	36	90
USGS	2300500	10/9/1968	34	102
USGS	2300500	10/10/1968	38	84
USGS	2300500	10/11/1968	45	79
USGS	2300500	10/12/1968	42	102
USGS	2300500	10/13/1968	34	99
USGS	2300500	10/14/1968	31	78
USGS	2300500	10/15/1968	30	104
USGS	2300500	10/16/1968	30	91
USGS	2300500	10/17/1968	38	96
USGS	2300500	10/18/1968	83	102
USGS	2300500	10/19/1968	185	80
USGS	2300500	10/20/1968	275	89
USGS	2300500	10/21/1968	325	90
USGS	2300500	10/22/1968	255	78
USGS	2300500	10/23/1968	173	77
USGS	2300500	10/24/1968	131	78
USGS	2300500	10/25/1968	125	94
USGS	2300500	10/26/1968	115	75
USGS	2300500	10/27/1968	106	72
USGS	2300500	10/28/1968	99	83
USGS	2300500	10/29/1968	85	75
USGS	2300500	10/30/1968	71	73
USGS	2300500	10/31/1968	62	92
USGS	2300500	11/1/1968	56	80
USGS	2300500	11/2/1968	51	160
USGS	2300500	11/3/1968	48	91
USGS	2300500	11/4/1968	46	90
USGS	2300500	11/5/1968	42	81
USGS	2300500	11/6/1968	44	100
USGS	2300500	11/7/1968	40	80
USGS	2300500	11/8/1968	39	88

USGS	2300500	11/9/1968	46	152
USGS	2300500	11/10/1968	211	133
USGS	2300500	11/12/1968	384	70
USGS	2300500	11/13/1968	426	70
USGS	2300500	11/14/1968	348	71
USGS	2300500	11/15/1968	257	79
USGS	2300500	11/16/1968	197	70
USGS	2300500	11/17/1968	155	72
USGS	2300500	11/18/1968	126	79
USGS	2300500	11/19/1968	119	109
USGS	2300500	11/20/1968	116	80
USGS	2300500	11/21/1968	109	108
USGS	2300500	11/22/1968	99	138
USGS	2300500	11/23/1968	88	88
USGS	2300500	11/24/1968	79	85
USGS	2300500	11/25/1968	73	87
USGS	2300500	11/26/1968	65	89
USGS	2300500	11/27/1968	62	81
USGS	2300500	11/28/1968	59	80
USGS	2300500	11/29/1968	56	82
USGS	2300500	11/30/1968	55	88
USGS	2300500	12/1/1968	55	81
USGS	2300500	12/2/1968	54	86
USGS	2300500	12/3/1968	54	81
USGS	2300500	12/4/1968	50	77
USGS	2300500	12/5/1968	47	84
USGS	2300500	12/6/1968	48	100
USGS	2300500	12/7/1968	47	110
USGS	2300500	12/8/1968	46	120
USGS	2300500	12/9/1968	45	120
USGS	2300500	12/10/1968	45	140
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USGS	2300500	12/12/1968	44	130
USGS	2300500	12/13/1968	44	120
USGS	2300500	12/14/1968	44	130
USGS	2300500	12/15/1968	42	94
USGS	2300500	12/16/1968	42	92
USGS	2300500	12/17/1968	42	100
USGS	2300500	12/18/1968	44	100
USGS	2300500	12/19/1968	44	110
USGS	2300500	12/20/1968	43	100
USGS	2300500	12/21/1968	45	88
USGS	2300500	12/22/1968	45	110
USGS	2300500	12/23/1968	42	94
USGS	2300500	12/24/1968	42	110
USGS	2300500	12/25/1968	41	100
USGS	2300500	12/26/1968	39	110
USGS	2300500	12/27/1968	41	110
USGS	2300500	12/28/1968	42	94
USGS	2300500	12/29/1968	47	91
USGS	2300500	12/30/1968	50	110
USGS	2300500	12/31/1968	48	100

USGS	2300500	1/1/1969	45	128
USGS	2300500	1/2/1969	43	120
USGS	2300500	1/3/1969	42	136
USGS	2300500	1/4/1969	236	157
USGS	2300500	1/5/1969	460	114
USGS	2300500	1/6/1969	412	114
USGS	2300500	1/7/1969	329	112
USGS	2300500	1/8/1969	248	98
USGS	2300500	1/9/1969	191	103
USGS	2300500	1/10/1969	150	106
USGS	2300500	1/11/1969	130	124
USGS	2300500	1/12/1969	172	97
USGS	2300500	1/13/1969	139	98
USGS	2300500	1/14/1969	114	94
USGS	2300500	1/15/1969	100	91
USGS	2300500	1/16/1969	90	93
USGS	2300500	1/17/1969	81	98
USGS	2300500	1/18/1969	74	96
USGS	2300500	1/19/1969	71	93
USGS	2300500	1/20/1969	81	93
USGS	2300500	1/21/1969	82	88
USGS	2300500	1/22/1969	77	85
USGS	2300500	1/23/1969	72	88
USGS	2300500	1/24/1969	67	87
USGS	2300500	1/25/1969	64	86
USGS	2300500	1/26/1969	65	91
USGS	2300500	1/27/1969	65	90
USGS	2300500	1/28/1969	62	89
USGS	2300500	1/29/1969	59	86
USGS	2300500	1/30/1969	57	94
USGS	2300500	1/31/1969	54	112
USGS	2300500	2/1/1969	52	110
USGS	2300500	2/2/1969	51	112
USGS	2300500	2/3/1969	50	111
USGS	2300500	2/4/1969	48	132
USGS	2300500	2/5/1969	46	136
USGS	2300500	2/6/1969	46	139
USGS	2300500	2/7/1969	47	155
USGS	2300500	2/8/1969	46	112
USGS	2300500	2/9/1969	112	140
USGS	2300500	2/10/1969	116	99
USGS	2300500	2/11/1969	101	87
USGS	2300500	2/12/1969	85	90
USGS	2300500	2/13/1969	75	108
USGS	2300500	2/14/1969	66	94
USGS	2300500	2/15/1969	113	87
USGS	2300500	2/16/1969	289	88
USGS	2300500	2/17/1969	221	87
USGS	2300500	2/18/1969	181	89
USGS	2300500	2/19/1969	146	92
USGS	2300500	2/20/1969	119	86
USGS	2300500	2/21/1969	99	91

USGS	2300500	2/22/1969	85	90
USGS	2300500	2/23/1969	76	90
USGS	2300500	2/24/1969	69	87
USGS	2300500	2/25/1969	65	98
USGS	2300500	2/26/1969	63	132
USGS	2300500	2/27/1969	60	132
USGS	2300500	2/28/1969	58	135
USGS	2300500	3/1/1969	55	138
USGS	2300500	3/3/1969	50	118
USGS	2300500	3/4/1969	50	108
USGS	2300500	3/5/1969	49	100
USGS	2300500	3/6/1969	53	96
USGS	2300500	3/7/1969	77	140
USGS	2300500	3/8/1969	101	96
USGS	2300500	3/9/1969	810	75
USGS	2300500	3/10/1969	961	63
USGS	2300500	3/11/1969	987	64
USGS	2300500	3/12/1969	491	67
USGS	2300500	3/13/1969	285	69
USGS	2300500	3/14/1969	214	73
USGS	2300500	3/15/1969	164	88
USGS	2300500	3/16/1969	235	75
USGS	2300500	3/17/1969	1130	70
USGS	2300500	3/18/1969	1160	67
USGS	2300500	3/19/1969	991	67
USGS	2300500	3/20/1969	570	69
USGS	2300500	3/21/1969	329	70
USGS	2300500	3/22/1969	230	77
USGS	2300500	3/23/1969	171	85
USGS	2300500	3/24/1969	137	86
USGS	2300500	3/25/1969	116	86
USGS	2300500	3/30/1969	79	107
USGS	2300500	4/7/1969	41	88
USGS	2300500	4/8/1969	39	107
USGS	2300500	4/9/1969	38	127
USGS	2300500	4/10/1969	37	150
USGS	2300500	4/13/1969	52	112
USGS	2300500	4/14/1969	43	117
USGS	2300500	4/15/1969	39	114
USGS	2300500	4/16/1969	38	116
USGS	2300500	4/17/1969	58	103
USGS	2300500	4/18/1969	121	90
USGS	2300500	4/19/1969	62	92
USGS	2300500	4/22/1969	41	149
USGS	2300500	4/23/1969	40	154
USGS	2300500	4/24/1969	35	165
USGS	2300500	4/25/1969	31	157
USGS	2300500	4/26/1969	28	167
USGS	2300500	4/27/1969	25	152
USGS	2300500	4/28/1969	21	129
USGS	2300500	4/29/1969	23	125
USGS	2300500	4/30/1969	24	161

USGS	2300500	5/1/1969	22	116
USGS	2300500	5/2/1969	20	124
USGS	2300500	5/3/1969	20	103
USGS	2300500	5/4/1969	21	97
USGS	2300500	5/5/1969	20	122
USGS	2300500	5/6/1969	19	128
USGS	2300500	5/7/1969	20	174
USGS	2300500	5/8/1969	19	199
USGS	2300500	5/9/1969	18	231
USGS	2300500	5/10/1969	20	240
USGS	2300500	5/11/1969	18	160
USGS	2300500	5/12/1969	17	114
USGS	2300500	5/13/1969	16	105
USGS	2300500	5/14/1969	16	103
USGS	2300500	5/15/1969	17	138
USGS	2300500	5/16/1969	16	116
USGS	2300500	5/17/1969	20	102
USGS	2300500	5/18/1969	26	123
USGS	2300500	5/19/1969	116	89
USGS	2300500	5/20/1969	87	105
USGS	2300500	5/21/1969	101	126
USGS	2300500	5/22/1969	66	117
USGS	2300500	5/24/1969	38	100
USGS	2300500	5/25/1969	31	104
USGS	2300500	5/26/1969	27	100
USGS	2300500	5/27/1969	27	79
USGS	2300500	5/28/1969	72	84
USGS	2300500	5/29/1969	58	85
USGS	2300500	5/30/1969	38	97
USGS	2300500	5/31/1969	28	100
USGS	2300500	6/1/1969	23	105
USGS	2300500	6/2/1969	21	98
USGS	2300500	6/3/1969	22	100
USGS	2300500	6/4/1969	23	106
USGS	2300500	6/5/1969	21	104
USGS	2300500	6/7/1969	24	109
USGS	2300500	6/8/1969	30	96
USGS	2300500	6/9/1969	50	120
USGS	2300500	6/10/1969	69	106
USGS	2300500	6/11/1969	67	97
USGS	2300500	6/12/1969	105	96
USGS	2300500	6/13/1969	120	84
USGS	2300500	6/14/1969	182	97
USGS	2300500	6/15/1969	217	114
USGS	2300500	6/16/1969	138	139
USGS	2300500	6/17/1969	127	141
USGS	2300500	6/18/1969	103	90
USGS	2300500	6/19/1969	91	74
USGS	2300500	6/21/1969	204	83
USGS	2300500	6/22/1969	226	82
USGS	2300500	6/24/1969	212	78
USGS	2300500	6/25/1969	228	77

USGS	2300500	6/26/1969	203	76
USGS	2300500	6/27/1969	143	78
USGS	2300500	6/28/1969	101	80
USGS	2300500	6/29/1969	74	81
USGS	2300500	6/30/1969	58	80
USGS	2300500	7/1/1969	48	80
USGS	2300500	7/2/1969	43	80
USGS	2300500	7/3/1969	62	70
USGS	2300500	7/4/1969	133	77
USGS	2300500	7/5/1969	121	77
USGS	2300500	7/6/1969	72	80
USGS	2300500	7/7/1969	51	80
USGS	2300500	7/8/1969	128	67
USGS	2300500	7/9/1969	75	77
USGS	2300500	7/10/1969	61	82
USGS	2300500	7/11/1969	45	87
USGS	2300500	7/12/1969	37	88
USGS	2300500	7/13/1969	32	85
USGS	2300500	7/14/1969	30	85
USGS	2300500	7/15/1969	30	85
USGS	2300500	7/16/1969	33	85
USGS	2300500	7/17/1969	40	80
USGS	2300500	7/18/1969	41	80
USGS	2300500	7/19/1969	43	75
USGS	2300500	7/20/1969	138	73
USGS	2300500	7/21/1969	104	85
USGS	2300500	7/22/1969	69	82
USGS	2300500	7/23/1969	57	80
USGS	2300500	7/24/1969	81	75
USGS	2300500	7/25/1969	81	75
USGS	2300500	7/26/1969	76	75
USGS	2300500	7/27/1969	85	78
USGS	2300500	7/28/1969	71	73
USGS	2300500	7/29/1969	59	77
USGS	2300500	7/30/1969	52	77
USGS	2300500	7/31/1969	47	80
USGS	2300500	8/2/1969	307	72
USGS	2300500	8/3/1969	378	76
USGS	2300500	8/4/1969	562	58
USGS	2300500	8/5/1969	1030	62
USGS	2300500	8/6/1969	934	66
USGS	2300500	8/7/1969	909	61
USGS	2300500	8/8/1969	473	67
USGS	2300500	8/9/1969	341	63
USGS	2300500	8/10/1969	274	62
USGS	2300500	8/11/1969	194	65
USGS	2300500	8/12/1969	353	58
USGS	2300500	8/13/1969	410	60
USGS	2300500	8/14/1969	361	68
USGS	2300500	8/17/1969	1020	50
USGS	2300500	8/18/1969	644	55
USGS	2300500	8/19/1969	509	55

USGS	2300500	8/20/1969	605	48
USGS	2300500	8/21/1969	693	49
USGS	2300500	8/25/1969	207	70
USGS	2300500	8/26/1969	168	66
USGS	2300500	8/27/1969	129	69
USGS	2300500	8/28/1969	97	70
USGS	2300500	8/29/1969	77	75
USGS	2300500	8/30/1969	69	78
USGS	2300500	9/2/1969	668	56
USGS	2300500	9/3/1969	1780	39
USGS	2300500	9/4/1969	1210	52
USGS	2300500	9/5/1969	596	54
USGS	2300500	9/7/1969	218	60
USGS	2300500	9/8/1969	195	63
USGS	2300500	9/9/1969	165	66
USGS	2300500	9/10/1969	142	68
USGS	2300500	9/11/1969	112	73
USGS	2300500	9/12/1969	94	73
USGS	2300500	9/13/1969	84	75
USGS	2300500	9/15/1969	86	77
USGS	2300500	9/16/1969	151	76
USGS	2300500	9/18/1969	241	70
USGS	2300500	9/19/1969	252	67
USGS	2300500	9/20/1969	275	64
USGS	2300500	9/21/1969	233	64
USGS	2300500	9/22/1969	1230	38
USGS	2300500	9/23/1969	1430	36
USGS	2300500	9/24/1969	1030	46
USGS	2300500	9/25/1969	626	53
USGS	2300500	9/26/1969	334	57
USGS	2300500	9/29/1969	146	65
USGS	2300500	9/30/1969	129	67
USGS	2300500	10/2/1969	287	68
USGS	2300500	10/3/1969	897	51
USGS	2300500	10/5/1969	822	51
USGS	2300500	10/6/1969	596	56
USGS	2300500	10/7/1969	383	60
USGS	2300500	10/8/1969	258	62
USGS	2300500	10/9/1969	195	64
USGS	2300500	10/10/1969	152	72
USGS	2300500	10/11/1969	124	70
USGS	2300500	10/13/1969	89	74
USGS	2300500	10/14/1969	79	72
USGS	2300500	10/15/1969	72	77
USGS	2300500	10/16/1969	67	78
USGS	2300500	10/17/1969	63	79
USGS	2300500	10/18/1969	60	75
USGS	2300500	10/19/1969	60	77
USGS	2300500	10/20/1969	64	76
USGS	2300500	10/21/1969	70	76
USGS	2300500	10/22/1969	69	75
USGS	2300500	10/23/1969	66	76

USGS	2300500	10/24/1969	61	75
USGS	2300500	10/26/1969	146	83
USGS	2300500	10/28/1969	159	80
USGS	2300500	10/29/1969	126	79
USGS	2300500	10/30/1969	108	79
USGS	2300500	10/31/1969	101	78
USGS	2300500	11/1/1969	102	79
USGS	2300500	11/2/1969	103	78
USGS	2300500	11/4/1969	78	83
USGS	2300500	11/5/1969	71	84
USGS	2300500	11/6/1969	67	85
USGS	2300500	11/7/1969	63	84
USGS	2300500	11/8/1969	61	83
USGS	2300500	11/9/1969	60	81
USGS	2300500	11/10/1969	59	84
USGS	2300500	11/11/1969	58	81
USGS	2300500	11/12/1969	54	80
USGS	2300500	11/13/1969	58	81
USGS	2300500	11/14/1969	306	80
USGS	2300500	11/15/1969	407	78
USGS	2300500	11/16/1969	325	80
USGS	2300500	11/17/1969	257	78
USGS	2300500	11/18/1969	205	76
USGS	2300500	11/19/1969	164	77
USGS	2300500	11/20/1969	131	77
USGS	2300500	11/21/1969	105	78
USGS	2300500	11/22/1969	91	78
USGS	2300500	11/23/1969	82	81
USGS	2300500	11/24/1969	76	81
USGS	2300500	11/25/1969	71	80
USGS	2300500	11/26/1969	69	81
USGS	2300500	11/27/1969	66	84
USGS	2300500	11/28/1969	65	86
USGS	2300500	11/29/1969	92	80
USGS	2300500	11/30/1969	94	83
USGS	2300500	12/1/1969	81	82
USGS	2300500	12/2/1969	73	80
USGS	2300500	12/3/1969	69	84
USGS	2300500	12/4/1969	67	86
USGS	2300500	12/7/1969	68	88
USGS	2300500	12/8/1969	118	88
USGS	2300500	12/10/1969	1140	68
USGS	2300500	12/11/1969	1120	72
USGS	2300500	12/12/1969	813	72
USGS	2300500	12/14/1969	326	77
USGS	2300500	12/16/1969	199	76
USGS	2300500	12/17/1969	166	76
USGS	2300500	12/18/1969	142	80
USGS	2300500	12/19/1969	127	82
USGS	2300500	12/20/1969	115	82
USGS	2300500	12/21/1969	107	84
USGS	2300500	12/22/1969	187	78

USGS	2300500	12/23/1969	195	79
USGS	2300500	12/24/1969	168	78
USGS	2300500	12/25/1969	145	78
USGS	2300500	12/26/1969	177	78
USGS	2300500	12/28/1969	149	77
USGS	2300500	12/29/1969	132	77
USGS	2300500	12/30/1969	119	77
USGS	2300500	12/31/1969	110	77
USGS	2300500	1/1/1970	103	81
USGS	2300500	1/2/1970	103	82
USGS	2300500	1/3/1970	217	80
USGS	2300500	1/4/1970	291	83
USGS	2300500	1/5/1970	217	83
USGS	2300500	1/6/1970	342	77
USGS	2300500	1/8/1970	535	73
USGS	2300500	1/9/1970	399	72
USGS	2300500	1/10/1970	288	73
USGS	2300500	1/11/1970	223	74
USGS	2300500	1/12/1970	187	76
USGS	2300500	1/13/1970	161	76
USGS	2300500	1/14/1970	141	78
USGS	2300500	1/15/1970	146	80
USGS	2300500	1/16/1970	299	72
USGS	2300500	1/17/1970	188	79
USGS	2300500	1/18/1970	149	81
USGS	2300500	1/19/1970	130	80
USGS	2300500	1/20/1970	117	80
USGS	2300500	1/21/1970	107	80
USGS	2300500	1/22/1970	97	81
USGS	2300500	1/25/1970	85	84
USGS	2300500	1/29/1970	75	88
USGS	2300500	1/30/1970	73	84
USGS	2300500	1/31/1970	71	85
USGS	2300500	2/1/1970	68	90
USGS	2300500	2/2/1970	65	116
USGS	2300500	2/3/1970	136	95
USGS	2300500	2/4/1970	192	93
USGS	2300500	2/5/1970	151	87
USGS	2300500	2/6/1970	124	86
USGS	2300500	2/7/1970	107	85
USGS	2300500	2/8/1970	97	84
USGS	2300500	2/9/1970	91	86
USGS	2300500	2/10/1970	88	95
USGS	2300500	2/11/1970	82	91
USGS	2300500	2/12/1970	78	88
USGS	2300500	2/15/1970	71	107
USGS	2300500	2/16/1970	74	122
USGS	2300500	2/17/1970	95	101
USGS	2300500	2/18/1970	92	86
USGS	2300500	2/19/1970	85	85
USGS	2300500	2/20/1970	79	109
USGS	2300500	2/21/1970	72	110

USGS	2300500	2/24/1970	68	141
USGS	2300500	2/25/1970	76	144
USGS	2300500	2/26/1970	121	97
USGS	2300500	2/27/1970	125	84
USGS	2300500	2/28/1970	116	98
USGS	2300500	3/1/1970	103	108
USGS	2300500	3/2/1970	92	101
USGS	2300500	3/3/1970	83	104
USGS	2300500	3/4/1970	77	119
USGS	2300500	3/5/1970	200	91
USGS	2300500	3/6/1970	411	79
USGS	2300500	3/8/1970	829	89
USGS	2300500	3/9/1970	812	78
USGS	2300500	3/10/1970	619	79
USGS	2300500	3/11/1970	424	80
USGS	2300500	3/12/1970	855	70
USGS	2300500	3/13/1970	770	72
USGS	2300500	3/14/1970	558	73
USGS	2300500	3/15/1970	370	74
USGS	2300500	3/16/1970	262	76
USGS	2300500	3/17/1970	200	77
USGS	2300500	3/18/1970	160	79
USGS	2300500	3/19/1970	135	80
USGS	2300500	3/20/1970	122	84
USGS	2300500	3/21/1970	108	99
USGS	2300500	3/22/1970	109	94
USGS	2300500	3/23/1970	142	79
USGS	2300500	3/27/1970	1910	57
USGS	2300500	3/28/1970	1970	58
USGS	2300500	3/29/1970	1260	64
USGS	2300500	3/30/1970	636	64
USGS	2300500	3/31/1970	362	66
USGS	2300500	4/4/1970	136	76
USGS	2300500	4/5/1970	121	76
USGS	2300500	4/6/1970	107	79
USGS	2300500	4/7/1970	92	78
USGS	2300500	4/8/1970	81	90
USGS	2300500	4/9/1970	75	102
USGS	2300500	4/10/1970	70	110
USGS	2300500	4/11/1970	64	101
USGS	2300500	4/12/1970	61	100
USGS	2300500	4/13/1970	58	93
USGS	2300500	4/14/1970	56	89
USGS	2300500	4/15/1970	54	115
USGS	2300500	4/16/1970	50	120
USGS	2300500	4/17/1970	47	139
USGS	2300500	4/18/1970	43	128
USGS	2300500	4/19/1970	39	119
USGS	2300500	4/20/1970	36	100
USGS	2300500	4/21/1970	34	95
USGS	2300500	4/22/1970	33	116
USGS	2300500	4/23/1970	33	116

USGS	2300500	4/24/1970	33	125
USGS	2300500	4/25/1970	32	133
USGS	2300500	4/26/1970	31	135
USGS	2300500	4/27/1970	31	123
USGS	2300500	4/28/1970	30	125
USGS	2300500	4/29/1970	29	134
USGS	2300500	4/30/1970	28	210
USGS	2300500	5/1/1970	27	200
USGS	2300500	5/2/1970	25	230
USGS	2300500	5/3/1970	24	155
USGS	2300500	5/4/1970	24	169
USGS	2300500	5/5/1970	23	130
USGS	2300500	5/6/1970	22	132
USGS	2300500	5/7/1970	23	160
USGS	2300500	5/8/1970	23	219
USGS	2300500	5/9/1970	23	220
USGS	2300500	5/10/1970	22	178
USGS	2300500	5/11/1970	21	148
USGS	2300500	5/12/1970	21	170
USGS	2300500	5/16/1970	20	180
USGS	2300500	5/17/1970	19	169
USGS	2300500	5/18/1970	17	180
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USGS	2300500	5/20/1970	16	140
USGS	2300500	5/21/1970	17	132
USGS	2300500	5/22/1970	17	121
USGS	2300500	5/23/1970	16	123
USGS	2300500	5/24/1970	37	140
USGS	2300500	5/25/1970	84	250
USGS	2300500	5/26/1970	78	175
USGS	2300500	5/27/1970	57	155
USGS	2300500	5/28/1970	45	130
USGS	2300500	5/29/1970	80	150
USGS	2300500	5/30/1970	413	88
USGS	2300500	5/31/1970	653	74
USGS	2300500	6/1/1970	541	65
USGS	2300500	6/2/1970	454	70
USGS	2300500	6/3/1970	304	73
USGS	2300500	6/4/1970	205	78
USGS	2300500	6/5/1970	148	77
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USGS	2300500	6/7/1970	88	80
USGS	2300500	6/8/1970	71	82
USGS	2300500	6/10/1970	50	85
USGS	2300500	6/11/1970	44	86
USGS	2300500	6/12/1970	39	89
USGS	2300500	6/13/1970	34	89
USGS	2300500	6/14/1970	33	92
USGS	2300500	6/17/1970	32	87
USGS	2300500	6/18/1970	42	87
USGS	2300500	6/20/1970	40	89
USGS	2300500	6/21/1970	34	89

USGS	2300500	6/22/1970	30	87
USGS	2300500	6/23/1970	129	78
USGS	2300500	6/24/1970	173	74
USGS	2300500	6/25/1970	101	74
USGS	2300500	6/26/1970	114	75
USGS	2300500	6/27/1970	189	75
USGS	2300500	6/28/1970	149	76
USGS	2300500	6/29/1970	107	75
USGS	2300500	6/30/1970	122	75
USGS	2300500	7/1/1970	83	85
USGS	2300500	7/2/1970	62	82
USGS	2300500	7/4/1970	44	86
USGS	2300500	7/5/1970	39	85
USGS	2300500	7/6/1970	34	86
USGS	2300500	7/7/1970	38	90
USGS	2300500	7/8/1970	37	88
USGS	2300500	7/9/1970	34	89
USGS	2300500	7/11/1970	52	95
USGS	2300500	7/12/1970	81	95
USGS	2300500	7/13/1970	73	95
USGS	2300500	7/14/1970	66	94
USGS	2300500	7/15/1970	68	92
USGS	2300500	7/16/1970	52	95
USGS	2300500	7/18/1970	36	95
USGS	2300500	7/19/1970	30	97
USGS	2300500	7/20/1970	28	96
USGS	2300500	7/21/1970	45	86
USGS	2300500	7/22/1970	50	87
USGS	2300500	7/23/1970	48	75
USGS	2300500	7/24/1970	61	77
USGS	2300500	7/25/1970	51	76
USGS	2300500	7/26/1970	39	87
USGS	2300500	7/27/1970	32	90
USGS	2300500	7/28/1970	35	98
USGS	2300500	7/29/1970	28	94
USGS	2300500	7/30/1970	25	95
USGS	2300500	7/31/1970	24	104
USGS	2300500	9/1/1970	46	83
USGS	2300500	9/2/1970	38	88
USGS	2300500	9/3/1970	33	92
USGS	2300500	9/4/1970	31	97
USGS	2300500	9/5/1970	33	103
USGS	2300500	9/6/1970	36	95
USGS	2300500	9/7/1970	34	85
USGS	2300500	9/8/1970	51	82
USGS	2300500	9/9/1970	132	83
USGS	2300500	9/10/1970	126	87
USGS	2300500	9/13/1970	67	95
USGS	2300500	9/14/1970	71	87
USGS	2300500	9/15/1970	119	81
USGS	2300500	9/16/1970	158	80
USGS	2300500	9/18/1970	75	85

USGS	2300500	9/19/1970	59	85
USGS	2300500	9/20/1970	51	83
USGS	2300500	9/21/1970	48	83
USGS	2300500	9/22/1970	47	85
USGS	2300500	9/25/1970	77	81
USGS	2300500	9/26/1970	91	78
USGS	2300500	9/27/1970	77	77
USGS	2300500	9/28/1970	62	79
USGS	2300500	9/29/1970	52	82
USGS	2300500	9/30/1970	46	85
USGS	2300500	10/1/1970	40	92
USGS	2300500	10/2/1970	36	100
USGS	2300500	10/3/1970	33	107
USGS	2300500	10/4/1970	33	93
USGS	2300500	10/5/1970	32	90
USGS	2300500	10/6/1970	27	87
USGS	2300500	10/7/1970	25	91
USGS	2300500	10/8/1970	24	110
USGS	2300500	10/9/1970	26	93
USGS	2300500	10/10/1970	24	92
USGS	2300500	10/11/1970	21	91
USGS	2300500	10/12/1970	19	91
USGS	2300500	10/13/1970	18	94
USGS	2300500	10/14/1970	18	108
USGS	2300500	10/16/1970	17	101
USGS	2300500	10/17/1970	16	97
USGS	2300500	10/18/1970	16	95
USGS	2300500	10/19/1970	16	97
USGS	2300500	10/20/1970	16	127
USGS	2300500	10/21/1970	18	108
USGS	2300500	10/22/1970	20	96
USGS	2300500	10/23/1970	25	94
USGS	2300500	10/24/1970	24	88
USGS	2300500	10/25/1970	23	101
USGS	2300500	10/26/1970	22	97
USGS	2300500	10/27/1970	21	110
USGS	2300500	10/28/1970	21	98
USGS	2300500	10/29/1970	20	111
USGS	2300500	10/30/1970	24	113
USGS	2300500	10/31/1970	30	110
USGS	2300500	11/1/1970	27	107
USGS	2300500	11/2/1970	25	98
USGS	2300500	11/3/1970	23	106
USGS	2300500	11/4/1970	23	108
USGS	2300500	11/5/1970	21	128
USGS	2300500	11/6/1970	21	139
USGS	2300500	11/7/1970	20	146
USGS	2300500	11/9/1970	18	118
USGS	2300500	11/12/1970	22	161
USGS	2300500	11/13/1970	22	145
USGS	2300500	11/14/1970	20	103
USGS	2300500	11/15/1970	29	101

USGS	2300500	11/16/1970	37	98
USGS	2300500	11/17/1970	32	98
USGS	2300500	11/18/1970	26	97
USGS	2300500	11/19/1970	24	101
USGS	2300500	11/21/1970	23	140
USGS	2300500	11/22/1970	21	103
USGS	2300500	11/23/1970	20	110
USGS	2300500	11/24/1970	18	99
USGS	2300500	11/26/1970	19	145
USGS	2300500	11/27/1970	19	106
USGS	2300500	11/28/1970	20	106
USGS	2300500	11/29/1970	18	106
USGS	2300500	11/30/1970	18	99
USGS	2300500	12/1/1970	18	97
USGS	2300500	12/2/1970	19	105
USGS	2300500	12/3/1970	19	129
USGS	2300500	12/4/1970	18	138
USGS	2300500	12/6/1970	17	101
USGS	2300500	12/7/1970	16	98
USGS	2300500	12/8/1970	16	97
USGS	2300500	12/9/1970	18	109
USGS	2300500	12/10/1970	18	135
USGS	2300500	12/11/1970	18	147
USGS	2300500	12/12/1970	19	121
USGS	2300500	12/14/1970	19	119
USGS	2300500	12/15/1970	19	127
USGS	2300500	12/16/1970	20	121
USGS	2300500	12/17/1970	21	108
USGS	2300500	12/18/1970	24	117
USGS	2300500	12/19/1970	23	114
USGS	2300500	12/20/1970	22	134
USGS	2300500	12/21/1970	20	125
USGS	2300500	12/22/1970	20	108
USGS	2300500	12/23/1970	21	126
USGS	2300500	12/24/1970	20	134
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USGS	2300500	12/26/1970	21	107
USGS	2300500	12/27/1970	23	114
USGS	2300500	12/28/1970	23	116
USGS	2300500	12/29/1970	22	127
USGS	2300500	12/30/1970	23	128
USGS	2300500	1/2/1971	31	134
USGS	2300500	1/3/1971	28	122
USGS	2300500	1/4/1971	25	123
USGS	2300500	1/5/1971	24	121
USGS	2300500	1/6/1971	24	121
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USGS	2300500	1/9/1971	28	113
USGS	2300500	1/10/1971	26	112
USGS	2300500	1/11/1971	25	111
USGS	2300500	1/14/1971	23	108
USGS	2300500	1/15/1971	22	114

USGS	2300500	1/16/1971	22	118
USGS	2300500	1/17/1971	21	128
USGS	2300500	1/18/1971	22	137
USGS	2300500	1/19/1971	24	178
USGS	2300500	1/20/1971	23	186
USGS	2300500	1/21/1971	23	192
USGS	2300500	1/22/1971	23	200
USGS	2300500	1/23/1971	24	179
USGS	2300500	1/24/1971	24	170
USGS	2300500	1/25/1971	23	173
USGS	2300500	1/26/1971	23	174
USGS	2300500	1/27/1971	22	174
USGS	2300500	1/28/1971	21	173
USGS	2300500	1/29/1971	21	187
USGS	2300500	1/30/1971	22	172
USGS	2300500	1/31/1971	24	157
USGS	2300500	2/1/1971	23	150
USGS	2300500	2/2/1971	24	170
USGS	2300500	2/3/1971	25	210
USGS	2300500	2/4/1971	26	258
USGS	2300500	2/6/1971	31	236
USGS	2300500	2/9/1971	480	142
USGS	2300500	2/11/1971	216	145
USGS	2300500	2/12/1971	153	160
USGS	2300500	2/13/1971	138	154
USGS	2300500	2/14/1971	116	150
USGS	2300500	2/15/1971	93	135
USGS	2300500	2/17/1971	69	135
USGS	2300500	2/18/1971	63	142
USGS	2300500	2/19/1971	59	145
USGS	2300500	2/20/1971	56	143
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USGS	2300500	2/23/1971	50	145
USGS	2300500	2/24/1971	49	140
USGS	2300500	2/25/1971	48	145
USGS	2300500	2/26/1971	45	160
USGS	2300500	2/27/1971	43	155
USGS	2300500	2/28/1971	40	135
USGS	2300500	3/1/1971	38	133
USGS	2300500	3/2/1971	38	137
USGS	2300500	3/3/1971	38	147
USGS	2300500	3/4/1971	38	135
USGS	2300500	3/6/1971	38	168
USGS	2300500	3/7/1971	46	165
USGS	2300500	3/8/1971	59	130
USGS	2300500	3/9/1971	54	129
USGS	2300500	3/10/1971	47	120
USGS	2300500	3/11/1971	43	116
USGS	2300500	3/13/1971	39	160
USGS	2300500	3/14/1971	36	142
USGS	2300500	3/16/1971	34	135

USGS	2300500	3/17/1971	36	117
USGS	2300500	3/18/1971	37	114
USGS	2300500	3/19/1971	35	115
USGS	2300500	3/20/1971	34	117
USGS	2300500	3/21/1971	33	117
USGS	2300500	3/22/1971	32	195
USGS	2300500	3/23/1971	30	123
USGS	2300500	3/24/1971	31	124
USGS	2300500	3/25/1971	30	142
USGS	2300500	3/26/1971	29	168
USGS	2300500	3/27/1971	27	165
USGS	2300500	3/28/1971	24	140
USGS	2300500	3/29/1971	23	134
USGS	2300500	3/30/1971	25	133
USGS	2300500	3/31/1971	27	137
USGS	2300500	4/1/1971	26	139
USGS	2300500	4/4/1971	23	241
USGS	2300500	4/5/1971	25	171
USGS	2300500	4/6/1971	29	122
USGS	2300500	4/9/1971	20	135
USGS	2300500	4/10/1971	19	127
USGS	2300500	4/11/1971	18	156
USGS	2300500	4/12/1971	17	177
USGS	2300500	4/13/1971	16	140
USGS	2300500	4/14/1971	16	141
USGS	2300500	4/15/1971	15	132
USGS	2300500	4/16/1971	15	123
USGS	2300500	4/17/1971	16	133
USGS	2300500	4/18/1971	16	187
USGS	2300500	4/19/1971	15	258
USGS	2300500	4/20/1971	16	255
USGS	2300500	4/21/1971	16	188
USGS	2300500	4/22/1971	15	222
USGS	2300500	4/23/1971	14	193
USGS	2300500	4/24/1971	16	200
USGS	2300500	4/25/1971	15	235
USGS	2300500	4/26/1971	13	220
USGS	2300500	4/27/1971	12	212
USGS	2300500	4/28/1971	12	200
USGS	2300500	4/29/1971	12	220
USGS	2300500	4/30/1971	13	203
USGS	2300500	5/2/1971	14	362
USGS	2300500	5/3/1971	12	260
USGS	2300500	5/4/1971	11	228
USGS	2300500	5/5/1971	11	169
USGS	2300500	5/6/1971	12	321
USGS	2300500	5/7/1971	11	253
USGS	2300500	5/8/1971	10	198
USGS	2300500	5/9/1971	11	173
USGS	2300500	5/10/1971	11	284
USGS	2300500	5/11/1971	12	292
USGS	2300500	5/12/1971	12	307

USGS	2300500	5/13/1971	13	200
USGS	2300500	5/14/1971	12	191
USGS	2300500	5/16/1971	35	269
USGS	2300500	5/17/1971	36	161
USGS	2300500	5/18/1971	28	146
USGS	2300500	5/19/1971	21	147
USGS	2300500	5/21/1971	13	155
USGS	2300500	5/22/1971	11	156
USGS	2300500	5/23/1971	10	160
USGS	2300500	5/24/1971	10	185
USGS	2300500	5/25/1971	10	171
USGS	2300500	5/26/1971	9	189
USGS	2300500	5/27/1971	8	163
USGS	2300500	5/28/1971	8	134
USGS	2300500	5/29/1971	8	133
USGS	2300500	5/30/1971	7	138
USGS	2300500	5/31/1971	7	171
USGS	2300500	6/1/1971	6	182
USGS	2300500	6/2/1971	6	167
USGS	2300500	6/3/1971	6	188
USGS	2300500	6/5/1971	6	204
USGS	2300500	6/6/1971	4	221
USGS	2300500	6/7/1971	4	191
USGS	2300500	6/8/1971	13	161
USGS	2300500	6/10/1971	9	150
USGS	2300500	6/11/1971	7	160
USGS	2300500	6/12/1971	7	154
USGS	2300500	6/14/1971	13	127
USGS	2300500	6/15/1971	12	114
USGS	2300500	6/16/1971	8	111
USGS	2300500	6/17/1971	7	118
USGS	2300500	6/18/1971	6	117
USGS	2300500	6/19/1971	6	118
USGS	2300500	6/20/1971	6	110
USGS	2300500	6/21/1971	17	108
USGS	2300500	6/22/1971	17	120
USGS	2300500	6/23/1971	16	117
USGS	2300500	6/24/1971	40	136
USGS	2300500	6/25/1971	54	131
USGS	2300500	6/26/1971	38	130
USGS	2300500	6/27/1971	44	133
USGS	2300500	6/28/1971	27	133
USGS	2300500	6/29/1971	52	104
USGS	2300500	6/30/1971	48	118
USGS	2300500	7/1/1971	35	104
USGS	2300500	7/2/1971	31	105
USGS	2300500	7/3/1971	84	84
USGS	2300500	7/4/1971	69	93
USGS	2300500	7/5/1971	193	90
USGS	2300500	7/6/1971	147	101
USGS	2300500	7/8/1971	62	103
USGS	2300500	7/9/1971	50	106

USGS	2300500	7/10/1971	38	105
USGS	2300500	7/11/1971	32	102
USGS	2300500	7/12/1971	36	99
USGS	2300500	7/13/1971	58	102
USGS	2300500	7/14/1971	53	101
USGS	2300500	7/15/1971	52	100
USGS	2300500	7/16/1971	67	95
USGS	2300500	7/17/1971	58	95
USGS	2300500	7/18/1971	39	97
USGS	2300500	7/19/1971	33	108
USGS	2300500	7/20/1971	27	97
USGS	2300500	7/21/1971	27	98
USGS	2300500	7/23/1971	72	83
USGS	2300500	7/24/1971	182	84
USGS	2300500	7/25/1971	123	98
USGS	2300500	7/26/1971	87	99
USGS	2300500	7/27/1971	60	97
USGS	2300500	7/29/1971	231	100
USGS	2300500	7/30/1971	461	97
USGS	2300500	7/31/1971	236	92
USGS	2300500	8/1/1971	151	128
USGS	2300500	8/2/1971	119	124
USGS	2300500	8/5/1971	258	118
USGS	2300500	8/6/1971	715	123
USGS	2300500	8/7/1971	254	128
USGS	2300500	8/8/1971	145	127
USGS	2300500	8/9/1971	111	121
USGS	2300500	8/10/1971	161	86
USGS	2300500	8/11/1971	317	86
USGS	2300500	8/12/1971	824	88
USGS	2300500	8/14/1971	550	94
USGS	2300500	8/15/1971	1380	67
USGS	2300500	8/16/1971	1940	79
USGS	2300500	8/17/1971	1920	71
USGS	2300500	8/18/1971	1390	79
USGS	2300500	8/19/1971	877	84
USGS	2300500	8/21/1971	330	97
USGS	2300500	8/22/1971	256	98
USGS	2300500	8/23/1971	200	103
USGS	2300500	8/24/1971	173	106
USGS	2300500	8/25/1971	162	111
USGS	2300500	8/26/1971	293	94
USGS	2300500	8/27/1971	374	95
USGS	2300500	8/28/1971	272	75
USGS	2300500	8/29/1971	389	84
USGS	2300500	8/30/1971	302	92
USGS	2300500	8/31/1971	263	92
USGS	2300500	9/1/1971	277	83
USGS	2300500	9/2/1971	274	81
USGS	2300500	9/3/1971	400	79
USGS	2300500	9/4/1971	367	78
USGS	2300500	9/5/1971	318	75

USGS	2300500	9/6/1971	289	78
USGS	2300500	9/7/1971	308	83
USGS	2300500	9/8/1971	406	79
USGS	2300500	9/9/1971	720	78
USGS	2300500	9/12/1971	877	73
USGS	2300500	9/13/1971	1000	78
USGS	2300500	9/14/1971	1110	66
USGS	2300500	9/15/1971	1240	68
USGS	2300500	9/16/1971	967	66
USGS	2300500	9/17/1971	559	71
USGS	2300500	9/18/1971	487	73
USGS	2300500	9/19/1971	559	60
USGS	2300500	9/20/1971	512	67
USGS	2300500	9/21/1971	311	70
USGS	2300500	9/22/1971	247	76
USGS	2300500	9/23/1971	192	84
USGS	2300500	9/24/1971	149	82
USGS	2300500	9/25/1971	121	85
USGS	2300500	9/26/1971	99	88
USGS	2300500	9/27/1971	85	92
USGS	2300500	9/28/1971	71	96
USGS	2300500	9/29/1971	63	98
USGS	2300500	9/30/1971	57	110
USGS	2300500	10/2/1971	46	104
USGS	2300500	10/3/1971	42	97
USGS	2300500	10/4/1971	40	98
USGS	2300500	10/5/1971	38	99
USGS	2300500	10/6/1971	61	99
USGS	2300500	10/7/1971	78	91
USGS	2300500	10/8/1971	117	79
USGS	2300500	10/9/1971	256	78
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USGS	2300500	10/15/1971	743	60
USGS	2300500	10/16/1971	529	63
USGS	2300500	10/17/1971	380	65
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USGS	2300500	10/21/1971	271	78
USGS	2300500	10/22/1971	189	35
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USGS	2300500	10/24/1971	547	60
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USGS	2300500	10/26/1971	170	81
USGS	2300500	10/27/1971	133	82
USGS	2300500	10/28/1971	111	83
USGS	2300500	10/29/1971	97	85
USGS	2300500	10/30/1971	89	85
USGS	2300500	10/31/1971	81	84
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USGS	2300500	11/2/1971	72	96
USGS	2300500	11/3/1971	87	88

USGS	2300500	11/4/1971	134	86
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USGS	2300500	11/18/1971	47	104
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USGS	2300500	11/26/1971	35	106
USGS	2300500	11/27/1971	36	131
USGS	2300500	11/28/1971	35	137
USGS	2300500	11/29/1971	39	115
USGS	2300500	11/30/1971	53	112
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USGS	2300500	12/7/1971	104	98
USGS	2300500	12/8/1971	84	98
USGS	2300500	12/9/1971	73	98
USGS	2300500	12/10/1971	68	106
USGS	2300500	12/11/1971	64	108
USGS	2300500	12/12/1971	57	100
USGS	2300500	12/13/1971	54	101
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USGS	2300500	12/15/1971	50	118
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USGS	2300500	12/26/1971	34	96
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USGS	2300500	12/31/1971	32	117

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USGS	2300500	1/3/1972	32	134
USGS	2300500	1/4/1972	35	134
USGS	2300500	1/5/1972	36	134
USGS	2300500	1/6/1972	37	129
USGS	2300500	1/8/1972	36	116
USGS	2300500	1/9/1972	32	113
USGS	2300500	1/10/1972	31	114
USGS	2300500	1/11/1972	30	110
USGS	2300500	1/12/1972	30	112
USGS	2300500	1/13/1972	32	116
USGS	2300500	1/14/1972	29	126
USGS	2300500	1/16/1972	32	117
USGS	2300500	1/19/1972	32	136
USGS	2300500	1/20/1972	32	122
USGS	2300500	1/21/1972	31	132
USGS	2300500	1/22/1972	36	131
USGS	2300500	1/23/1972	43	124
USGS	2300500	1/24/1972	45	122
USGS	2300500	1/25/1972	40	114
USGS	2300500	1/26/1972	38	115
USGS	2300500	1/27/1972	36	120
USGS	2300500	1/28/1972	35	123
USGS	2300500	1/29/1972	34	125
USGS	2300500	1/30/1972	33	138
USGS	2300500	1/31/1972	32	146
USGS	2300500	2/2/1972	2130	50
USGS	2300500	2/3/1972	2150	64
USGS	2300500	2/5/1972	1290	71
USGS	2300500	2/6/1972	798	75
USGS	2300500	2/7/1972	440	80
USGS	2300500	2/8/1972	361	84
USGS	2300500	2/9/1972	394	88
USGS	2300500	2/10/1972	557	87
USGS	2300500	2/11/1972	409	86
USGS	2300500	2/12/1972	324	87
USGS	2300500	2/13/1972	490	78
USGS	2300500	2/14/1972	382	85
USGS	2300500	2/15/1972	264	87
USGS	2300500	2/16/1972	247	92
USGS	2300500	2/17/1972	259	91
USGS	2300500	2/20/1972	156	94
USGS	2300500	2/21/1972	130	96
USGS	2300500	2/22/1972	116	97
USGS	2300500	2/23/1972	105	108
USGS	2300500	2/24/1972	97	112
USGS	2300500	2/25/1972	85	104
USGS	2300500	2/26/1972	81	111
USGS	2300500	2/27/1972	74	113
USGS	2300500	2/28/1972	68	108
USGS	2300500	2/29/1972	65	106

USGS	2300500	3/1/1972	62	107
USGS	2300500	3/2/1972	62	115
USGS	2300500	3/3/1972	80	123
USGS	2300500	3/4/1972	93	114
USGS	2300500	3/5/1972	80	104
USGS	2300500	3/6/1972	73	108
USGS	2300500	3/7/1972	66	106
USGS	2300500	3/8/1972	62	104
USGS	2300500	3/9/1972	57	108
USGS	2300500	3/11/1972	52	149
USGS	2300500	3/12/1972	50	140
USGS	2300500	3/13/1972	48	144
USGS	2300500	3/14/1972	46	132
USGS	2300500	3/15/1972	46	139
USGS	2300500	3/16/1972	43	142
USGS	2300500	3/17/1972	45	137
USGS	2300500	3/18/1972	46	130
USGS	2300500	3/19/1972	47	119
USGS	2300500	3/20/1972	51	120
USGS	2300500	3/21/1972	49	108
USGS	2300500	3/22/1972	45	104
USGS	2300500	3/23/1972	44	107
USGS	2300500	3/24/1972	41	112
USGS	2300500	3/25/1972	38	114
USGS	2300500	3/26/1972	36	134
USGS	2300500	3/27/1972	35	162
USGS	2300500	3/28/1972	35	192
USGS	2300500	3/29/1972	35	171
USGS	2300500	3/30/1972	32	130
USGS	2300500	3/31/1972	213	95
USGS	2300500	4/1/1972	435	93
USGS	2300500	4/2/1972	444	84
USGS	2300500	4/3/1972	333	84
USGS	2300500	4/4/1972	224	86
USGS	2300500	4/5/1972	152	88
USGS	2300500	4/6/1972	108	88
USGS	2300500	4/7/1972	81	90
USGS	2300500	4/8/1972	67	100
USGS	2300500	4/9/1972	59	107
USGS	2300500	4/10/1972	61	107
USGS	2300500	4/11/1972	59	107
USGS	2300500	4/12/1972	56	125
USGS	2300500	4/13/1972	52	148
USGS	2300500	4/14/1972	47	166
USGS	2300500	4/16/1972	36	140
USGS	2300500	4/17/1972	31	145
USGS	2300500	4/18/1972	28	165
USGS	2300500	4/19/1972	25	155
USGS	2300500	4/20/1972	23	145
USGS	2300500	4/22/1972	24	231
USGS	2300500	4/23/1972	21	208
USGS	2300500	4/24/1972	18	174

USGS	2300500	4/25/1972	17	156
USGS	2300500	4/26/1972	15	140
USGS	2300500	4/28/1972	14	240
USGS	2300500	4/29/1972	18	238
USGS	2300500	4/30/1972	23	236
USGS	2300500	5/1/1972	18	190
USGS	2300500	5/2/1972	17	145
USGS	2300500	5/3/1972	18	130
USGS	2300500	5/4/1972	16	125
USGS	2300500	5/5/1972	15	120
USGS	2300500	5/6/1972	15	130
USGS	2300500	5/7/1972	15	140
USGS	2300500	5/8/1972	15	175
USGS	2300500	5/9/1972	14	205
USGS	2300500	5/10/1972	14	155
USGS	2300500	5/11/1972	14	145
USGS	2300500	5/12/1972	36	145
USGS	2300500	5/13/1972	47	135
USGS	2300500	5/14/1972	68	140
USGS	2300500	5/15/1972	59	130
USGS	2300500	5/16/1972	72	170
USGS	2300500	5/17/1972	176	110
USGS	2300500	5/18/1972	97	110
USGS	2300500	5/19/1972	68	110
USGS	2300500	5/20/1972	52	110
USGS	2300500	5/21/1972	41	105
USGS	2300500	5/22/1972	34	105
USGS	2300500	5/23/1972	30	110
USGS	2300500	5/24/1972	24	120
USGS	2300500	5/25/1972	22	120
USGS	2300500	5/27/1972	20	125
USGS	2300500	5/28/1972	21	120
USGS	2300500	5/29/1972	19	115
USGS	2300500	5/30/1972	18	105
USGS	2300500	5/31/1972	16	115
USGS	2300500	6/1/1972	16	125
USGS	2300500	6/2/1972	14	128
USGS	2300500	6/3/1972	14	133
USGS	2300500	6/4/1972	13	135
USGS	2300500	6/5/1972	13	140
USGS	2300500	6/6/1972	12	140
USGS	2300500	6/7/1972	12	138
USGS	2300500	6/8/1972	12	137
USGS	2300500	6/10/1972	14	109
USGS	2300500	6/11/1972	21	103
USGS	2300500	6/14/1972	26	108
USGS	2300500	6/15/1972	28	105
USGS	2300500	6/17/1972	25	101
USGS	2300500	6/18/1972	48	104
USGS	2300500	6/19/1972	584	101
USGS	2300500	6/20/1972	685	96
USGS	2300500	6/21/1972	663	80

USGS	2300500	6/22/1972	460	75
USGS	2300500	6/24/1972	204	87
USGS	2300500	6/25/1972	153	87
USGS	2300500	6/26/1972	118	87
USGS	2300500	6/27/1972	86	88
USGS	2300500	6/28/1972	67	94
USGS	2300500	6/29/1972	52	95
USGS	2300500	6/30/1972	45	99
USGS	2300500	7/1/1972	39	102
USGS	2300500	7/2/1972	32	106
USGS	2300500	7/3/1972	26	106
USGS	2300500	7/5/1972	45	110
USGS	2300500	7/6/1972	52	108
USGS	2300500	7/7/1972	38	108
USGS	2300500	7/8/1972	36	102
USGS	2300500	7/9/1972	38	98
USGS	2300500	7/10/1972	38	96
USGS	2300500	7/11/1972	34	94
USGS	2300500	7/12/1972	27	100
USGS	2300500	7/13/1972	25	100
USGS	2300500	7/15/1972	99	88
USGS	2300500	7/16/1972	88	91
USGS	2300500	7/17/1972	74	96
USGS	2300500	7/18/1972	63	98
USGS	2300500	7/19/1972	61	98
USGS	2300500	7/20/1972	57	90
USGS	2300500	7/21/1972	59	96
USGS	2300500	7/22/1972	59	90
USGS	2300500	7/23/1972	48	96
USGS	2300500	7/24/1972	39	96
USGS	2300500	7/25/1972	35	96
USGS	2300500	7/26/1972	33	96
USGS	2300500	7/27/1972	33	99
USGS	2300500	7/31/1972	21	104
USGS	2300500	8/1/1972	29	95
USGS	2300500	8/2/1972	32	95
USGS	2300500	8/3/1972	49	97
USGS	2300500	8/4/1972	34	115
USGS	2300500	8/5/1972	28	110
USGS	2300500	8/6/1972	28	100
USGS	2300500	8/7/1972	23	102
USGS	2300500	8/8/1972	23	115
USGS	2300500	8/9/1972	42	108
USGS	2300500	8/10/1972	37	105
USGS	2300500	8/11/1972	24	108
USGS	2300500	8/12/1972	20	110
USGS	2300500	8/13/1972	36	105
USGS	2300500	8/14/1972	36	104
USGS	2300500	8/15/1972	26	95
USGS	2300500	8/16/1972	37	85
USGS	2300500	8/18/1972	176	100
USGS	2300500	8/19/1972	299	95

USGS	2300500	8/20/1972	221	100
USGS	2300500	8/21/1972	219	90
USGS	2300500	8/22/1972	389	85
USGS	2300500	8/23/1972	461	90
USGS	2300500	8/24/1972	528	82
USGS	2300500	8/27/1972	981	62
USGS	2300500	8/28/1972	1330	65
USGS	2300500	8/29/1972	1420	62
USGS	2300500	8/30/1972	1210	67
USGS	2300500	8/31/1972	1190	64
USGS	2300500	9/1/1972	1150	60
USGS	2300500	9/2/1972	791	70
USGS	2300500	9/3/1972	583	77
USGS	2300500	9/4/1972	435	78
USGS	2300500	9/5/1972	415	81
USGS	2300500	9/6/1972	290	83
USGS	2300500	9/7/1972	222	79
USGS	2300500	9/10/1972	105	92
USGS	2300500	9/11/1972	86	95
USGS	2300500	9/14/1972	60	127
USGS	2300500	9/15/1972	55	131
USGS	2300500	9/16/1972	46	130
USGS	2300500	9/17/1972	44	135
USGS	2300500	9/18/1972	38	127
USGS	2300500	9/19/1972	34	158
USGS	2300500	9/20/1972	32	128
USGS	2300500	9/21/1972	30	122
USGS	2300500	9/22/1972	28	144
USGS	2300500	9/23/1972	26	148
USGS	2300500	9/24/1972	22	149
USGS	2300500	9/25/1972	22	162
USGS	2300500	9/26/1972	22	189
USGS	2300500	9/27/1972	21	199
USGS	2300500	9/28/1972	20	181
USGS	2300500	10/1/1972	31	120
USGS	2300500	10/2/1972	52	103
USGS	2300500	10/3/1972	173	99
USGS	2300500	10/4/1972	206	114
USGS	2300500	10/5/1972	173	89
USGS	2300500	10/6/1972	142	94
USGS	2300500	10/7/1972	108	94
USGS	2300500	10/8/1972	83	93
USGS	2300500	10/9/1972	66	94
USGS	2300500	10/10/1972	55	100
USGS	2300500	10/11/1972	47	109
USGS	2300500	10/12/1972	41	130
USGS	2300500	10/16/1972	29	135
USGS	2300500	10/17/1972	27	140
USGS	2300500	10/18/1972	26	114
USGS	2300500	10/19/1972	27	125
USGS	2300500	10/20/1972	24	177
USGS	2300500	10/21/1972	24	199

USGS	2300500	10/22/1972	21	152
USGS	2300500	10/23/1972	19	174
USGS	2300500	10/24/1972	21	192
USGS	2300500	10/25/1972	20	165
USGS	2300500	10/26/1972	20	160
USGS	2300500	10/27/1972	19	140
USGS	2300500	10/28/1972	21	125
USGS	2300500	10/29/1972	22	111
USGS	2300500	10/30/1972	24	123
USGS	2300500	10/31/1972	23	130
USGS	2300500	11/1/1972	22	160
USGS	2300500	11/2/1972	21	185
USGS	2300500	11/3/1972	20	165
USGS	2300500	11/4/1972	19	165
USGS	2300500	11/5/1972	18	137
USGS	2300500	11/6/1972	19	149
USGS	2300500	11/7/1972	22	132
USGS	2300500	11/8/1972	28	129
USGS	2300500	11/9/1972	25	117
USGS	2300500	11/10/1972	24	180
USGS	2300500	11/11/1972	24	221
USGS	2300500	11/12/1972	22	168
USGS	2300500	11/13/1972	50	123
USGS	2300500	11/14/1972	92	139
USGS	2300500	11/15/1972	126	123
USGS	2300500	11/16/1972	81	115
USGS	2300500	11/17/1972	59	116
USGS	2300500	11/18/1972	48	116
USGS	2300500	11/20/1972	154	126
USGS	2300500	11/21/1972	203	111
USGS	2300500	11/22/1972	165	104
USGS	2300500	11/23/1972	115	104
USGS	2300500	11/24/1972	89	107
USGS	2300500	11/25/1972	79	106
USGS	2300500	11/26/1972	113	114
USGS	2300500	11/27/1972	112	109
USGS	2300500	11/28/1972	95	107
USGS	2300500	11/29/1972	143	114
USGS	2300500	11/30/1972	169	106
USGS	2300500	12/1/1972	137	107
USGS	2300500	12/2/1972	102	108
USGS	2300500	12/3/1972	84	107
USGS	2300500	12/4/1972	74	107
USGS	2300500	12/5/1972	67	109
USGS	2300500	12/6/1972	63	107
USGS	2300500	12/7/1972	62	113
USGS	2300500	12/10/1972	51	110
USGS	2300500	12/11/1972	48	121
USGS	2300500	12/12/1972	45	121
USGS	2300500	12/13/1972	43	124
USGS	2300500	12/14/1972	42	138
USGS	2300500	12/15/1972	48	136

USGS	2300500	12/16/1972	75	118
USGS	2300500	12/17/1972	106	101
USGS	2300500	12/18/1972	104	100
USGS	2300500	12/19/1972	86	107
USGS	2300500	12/20/1972	75	106
USGS	2300500	12/21/1972	95	115
USGS	2300500	12/24/1972	510	87
USGS	2300500	12/26/1972	236	94
USGS	2300500	12/27/1972	175	94
USGS	2300500	12/28/1972	138	99
USGS	2300500	12/29/1972	112	99
USGS	2300500	12/30/1972	95	99
USGS	2300500	12/31/1972	86	100
USGS	2300500	1/1/1973	78	116
USGS	2300500	1/2/1973	72	114
USGS	2300500	1/3/1973	66	111
USGS	2300500	1/4/1973	63	113
USGS	2300500	1/5/1973	59	120
USGS	2300500	1/6/1973	57	110
USGS	2300500	1/7/1973	54	109
USGS	2300500	1/8/1973	52	104
USGS	2300500	1/9/1973	50	107
USGS	2300500	1/10/1973	49	118
USGS	2300500	1/11/1973	83	124
USGS	2300500	1/12/1973	331	122
USGS	2300500	1/13/1973	379	149
USGS	2300500	1/14/1973	331	93
USGS	2300500	1/15/1973	260	93
USGS	2300500	1/16/1973	197	98
USGS	2300500	1/17/1973	154	100
USGS	2300500	1/18/1973	123	103
USGS	2300500	1/19/1973	103	108
USGS	2300500	1/21/1973	80	114
USGS	2300500	1/22/1973	276	111
USGS	2300500	1/23/1973	1000	83
USGS	2300500	1/24/1973	1390	71
USGS	2300500	1/25/1973	1490	72
USGS	2300500	1/26/1973	1040	75
USGS	2300500	1/27/1973	551	79
USGS	2300500	1/28/1973	430	86
USGS	2300500	1/29/1973	606	82
USGS	2300500	1/30/1973	554	79
USGS	2300500	1/31/1973	447	80
USGS	2300500	2/1/1973	334	80
USGS	2300500	2/3/1973	267	88
USGS	2300500	2/4/1973	231	85
USGS	2300500	2/5/1973	197	88
USGS	2300500	2/6/1973	165	90
USGS	2300500	2/7/1973	140	93
USGS	2300500	2/8/1973	121	98
USGS	2300500	2/9/1973	114	103
USGS	2300500	2/11/1973	193	90

USGS	2300500	2/12/1973	159	92
USGS	2300500	2/13/1973	136	90
USGS	2300500	2/14/1973	121	95
USGS	2300500	2/15/1973	165	100
USGS	2300500	2/16/1973	198	98
USGS	2300500	2/17/1973	152	93
USGS	2300500	2/18/1973	136	92
USGS	2300500	2/19/1973	203	100
USGS	2300500	2/20/1973	194	92
USGS	2300500	2/21/1973	162	90
USGS	2300500	2/22/1973	134	92
USGS	2300500	2/23/1973	114	95
USGS	2300500	2/24/1973	101	97
USGS	2300500	2/25/1973	91	102
USGS	2300500	2/26/1973	86	110
USGS	2300500	3/3/1973	63	148
USGS	2300500	3/13/1973	73	114
USGS	2300500	3/14/1973	66	122
USGS	2300500	3/15/1973	61	149
USGS	2300500	3/16/1973	56	124
USGS	2300500	3/17/1973	58	128
USGS	2300500	3/18/1973	49	117
USGS	2300500	3/19/1973	45	120
USGS	2300500	3/20/1973	44	136
USGS	2300500	3/21/1973	48	138
USGS	2300500	3/22/1973	54	150
USGS	2300500	3/23/1973	50	95
USGS	2300500	3/30/1973	128	95
USGS	2300500	3/31/1973	102	98
USGS	2300500	4/3/1973	382	58
USGS	2300500	4/6/1973	2150	73
USGS	2300500	4/7/1973	1260	84
USGS	2300500	4/8/1973	794	80
USGS	2300500	4/9/1973	567	80
USGS	2300500	4/11/1973	302	86
USGS	2300500	4/12/1973	219	85
USGS	2300500	4/13/1973	167	95
USGS	2300500	4/14/1973	129	93
USGS	2300500	4/15/1973	104	103
USGS	2300500	4/16/1973	84	100
USGS	2300500	4/17/1973	72	100
USGS	2300500	4/19/1973	59	130
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USGS	2300500	4/21/1973	50	155
USGS	2300500	4/22/1973	44	150
USGS	2300500	4/23/1973	44	169
USGS	2300500	4/24/1973	40	150
USGS	2300500	4/25/1973	39	180
USGS	2300500	4/26/1973	40	153
USGS	2300500	4/27/1973	60	212
USGS	2300500	4/28/1973	59	130
USGS	2300500	4/29/1973	45	113

USGS	2300500	4/30/1973	38	109
USGS	2300500	5/1/1973	35	109
USGS	2300500	5/2/1973	32	158
USGS	2300500	5/3/1973	32	181
USGS	2300500	5/4/1973	31	181
USGS	2300500	5/5/1973	27	164
USGS	2300500	5/6/1973	26	168
USGS	2300500	5/7/1973	23	160
USGS	2300500	5/8/1973	23	153
USGS	2300500	5/9/1973	24	155
USGS	2300500	5/10/1973	23	157
USGS	2300500	5/11/1973	22	230
USGS	2300500	5/12/1973	23	145
USGS	2300500	5/13/1973	21	200
USGS	2300500	5/14/1973	21	157
USGS	2300500	5/15/1973	21	190
USGS	2300500	5/16/1973	19	240
USGS	2300500	5/17/1973	20	220
USGS	2300500	5/18/1973	18	183
USGS	2300500	5/19/1973	18	182
USGS	2300500	5/20/1973	19	208
USGS	2300500	5/21/1973	18	212
USGS	2300500	5/22/1973	17	233
USGS	2300500	5/23/1973	17	227
USGS	2300500	5/24/1973	18	339
USGS	2300500	5/25/1973	16	225
USGS	2300500	5/26/1973	14	231
USGS	2300500	5/27/1973	14	259
USGS	2300500	5/28/1973	14	284
USGS	2300500	5/29/1973	14	275
USGS	2300500	5/30/1973	14	200
USGS	2300500	5/31/1973	26	170
USGS	2300500	6/1/1973	42	192
USGS	2300500	6/2/1973	41	172
USGS	2300500	6/3/1973	38	165
USGS	2300500	6/5/1973	29	132
USGS	2300500	6/6/1973	24	132
USGS	2300500	6/7/1973	20	143
USGS	2300500	6/8/1973	18	140
USGS	2300500	6/9/1973	17	147
USGS	2300500	6/10/1973	16	127
USGS	2300500	6/11/1973	18	124
USGS	2300500	6/12/1973	20	175
USGS	2300500	6/13/1973	18	141
USGS	2300500	6/14/1973	32	189
USGS	2300500	6/15/1973	28	202
USGS	2300500	6/16/1973	23	140
USGS	2300500	6/17/1973	20	130
USGS	2300500	6/18/1973	17	127
USGS	2300500	6/19/1973	17	127
USGS	2300500	6/20/1973	16	128
USGS	2300500	6/21/1973	18	113

USGS	2300500	6/23/1973	42	142
USGS	2300500	6/24/1973	66	116
USGS	2300500	6/25/1973	80	138
USGS	2300500	6/26/1973	55	126
USGS	2300500	6/27/1973	39	123
USGS	2300500	6/28/1973	29	125
USGS	2300500	6/30/1973	23	119
USGS	2300500	7/1/1973	25	120
USGS	2300500	7/2/1973	105	128
USGS	2300500	7/3/1973	86	107
USGS	2300500	7/4/1973	107	100
USGS	2300500	7/5/1973	352	91
USGS	2300500	7/6/1973	366	105
USGS	2300500	7/7/1973	260	88
USGS	2300500	7/8/1973	128	92
USGS	2300500	7/9/1973	147	84
USGS	2300500	7/10/1973	264	81
USGS	2300500	7/11/1973	171	80
USGS	2300500	7/12/1973	213	92
USGS	2300500	7/13/1973	98	96
USGS	2300500	7/14/1973	69	95
USGS	2300500	7/15/1973	58	91
USGS	2300500	7/16/1973	51	90
USGS	2300500	7/17/1973	42	93
USGS	2300500	7/18/1973	40	95
USGS	2300500	7/19/1973	247	88
USGS	2300500	7/20/1973	1030	66
USGS	2300500	7/21/1973	1170	67
USGS	2300500	7/22/1973	1000	64
USGS	2300500	7/25/1973	223	77
USGS	2300500	7/26/1973	312	81
USGS	2300500	7/27/1973	278	80
USGS	2300500	7/28/1973	370	82
USGS	2300500	7/29/1973	188	79
USGS	2300500	7/30/1973	136	83
USGS	2300500	7/31/1973	326	89
USGS	2300500	8/1/1973	624	68
USGS	2300500	8/2/1973	930	76
USGS	2300500	8/5/1973	513	78
USGS	2300500	8/6/1973	468	71
USGS	2300500	8/7/1973	596	68
USGS	2300500	8/8/1973	432	76
USGS	2300500	8/9/1973	680	68
USGS	2300500	8/12/1973	282	74
USGS	2300500	8/13/1973	215	77
USGS	2300500	8/14/1973	174	80
USGS	2300500	8/17/1973	380	66
USGS	2300500	8/18/1973	223	73
USGS	2300500	8/19/1973	150	77
USGS	2300500	8/23/1973	255	75
USGS	2300500	8/24/1973	248	72
USGS	2300500	8/25/1973	215	72

USGS	2300500	8/27/1973	236		71
USGS	2300500	8/28/1973	200		70
USGS	2300500	8/29/1973	159		77
USGS	2300500	8/30/1973	115		85
USGS	2300500	8/31/1973	169		66
USGS	2300500	9/1/1973	566		67
USGS	2300500	9/2/1973	620		66
USGS	2300500	9/3/1973	636		63
USGS	2300500	9/4/1973	594		63
USGS	2300500	9/5/1973	662		59
USGS	2300500	9/6/1973	530		67
USGS	2300500	9/7/1973	383		69
USGS	2300500	9/8/1973	413		70
USGS	2300500	9/9/1973	523		70
USGS	2300500	9/10/1973	527		68
USGS	2300500	9/11/1973	572		73
USGS	2300500	9/12/1973	962		61
USGS	2300500	9/13/1973	1140		60
USGS	2300500	9/16/1973	518		65
USGS	2300500	9/18/1973	196		84
USGS	2300500	9/19/1973	150		82
USGS	2300500	9/20/1973	143		87
USGS	2300500	9/21/1973	122		87
USGS	2300500	9/22/1973	131		88
USGS	2300500	9/23/1973	203		89
USGS	2300500	9/24/1973	414		72
USGS	2300500	9/25/1973	248		82
USGS	2300500	9/26/1973	167		86
USGS	2300500	9/28/1973	231		80
USGS	2300500	9/29/1973	175		88
USGS	2300500	9/30/1973	141		89
USGS	2300500	10/1/1973	108	3.0	91
USGS	2300500	10/3/1973	74	2.63	101
USGS	2300500	10/4/1973	64	2.49	104
USGS	2300500	10/5/1973	58	2.4	118
USGS	2300500	10/6/1973	52	2.31	116
USGS	2300500	10/7/1973	46	2.21	114
USGS	2300500	10/8/1973	42	2.15	110
USGS	2300500	10/11/1973	39	2.08	117
USGS	2300500	10/12/1973	37	2.05	135
USGS	2300500	10/13/1973	35	2.03	142
USGS	2300500	10/14/1973	33	2.03	141
USGS	2300500	10/15/1973	33	2.04	133
USGS	2300500	10/16/1973	32	2.11	160
USGS	2300500	10/19/1973	28	1.88	142
USGS	2300500	10/20/1973	26	1.84	140
USGS	2300500	10/21/1973	26	1.84	164
USGS	2300500	10/22/1973	25	1.81	140
USGS	2300500	10/23/1973	25	1.82	149
USGS	2300500	10/24/1973	24	1.79	172
USGS	2300500	10/26/1973	24	1.85	206
USGS	2300500	10/27/1973	25	1.86	204

USGS	2300500	10/28/1973	22	1.97	149
USGS	2300500	10/29/1973	21	1.96	153
USGS	2300500	10/30/1973	22	1.78	186
USGS	2300500	10/31/1973	23	1.78	232
USGS	2300500	11/1/1973	38	2.16	229
USGS	2300500	11/3/1973	36	1.99	141
USGS	2300500	11/4/1973	35	1.97	140
USGS	2300500	11/5/1973	32	1.93	136
USGS	2300500	11/6/1973	31	1.9	182
USGS	2300500	11/7/1973	29	1.85	152
USGS	2300500	11/8/1973	26	1.81	147
USGS	2300500	11/9/1973	26	1.83	152
USGS	2300500	11/10/1973	26	1.83	217
USGS	2300500	11/11/1973	24	1.75	211
USGS	2300500	11/12/1973	22	1.72	178
USGS	2300500	11/13/1973	22	1.77	183
USGS	2300500	11/14/1973	22	1.84	158
USGS	2300500	11/15/1973	22	1.86	147
USGS	2300500	11/17/1973	24	1.78	250
USGS	2300500	11/18/1973	25	1.78	240
USGS	2300500	11/19/1973	26	1.85	217
USGS	2300500	11/20/1973	27	1.84	241
USGS	2300500	11/21/1973	27	1.88	186
USGS	2300500	11/22/1973	26	1.84	187
USGS	2300500	11/23/1973	25	1.79	178
USGS	2300500	11/24/1973	24	1.78	176
USGS	2300500	11/25/1973	24	1.9	178
USGS	2300500	11/26/1973	22	1.91	174
USGS	2300500	11/29/1973	20	1.73	181
USGS	2300500	11/30/1973	20	1.68	193
USGS	2300500	12/1/1973	21	1.69	255
USGS	2300500	12/2/1973	21	1.7	252
USGS	2300500	12/3/1973	21	1.69	277
USGS	2300500	12/4/1973	22	1.73	256
USGS	2300500	12/5/1973	24	1.86	204
USGS	2300500	12/7/1973	22	1.71	304
USGS	2300500	12/9/1973	43	2.15	171
USGS	2300500	12/10/1973	37	2.07	135
USGS	2300500	12/11/1973	33	2	141
USGS	2300500	12/13/1973	26	1.88	142
USGS	2300500	12/14/1973	30	1.99	134
USGS	2300500	12/15/1973	35	2.01	134
USGS	2300500	12/16/1973	41	2.12	131
USGS	2300500	12/17/1973	45	2.18	125
USGS	2300500	12/18/1973	49	2.25	138
USGS	2300500	12/19/1973	44	2.16	141
USGS	2300500	12/20/1973	70	2.49	215
USGS	2300500	12/21/1973	96	2.87	149
USGS	2300500	12/22/1973	65	2.49	148
USGS	2300500	12/23/1973	52	2.3	142
USGS	2300500	12/24/1973	45	2.2	136
USGS	2300500	12/25/1973	40	2.14	132

USGS	2300500	12/26/1973	38	2.1	129
USGS	2300500	12/27/1973	36	2.1	128
USGS	2300500	12/28/1973	45	2.25	136
USGS	2300500	12/29/1973	58	2.43	126
USGS	2300500	12/30/1973	54	2.36	128
USGS	2300500	12/31/1973	45	2.24	123
USGS	2300500	1/1/1974	40	2.15	123
USGS	2300500	1/2/1974	36	2.09	121
USGS	2300500	1/3/1974	33	2.04	121
USGS	2300500	1/5/1974	30	2.01	122
USGS	2300500	1/6/1974	30	2.01	130
USGS	2300500	1/7/1974	29	2.02	133
USGS	2300500	1/8/1974	28	2.02	130
USGS	2300500	1/9/1974	26	1.96	149
USGS	2300500	1/10/1974	25	1.95	140
USGS	2300500	1/11/1974	24	1.93	145
USGS	2300500	1/12/1974	23	1.9	145
USGS	2300500	1/13/1974	22	1.88	139
USGS	2300500	1/14/1974	26	1.95	136
USGS	2300500	1/15/1974	24	1.92	133
USGS	2300500	1/16/1974	25	1.93	172
USGS	2300500	1/17/1974	24	1.91	180
USGS	2300500	1/18/1974	25	1.93	168
USGS	2300500	1/19/1974	24	1.92	170
USGS	2300500	1/20/1974	23	1.9	156
USGS	2300500	1/21/1974	23	1.93	140
USGS	2300500	1/23/1974	23	1.91	200
USGS	2300500	1/24/1974	23	1.89	212
USGS	2300500	1/25/1974	21	1.87	228
USGS	2300500	1/26/1974	23	1.9	231
USGS	2300500	1/27/1974	21	1.86	240
USGS	2300500	1/28/1974	18	1.81	207
USGS	2300500	1/29/1974	19	1.83	230
USGS	2300500	1/30/1974	20	1.85	238
USGS	2300500	1/31/1974	21	1.85	260
USGS	2300500	2/5/1974	16	1.75	198
USGS	2300500	2/6/1974	17	1.79	237
USGS	2300500	2/7/1974	18	1.87	259
USGS	2300500	2/10/1974	19	1.82	187
USGS	2300500	2/11/1974	18	1.81	208
USGS	2300500	2/15/1974	18	1.8	249
USGS	2300500	2/16/1974	29	1.96	466
USGS	2300500	2/19/1974	35	2.07	136
USGS	2300500	2/20/1974	38	2.07	141
USGS	2300500	2/21/1974	33	1.96	154
USGS	2300500	2/24/1974	26	1.82	154
USGS	2300500	2/25/1974	25	1.79	187
USGS	2300500	2/26/1974	24	1.78	191
USGS	2300500	2/27/1974	25	1.79	241
USGS	2300500	3/1/1974	27	1.83	266
USGS	2300500	3/2/1974	28	1.84	291
USGS	2300500	3/7/1974	24	1.78	271

USGS	2300500	3/8/1974	25	1.79	292
USGS	2300500	3/24/1974	20	1.72	225
USGS	2300500	3/29/1974	19	1.79	262
USGS	2300500	5/29/1974	12	1.56	170
USGS	2300500	5/30/1974	12	1.55	187
USGS	2300500	5/31/1974	11	1.55	162
USGS	2300500	6/1/1974	12	1.58	179
USGS	2300500	6/2/1974	11	1.57	179
USGS	2300500	6/3/1974	12	1.58	182
USGS	2300500	6/4/1974	17	1.71	182
USGS	2300500	6/6/1974	17	1.72	128
USGS	2300500	6/8/1974	18	1.72	157
USGS	2300500	6/9/1974	28	1.95	132
USGS	2300500	6/11/1974	33	2	160
USGS	2300500	6/13/1974	27	1.86	150
USGS	2300500	6/14/1974	23	1.79	142
USGS	2300500	6/15/1974	22	1.79	145
USGS	2300500	6/16/1974	22	1.82	148
USGS	2300500	6/17/1974	22	1.8	137
USGS	2300500	6/18/1974	20	1.78	131
USGS	2300500	6/20/1974	22	1.82	123
USGS	2300500	9/20/1974	38	2.08	226
USGS	2300500	9/21/1974	35	1.98	190
USGS	2300500	9/22/1974	31	1.94	158
USGS	2300500	9/23/1974	29	1.87	130
USGS	2300500	9/24/1974	32	1.91	85
USGS	2300500	9/26/1974	67	2.53	102
USGS	2300500	9/27/1974	50	2.36	159
USGS	2300500	9/28/1974	44	2.18	110
USGS	2300500	9/30/1974	34	1.96	133
USGS	2300500	10/1/1974	32	1.89	122
USGS	2300500	10/2/1974	29	1.83	142
USGS	2300500	10/3/1974	27	1.81	207
USGS	2300500	10/4/1974	26	1.77	242
USGS	2300500	10/6/1974	25	1.77	252
USGS	2300500	10/7/1974	23	1.73	190
USGS	2300500	10/8/1974	22	1.82	172
USGS	2300500	10/9/1974	24	1.79	265
USGS	2300500	10/12/1974	23	1.72	260
USGS	2300500	10/13/1974	22	1.71	263
USGS	2300500	10/14/1974	21	1.72	197
USGS	2300500	10/15/1974	21	1.8	273
USGS	2300500	10/16/1974	23	1.89	306
USGS	2300500	10/17/1974	23	1.82	200
USGS	2300500	10/20/1974	20	1.68	242
USGS	2300500	10/21/1974	18	1.65	259
USGS	2300500	10/23/1974	20	1.68	321
USGS	2300500	10/24/1974	19	1.67	265
USGS	2300500	10/25/1974	19	1.67	285
USGS	2300500	10/26/1974	19	1.66	232
USGS	2300500	10/28/1974	18	1.69	172
USGS	2300500	10/29/1974	19	1.75	285

USGS	2300500	10/30/1974	20	1.72	247
USGS	2300500	10/31/1974	18	1.67	265
USGS	2300500	11/6/1974	18	1.69	342
USGS	2300500	11/7/1974	17	1.68	341
USGS	2300500	11/8/1974	18	1.67	335
USGS	2300500	11/12/1974	16	1.73	258
USGS	2300500	11/13/1974	16	1.64	296
USGS	2300500	11/16/1974	21	1.76	312
USGS	2300500	11/20/1974	17	1.71	274
USGS	2300500	11/21/1974	17	1.66	218
USGS	2300500	11/23/1974	15	1.64	271
USGS	2300500	11/24/1974	17	1.67	303
USGS	2300500	11/25/1974	18	1.71	340
USGS	2300500	11/27/1974	18	1.7	311
USGS	2300500	11/28/1974	17	1.69	271
USGS	2300500	11/30/1974	17	1.72	254
USGS	2300500	12/2/1974	19	1.77	337
USGS	2300500	12/6/1974	19	1.75	282
USGS	2300500	12/8/1974	18	1.77	198
USGS	2300500	12/9/1974	15	1.67	285
USGS	2300500	12/11/1974	18	1.73	277
USGS	2300500	12/12/1974	19	1.84	276
USGS	2300500	12/14/1974	21	1.82	295
USGS	2300500	12/17/1974	49	2.4	374
USGS	2300500	12/18/1974	42	2.25	233
USGS	2300500	12/19/1974	34	2.07	220
USGS	2300500	12/21/1974	42	2.2	177
USGS	2300500	12/23/1974	35	2.08	200
USGS	2300500	12/26/1974	28	1.97	161
USGS	2300500	12/27/1974	27	1.95	152
USGS	2300500	12/28/1974	27	1.96	157
USGS	2300500	12/30/1974	26	1.94	157
USGS	2300500	12/31/1974	25	1.92	165
USGS	2300500	1/1/1975	24	1.9	153
USGS	2300500	1/2/1975	23	1.89	215
USGS	2300500	1/3/1975	23	1.87	163
USGS	2300500	1/5/1975	23	1.88	152
USGS	2300500	1/6/1975	23	1.89	185
USGS	2300500	1/7/1975	24	1.9	203
USGS	2300500	1/8/1975	23	1.89	195
USGS	2300500	1/9/1975	24	1.93	223
USGS	2300500	1/10/1975	25	1.93	237
USGS	2300500	1/11/1975	24	2.01	229
USGS	2300500	1/12/1975	23	1.91	258
USGS	2300500	1/14/1975	23	1.89	186
USGS	2300500	1/15/1975	24	1.91	205
USGS	2300500	1/17/1975	23	1.91	241
USGS	2300500	1/18/1975	25	1.95	270
USGS	2300500	1/19/1975	26	1.96	265
USGS	2300500	1/20/1975	25	1.95	305
USGS	2300500	1/21/1975	22	1.89	242
USGS	2300500	1/22/1975	23	1.91	222

USGS	2300500	1/23/1975	23	1.92	258
USGS	2300500	1/24/1975	24	1.93	230
USGS	2300500	1/25/1975	25	1.99	234
USGS	2300500	1/27/1975	35	2.15	212
USGS	2300500	1/28/1975	31	2.08	172
USGS	2300500	1/30/1975	29	2.04	228
USGS	2300500	1/31/1975	29	2.04	270
USGS	2300500	6/18/1975	44	2.53	182
USGS	2300500	6/21/1975	118	3.76	215
USGS	2300500	6/22/1975	390	6.26	184
USGS	2300500	6/23/1975	369	6.06	179
USGS	2300500	6/25/1975	138	3.94	195
USGS	2300500	6/26/1975	79	3.21	193
USGS	2300500	6/27/1975	59	2.84	195
USGS	2300500	6/30/1975	38	2.41	190
USGS	2300500	8/29/1975	59	2.85	144
USGS	2300500	8/30/1975	57	2.82	134
USGS	2300500	8/31/1975	176	4.23	122
USGS	2300500	9/1/1975	169	4.29	99
USGS	2300500	9/2/1975	91	3.41	118
USGS	2300500	9/3/1975	69	3.02	126
USGS	2300500	9/4/1975	145	4.04	131
USGS	2300500	9/5/1975	222	4.78	80
USGS	2300500	9/7/1975	132	3.9	77
USGS	2300500	9/8/1975	195	4.51	83
USGS	2300500	9/9/1975	400	6.32	63
USGS	2300500	9/10/1975	496	7.11	57
USGS	2300500	9/11/1975	642	8.06	57
USGS	2300500	9/12/1975	601	7.63	57
USGS	2300500	9/13/1975	269	5.05	68
USGS	2300500	9/14/1975	151	4.1	69
USGS	2300500	9/15/1975	133	3.81	80
USGS	2300500	9/16/1975	122	3.78	84
USGS	2300500	9/17/1975	109	3.61	88
USGS	2300500	9/18/1975	106	3.5	87
USGS	2300500	9/19/1975	192	4.4	79
USGS	2300500	9/20/1975	176	4.24	88
USGS	2300500	9/21/1975	124	3.72	88
USGS	2300500	9/22/1975	99	3.47	89
USGS	2300500	9/23/1975	132	3.8	100
USGS	2300500	9/24/1975	363	5.81	73
USGS	2300500	9/25/1975	388	6.02	83
USGS	2300500	9/26/1975	148	3.98	90
USGS	2300500	9/27/1975	103	3.47	94
USGS	2300500	9/28/1975	86	3.26	98
USGS	2300500	9/29/1975	82	3.23	100
USGS	2300500	9/30/1975	88	3.29	104
USGS	2300500	10/1/1975	60	2.91	108
USGS	2300500	10/2/1975	46	2.65	112
USGS	2300500	10/3/1975	96	3.17	103
USGS	2300500	10/4/1975	368	5.78	81
USGS	2300500	10/5/1975	85	3.09	118

USGS	2300500	10/6/1975	79	2.94	130
USGS	2300500	10/7/1975	164	4.06	101
USGS	2300500	10/8/1975	92	3.26	109
USGS	2300500	10/9/1975	70	2.87	113
USGS	2300500	10/10/1975	55	2.66	113
USGS	2300500	10/11/1975	60	2.69	103
USGS	2300500	10/12/1975	52	2.59	102
USGS	2300500	10/13/1975	39	2.36	111
USGS	2300500	10/14/1975	38	2.32	120
USGS	2300500	10/15/1975	35	2.31	137
USGS	2300500	10/16/1975	34	2.27	140
USGS	2300500	10/17/1975	46	2.51	156
USGS	2300500	10/18/1975	61	2.75	127
USGS	2300500	10/19/1975	62	2.73	126
USGS	2300500	10/20/1975	45	2.53	114
USGS	2300500	10/21/1975	37	2.32	136
USGS	2300500	10/22/1975	36	2.31	136
USGS	2300500	10/23/1975	36	2.35	153
USGS	2300500	10/24/1975	34	2.28	137
USGS	2300500	10/25/1975	34	2.28	171
USGS	2300500	10/26/1975	34	2.28	185
USGS	2300500	10/27/1975	35	2.27	178
USGS	2300500	10/28/1975	39	2.31	184
USGS	2300500	10/29/1975	430	6.47	87
USGS	2300500	10/30/1975	682	8.24	68
USGS	2300500	10/31/1975	724	8.48	69
USGS	2300500	11/1/1975	504	6.99	78
USGS	2300500	11/2/1975	291	5.19	82
USGS	2300500	11/3/1975	197	4.34	93
USGS	2300500	11/4/1975	154	3.84	101
USGS	2300500	11/5/1975	118	3.47	118
USGS	2300500	11/6/1975	86	3.05	140
USGS	2300500	11/7/1975	84	3.02	144
USGS	2300500	11/8/1975	84	2.96	126
USGS	2300500	11/9/1975	84	2.96	122
USGS	2300500	11/10/1975	85	2.96	114
USGS	2300500	11/12/1975	66	2.71	133
USGS	2300500	11/13/1975	71	2.74	134
USGS	2300500	11/14/1975	59	2.56	133
USGS	2300500	11/15/1975	55	2.49	142
USGS	2300500	11/16/1975	54	2.48	163
USGS	2300500	11/17/1975	53	2.46	194
USGS	2300500	11/18/1975	49	2.4	192
USGS	2300500	11/19/1975	49	2.39	188
USGS	2300500	11/20/1975	47	2.38	202
USGS	2300500	11/21/1975	46	2.36	180
USGS	2300500	11/22/1975	44	2.31	160
USGS	2300500	11/23/1975	42	2.28	160
USGS	2300500	11/24/1975	40	2.24	172
USGS	2300500	11/25/1975	39	2.21	175
USGS	2300500	11/26/1975	38	2.2	160
USGS	2300500	11/27/1975	39	2.22	158

USGS	2300500	11/28/1975	39	2.21	182
USGS	2300500	11/29/1975	39	2.22	182
USGS	2300500	11/30/1975	39	2.21	194
USGS	2300500	12/1/1975	37	2.2	174
USGS	2300500	12/2/1975	38	2.21	190
USGS	2300500	12/3/1975	37	2.17	182
USGS	2300500	12/4/1975	35	2.15	173
USGS	2300500	12/5/1975	35	2.13	177
USGS	2300500	12/6/1975	37	2.17	215
USGS	2300500	12/7/1975	36	2.16	223
USGS	2300500	12/22/1975	37	2.19	217
USGS	2300500	12/23/1975	36	2.18	220
USGS	2300500	12/24/1975	36	2.17	251
USGS	2300500	12/27/1975	41	2.28	154
USGS	2300500	12/28/1975	40	2.27	155
USGS	2300500	12/29/1975	37	2.21	150
USGS	2300500	12/30/1975	36	2.21	149
USGS	2300500	12/31/1975	35	2.21	151
USGS	2300500	1/1/1976	35	2.18	178
USGS	2300500	1/2/1976	34	2.17	143
USGS	2300500	1/3/1976	34	2.16	158
USGS	2300500	1/4/1976	32	2.13	160
USGS	2300500	1/5/1976	31	2.11	147
USGS	2300500	1/6/1976	31	2.11	158
USGS	2300500	1/7/1976	32	2.13	145
USGS	2300500	1/9/1976	33	2.21	156
USGS	2300500	1/10/1976	37	2.23	158
USGS	2300500	1/11/1976	35	2.2	176
USGS	2300500	1/12/1976	34	2.17	157
USGS	2300500	1/13/1976	33	2.15	166
USGS	2300500	1/14/1976	31	2.13	141
USGS	2300500	1/15/1976	32	2.14	184
USGS	2300500	1/16/1976	32	2.15	180
USGS	2300500	1/17/1976	33	2.2	212
USGS	2300500	1/18/1976	31	2.12	197
USGS	2300500	1/19/1976	30	2.11	200
USGS	2300500	1/20/1976	31	2.13	217
USGS	2300500	1/21/1976	31	2.15	197
USGS	2300500	1/22/1976	32	2.16	226
USGS	2300500	1/23/1976	32	2.15	244
USGS	2300500	1/24/1976	32	2.16	268
USGS	2300500	1/25/1976	30	2.13	193
USGS	2300500	1/26/1976	30	2.12	197
USGS	2300500	1/27/1976	34	2.21	193
USGS	2300500	1/29/1976	41	2.35	204
USGS	2300500	1/30/1976	38	2.29	196
USGS	2300500	1/31/1976	37	2.27	224
USGS	2300500	2/1/1976	36	2.31	275
USGS	2300500	2/2/1976	39	2.31	272
USGS	2300500	2/3/1976	38	2.3	186
USGS	2300500	2/4/1976	34	2.25	188
USGS	2300500	2/5/1976	32	2.23	216

USGS	2300500	2/6/1976	33	2.25	247
USGS	2300500	2/7/1976	36	2.31	291
USGS	2300500	2/8/1976	37	2.28	266
USGS	2300500	2/9/1976	32	2.25	286
USGS	2300500	2/10/1976	34	2.28	291
USGS	2300500	2/11/1976	34	2.26	291
USGS	2300500	2/12/1976	34	2.25	293
USGS	2300500	2/13/1976	34	2.28	318
USGS	2300500	2/14/1976	33	2.26	268
USGS	2300500	2/15/1976	30	2.22	267
USGS	2300500	2/16/1976	28	2.18	232
USGS	2300500	2/17/1976	27	2.17	194
USGS	2300500	2/18/1976	27	2.18	230
USGS	2300500	2/19/1976	28	2.2	284
USGS	2300500	2/20/1976	29	2.22	262
USGS	2300500	2/21/1976	30	2.27	252
USGS	2300500	2/22/1976	30	2.3	258
USGS	2300500	2/23/1976	28	2.24	252
USGS	2300500	2/24/1976	29	2.26	262
USGS	2300500	2/25/1976	29	2.28	281
USGS	2300500	2/26/1976	29	2.28	224
USGS	2300500	2/27/1976	28	2.28	279
USGS	2300500	2/28/1976	28	2.27	275
USGS	2300500	2/29/1976	27	2.27	275
USGS	2300500	3/1/1976	27	2.28	275
USGS	2300500	3/2/1976	27	2.3	263
USGS	2300500	3/3/1976	28	2.32	248
USGS	2300500	3/4/1976	28	2.39	245
USGS	2300500	3/5/1976	33	2.48	305
USGS	2300500	3/6/1976	43	2.66	200
USGS	2300500	3/7/1976	50	2.75	202
USGS	2300500	3/9/1976	32	2.58	185
USGS	2300500	3/10/1976	39	2.64	225
USGS	2300500	3/11/1976	34	2.52	245
USGS	2300500	3/12/1976	34	2.52	200
USGS	2300500	3/13/1976	35	2.55	266
USGS	2300500	3/14/1976	34	2.55	265
USGS	2300500	3/15/1976	33	2.51	282
USGS	2300500	3/16/1976	32	2.51	306
USGS	2300500	3/17/1976	28	2.44	235
USGS	2300500	3/18/1976	25	2.4	332
USGS	2300500	3/19/1976	24	2.37	256
USGS	2300500	3/21/1976	26	2.44	262
USGS	2300500	3/22/1976	23	2.4	300
USGS	2300500	3/23/1976	22	2.38	300
USGS	2300500	3/24/1976	19	2.32	298
USGS	2300500	3/25/1976	19	2.33	235
USGS	2300500	3/26/1976	19	2.34	287
USGS	2300500	3/27/1976	22	2.41	360
USGS	2300500	3/28/1976	23	2.44	352
USGS	2300500	3/29/1976	20	2.4	362
USGS	2300500	3/30/1976	16	2.32	316

USGS	2300500	3/31/1976	16	2.32	275
USGS	2300500	4/1/1976	15	2.3	320
USGS	2300500	4/2/1976	16	2.37	318
USGS	2300500	4/3/1976	16	2.34	295
USGS	2300500	4/4/1976	15	2.33	297
USGS	2300500	4/5/1976	16	2.36	338
USGS	2300500	4/6/1976	30	2.66	620
USGS	2300500	4/7/1976	38	2.87	780
USGS	2300500	4/8/1976	78	3.4	435
USGS	2300500	4/9/1976	55	3.06	325
USGS	2300500	4/11/1976	47	2.98	195
USGS	2300500	4/12/1976	36	2.78	190
USGS	2300500	4/13/1976	29	2.73	210
USGS	2300500	4/14/1976	27	2.64	255
USGS	2300500	4/15/1976	24	2.62	260
USGS	2300500	4/16/1976	26	2.59	280
USGS	2300500	4/17/1976	26	2.59	335
USGS	2300500	4/18/1976	26	2.56	340
USGS	2300500	4/19/1976	24	2.56	335
USGS	2300500	4/20/1976	22	2.51	325
USGS	2300500	4/21/1976	21	2.5	320
USGS	2300500	4/22/1976	17	2.43	340
USGS	2300500	4/23/1976	19	2.42	340
USGS	2300500	4/24/1976	17	2.41	330
USGS	2300500	4/25/1976	17	2.39	380
USGS	2300500	4/26/1976	17	2.38	320
USGS	2300500	4/27/1976	13	2.32	380
USGS	2300500	4/28/1976	11	2.25	330
USGS	2300500	4/29/1976	10	2.2	360
USGS	2300500	4/30/1976	10	2.22	370
USGS	2300500	5/1/1976	10	2.21	380
USGS	2300500	5/2/1976	10	2.2	380
USGS	2300500	5/3/1976	10	2.3	220
USGS	2300500	5/4/1976	10	2.22	215
USGS	2300500	5/5/1976	11	2.19	237
USGS	2300500	5/7/1976	26	2.57	486
USGS	2300500	5/8/1976	14	2.34	321
USGS	2300500	5/9/1976	12	2.23	320
USGS	2300500	5/10/1976	9	2.13	321
USGS	2300500	5/11/1976	9	2.15	312
USGS	2300500	5/13/1976	12	2.23	377
USGS	2300500	5/14/1976	9	2.2	377
USGS	2300500	5/15/1976	141	4.1	485
USGS	2300500	5/17/1976	290	5.48	206
USGS	2300500	5/18/1976	42	2.91	206
USGS	2300500	5/19/1976	12	2.3	220
USGS	2300500	5/20/1976	8	2.14	221
USGS	2300500	5/21/1976	7	2.03	233
USGS	2300500	5/22/1976	8	2.11	315
USGS	2300500	5/23/1976	17	2.41	315
USGS	2300500	5/24/1976	30	2.69	268
USGS	2300500	5/25/1976	15	2.38	200

USGS	2300500	5/26/1976	9	2.15	185
USGS	2300500	5/27/1976	6	2.02	228
USGS	2300500	5/28/1976	5	2.06	228
USGS	2300500	5/29/1976	8	2.18	192
USGS	2300500	5/30/1976	8	2.16	185
USGS	2300500	5/31/1976	6	2.09	190
USGS	2300500	6/1/1976	9	2.22	250
USGS	2300500	6/2/1976	32	2.69	245
USGS	2300500	6/3/1976	222	4.89	130
USGS	2300500	6/4/1976	59	3.26	127
USGS	2300500	6/5/1976	172	4.41	127
USGS	2300500	6/6/1976	238	5.11	128
USGS	2300500	6/11/1976	92	3.7	110
USGS	2300500	6/12/1976	56	3.15	110
USGS	2300500	6/15/1976	9	2.19	153
USGS	2300500	6/16/1976	8	2.2	153
USGS	2300500	6/17/1976	7	2.13	152
USGS	2300500	6/18/1976	8	2.13	160
USGS	2300500	6/19/1976	27	2.77	146
USGS	2300500	6/20/1976	68	3.41	103
USGS	2300500	6/21/1976	331	5.89	100
USGS	2300500	6/22/1976	529	7.34	87
USGS	2300500	6/23/1976	406	6.4	94
USGS	2300500	6/24/1976	163	4.34	106
USGS	2300500	6/25/1976	98	3.7	110
USGS	2300500	6/26/1976	60	3.22	140
USGS	2300500	6/27/1976	43	2.95	136
USGS	2300500	6/28/1976	35	2.85	140
USGS	2300500	6/29/1976	31	2.85	132
USGS	2300500	6/30/1976	41	2.98	145
USGS	2300500	7/1/1976	28	2.69	146
USGS	2300500	7/2/1976	26	2.67	128
USGS	2300500	7/3/1976	24	2.64	128
USGS	2300500	7/4/1976	28	2.84	119
USGS	2300500	7/5/1976	43	3.02	119
USGS	2300500	7/6/1976	30	2.74	130
USGS	2300500	7/7/1976	41	2.99	130
USGS	2300500	7/8/1976	35	2.86	148
USGS	2300500	7/9/1976	26	2.66	147
USGS	2300500	7/10/1976	141	3.71	144
USGS	2300500	7/11/1976	260	5.16	144
USGS	2300500	7/18/1976	22	2.71	117
USGS	2300500	7/19/1976	18	2.52	117
USGS	2300500	7/20/1976	8	2.27	124
USGS	2300500	7/21/1976	9	2.37	147
USGS	2300500	7/22/1976	18	2.52	145
USGS	2300500	7/23/1976	15	2.44	150
USGS	2300500	7/24/1976	21	2.62	124
USGS	2300500	7/25/1976	26	2.73	119
USGS	2300500	7/26/1976	45	3	170
USGS	2300500	7/27/1976	15	2.49	170
USGS	2300500	7/28/1976	22	2.64	124

USGS	2300500	7/29/1976	30	2.79	143
USGS	2300500	7/30/1976	28	2.75	144
USGS	2300500	7/31/1976	24	2.65	130
USGS	2300500	8/1/1976	47	3.09	94
USGS	2300500	8/2/1976	71	3.4	98
USGS	2300500	8/3/1976	141	4.12	105
USGS	2300500	8/4/1976	184	4.6	103
USGS	2300500	8/5/1976	111	3.88	141
USGS	2300500	8/6/1976	107	3.84	141
USGS	2300500	8/7/1976	86	3.61	142
USGS	2300500	8/8/1976	60	3.29	141
USGS	2300500	8/9/1976	46	3.12	136
USGS	2300500	8/10/1976	41	3.01	136
USGS	2300500	8/11/1976	39	2.98	164
USGS	2300500	8/12/1976	38	2.96	163
USGS	2300500	8/13/1976	49	3.09	118
USGS	2300500	8/14/1976	141	4.2	120
USGS	2300500	8/15/1976	172	4.46	119
USGS	2300500	8/18/1976	310	5.69	114
USGS	2300500	8/19/1976	142	4.25	120
USGS	2300500	8/20/1976	94	3.73	115
USGS	2300500	8/21/1976	67	3.4	150
USGS	2300500	8/22/1976	49	3.18	115
USGS	2300500	8/23/1976	42	3.06	150
USGS	2300500	8/26/1976	33	2.9	120
USGS	2300500	8/28/1976	31	2.89	165
USGS	2300500	8/29/1976	30	2.84	195
USGS	2300500	8/31/1976	28	2.82	190
USGS	2300500	9/1/1976	25	2.76	190
USGS	2300500	9/4/1976	33	2.93	250
USGS	2300500	9/5/1976	78	3.5	250
USGS	2300500	9/11/1976	26	2.79	155
USGS	2300500	9/12/1976	22	2.7	150
USGS	2300500	9/15/1976	28	2.83	175
USGS	2300500	9/16/1976	31	2.9	125
USGS	2300500	9/17/1976	26	2.78	175
USGS	2300500	9/18/1976	33	2.92	130
USGS	2300500	9/19/1976	34	2.97	235
USGS	2300500	9/20/1976	22	2.75	175
USGS	2300500	9/21/1976	20	2.71	165
USGS	2300500	9/24/1976	30	2.89	165
USGS	2300500	9/25/1976	28	2.85	165
USGS	2300500	9/26/1976	28	2.86	195
USGS	2300500	9/27/1976	25	2.82	200
USGS	2300500	9/28/1976	25	2.81	200
USGS	2300500	9/29/1976	25	2.8	200
USGS	2300500	10/6/1976	12	2.5	210
USGS	2300500	10/7/1976	26	2.81	205
USGS	2300500	10/8/1976	22	2.81	210
USGS	2300500	10/9/1976	24	2.94	240
USGS	2300500	10/10/1976	25	2.92	240
USGS	2300500	10/11/1976	26	2.96	230

USGS	2300500	10/12/1976	24	2.8	220
USGS	2300500	10/13/1976	20	2.74	315
USGS	2300500	10/14/1976	20	2.76	325
USGS	2300500	10/15/1976	21	2.75	315
USGS	2300500	10/16/1976	21	2.75	230
USGS	2300500	10/17/1976	18	2.78	215
USGS	2300500	10/24/1976	20	2.66	220
USGS	2300500	10/25/1976	20	2.65	195
USGS	2300500	10/27/1976	17	2.58	195
USGS	2300500	10/28/1976	15	2.53	355
USGS	2300500	10/29/1976	15	2.53	315
USGS	2300500	10/30/1976	15	2.54	300
USGS	2300500	10/31/1976	17	2.58	265
USGS	2300500	11/1/1976	15	2.53	195
USGS	2300500	11/2/1976	14	2.5	315
USGS	2300500	11/3/1976	52	3.23	360
USGS	2300500	11/4/1976	70	3.4	210
USGS	2300500	11/5/1976	70	3.33	210
USGS	2300500	11/7/1976	38	2.8	260
USGS	2300500	11/8/1976	30	2.64	265
USGS	2300500	11/13/1976	24	2.53	325
USGS	2300500	11/23/1976	13	2.32	251
USGS	2300500	11/24/1976	16	2.4	294
USGS	2300500	11/25/1976	17	2.41	243
USGS	2300500	11/26/1976	14	2.34	244
USGS	2300500	11/27/1976	14	2.32	236
USGS	2300500	11/28/1976	14	2.31	220
USGS	2300500	11/29/1976	17	2.39	240
USGS	2300500	11/30/1976	30	2.71	179
USGS	2300500	12/3/1976	38	2.79	165
USGS	2300500	12/4/1976	14	2.3	194
USGS	2300500	12/5/1976	8	2.18	196
USGS	2300500	12/6/1976	24	2.57	215
USGS	2300500	12/7/1976	4	2.08	212
USGS	2300500	12/8/1976	3	2.11	211
USGS	2300500	12/9/1976	2	2.03	239
USGS	2300500	12/10/1976	1	1.95	239
USGS	2300500	12/11/1976	1	1.94	216
USGS	2300500	12/12/1976	10	2.3	165
USGS	2300500	12/13/1976	14	2.34	176
USGS	2300500	12/14/1976	1	1.87	175
USGS	2300500	12/15/1976	1	1.89	174
USGS	2300500	12/16/1976	1	1.96	174
USGS	2300500	12/18/1976	1	1.84	190
USGS	2300500	12/19/1976	1	1.88	232
USGS	2300500	12/20/1976	1	1.91	235
USGS	2300500	12/21/1976	1	2.14	341
USGS	2300500	12/22/1976	2	1.95	341
USGS	2300500	12/23/1976	21	2.45	276
USGS	2300500	12/24/1976	33	2.7	276
USGS	2300500	1/1/1977	14	2.32	234
USGS	2300500	1/2/1977	17	2.39	234

USGS	2300500	1/3/1977	32	2.67	159
USGS	2300500	1/4/1977	44	2.91	162
USGS	2300500	1/5/1977	39	2.81	200
USGS	2300500	1/6/1977	31	2.67	196
USGS	2300500	1/7/1977	24	2.55	142
USGS	2300500	1/8/1977	17	2.38	146
USGS	2300500	1/9/1977	12	2.26	144
USGS	2300500	1/10/1977	20	2.43	152
USGS	2300500	1/11/1977	15	2.32	157
USGS	2300500	1/12/1977	12	2.26	222
USGS	2300500	1/13/1977	29	2.64	215
USGS	2300500	1/14/1977	15	2.32	219
USGS	2300500	1/15/1977	20	2.43	216
USGS	2300500	1/16/1977	28	2.49	212
USGS	2300500	1/17/1977	45	2.88	206
USGS	2300500	1/18/1977	15	2.34	205
USGS	2300500	1/19/1977	22	2.49	218
USGS	2300500	1/20/1977	18	2.42	214
USGS	2300500	1/21/1977	7	2.13	231
USGS	2300500	1/22/1977	7	2.13	231
USGS	2300500	1/23/1977	17	2.38	229
USGS	2300500	1/24/1977	10	2.2	226
USGS	2300500	1/25/1977	3	2	206
USGS	2300500	1/26/1977	7	2.11	202
USGS	2300500	1/27/1977	22	2.5	160
USGS	2300500	1/28/1977	26	2.57	161
USGS	2300500	1/29/1977	30	2.64	161
USGS	2300500	1/30/1977	26	2.56	162
USGS	2300500	1/31/1977	26	2.56	162
USGS	2300500	2/1/1977	30	2.63	159
USGS	2300500	2/2/1977	28	2.62	162
USGS	2300500	2/3/1977	22	2.48	218
USGS	2300500	2/4/1977	72	3.13	226
USGS	2300500	2/5/1977	68	2.94	166
USGS	2300500	2/6/1977	53	2.68	165
USGS	2300500	2/7/1977	39	2.44	221
USGS	2300500	2/8/1977	30	2.26	223
USGS	2300500	2/9/1977	25	2.17	234
USGS	2300500	2/10/1977	37	2.41	236
USGS	2300500	2/11/1977	26	2.2	225
USGS	2300500	2/12/1977	18	2.03	227
USGS	2300500	2/13/1977	18	2.04	226
USGS	2300500	2/14/1977	18	2.01	226
USGS	2300500	2/15/1977	14	1.96	226
USGS	2300500	2/16/1977	15	2.03	224
USGS	2300500	2/17/1977	13	1.98	306
USGS	2300500	2/18/1977	19	2.12	311
USGS	2300500	2/19/1977	10	1.94	322
USGS	2300500	2/20/1977	10	1.95	322
USGS	2300500	2/21/1977	10	1.97	312
USGS	2300500	2/22/1977	24	2.28	310
USGS	2300500	2/23/1977	5	1.85	272

USGS	2300500	2/24/1977	78	3.06	274
USGS	2300500	2/25/1977	100	3.48	154
USGS	2300500	2/26/1977	97	3.47	158
USGS	2300500	2/27/1977	78	3.21	178
USGS	2300500	2/28/1977	65	3.06	178
USGS	2300500	3/1/1977	44	2.68	225
USGS	2300500	3/2/1977	33	2.52	219
USGS	2300500	3/3/1977	27	2.4	218
USGS	2300500	3/4/1977	27	2.4	194
USGS	2300500	3/5/1977	23	2.33	195
USGS	2300500	3/6/1977	21	2.3	193
USGS	2300500	3/7/1977	20	2.29	231
USGS	2300500	3/8/1977	15	2.15	231
USGS	2300500	3/9/1977	11	2.09	336
USGS	2300500	3/11/1977	31	2.51	335
USGS	2300500	3/12/1977	27	2.45	334
USGS	2300500	3/13/1977	18	2.28	399
USGS	2300500	3/15/1977	18	2.28	392
USGS	2300500	3/16/1977	17	2.26	343
USGS	2300500	3/17/1977	16	2.23	346
USGS	2300500	3/18/1977	16	2.26	346
USGS	2300500	3/19/1977	18	2.28	294
USGS	2300500	3/20/1977	16	2.25	296
USGS	2300500	3/21/1977	12	2.15	272
USGS	2300500	3/22/1977	11	2.13	274
USGS	2300500	3/23/1977	12	2.16	272
USGS	2300500	3/24/1977	12	2.17	314
USGS	2300500	3/25/1977	16	2.26	312
USGS	2300500	3/26/1977	11	2.15	307
USGS	2300500	3/27/1977	10	2.13	314
USGS	2300500	3/28/1977	11	2.17	313
USGS	2300500	3/29/1977	14	2.23	327
USGS	2300500	3/30/1977	13	2.24	326
USGS	2300500	3/31/1977	13	2.21	353
USGS	2300500	4/1/1977	8	2.12	344
USGS	2300500	4/2/1977	8	2.11	350
USGS	2300500	4/3/1977	7	2.13	350
USGS	2300500	4/4/1977	6	2.08	350
USGS	2300500	4/5/1977	6	2.1	378
USGS	2300500	4/6/1977	6	2.09	377
USGS	2300500	4/7/1977	16	2.33	378
USGS	2300500	4/8/1977	20	2.47	387
USGS	2300500	4/9/1977	20	2.5	376
USGS	2300500	4/10/1977	25	2.57	378
USGS	2300500	4/11/1977	20	2.53	362
USGS	2300500	4/12/1977	16	2.42	422
USGS	2300500	4/13/1977	20	2.5	422
USGS	2300500	4/14/1977	20	2.52	362
USGS	2300500	4/15/1977	22	2.55	355
USGS	2300500	4/16/1977	21	2.53	370
USGS	2300500	4/17/1977	17	2.46	374
USGS	2300500	4/18/1977	17	2.41	391

USGS	2300500	4/19/1977	14	2.38	391
USGS	2300500	4/20/1977	9	2.25	393
USGS	2300500	4/21/1977	8	2.22	374
USGS	2300500	4/22/1977	12	2.33	376
USGS	2300500	4/23/1977	11	2.32	366
USGS	2300500	4/24/1977	17	2.47	368
USGS	2300500	4/25/1977	14	2.37	372
USGS	2300500	4/26/1977	10	2.3	372
USGS	2300500	4/27/1977	13	2.38	373
USGS	2300500	4/28/1977	8	2.25	345
USGS	2300500	4/29/1977	7	2.26	345
USGS	2300500	4/30/1977	11	2.33	347
USGS	2300500	5/1/1977	10	2.32	360
USGS	2300500	5/2/1977	8	2.28	361
USGS	2300500	5/3/1977	7	2.22	382
USGS	2300500	5/4/1977	8	2.27	382
USGS	2300500	5/5/1977	9	2.29	334
USGS	2300500	5/6/1977	7	2.24	336
USGS	2300500	5/7/1977	8	2.28	410
USGS	2300500	5/8/1977	10	2.34	410
USGS	2300500	5/9/1977	12	2.39	409
USGS	2300500	5/10/1977	8	2.31	436
USGS	2300500	5/11/1977	4	2.17	400
USGS	2300500	5/12/1977	4	2.18	470
USGS	2300500	5/13/1977	5	2.24	368
USGS	2300500	5/14/1977	9	2.31	368
USGS	2300500	5/15/1977	9	2.32	367
USGS	2300500	5/16/1977	8	2.3	367
USGS	2300500	5/17/1977	4	2.19	393
USGS	2300500	5/18/1977	4	2.19	390
USGS	2300500	5/19/1977	5	2.25	388
USGS	2300500	5/20/1977	4	2.16	413
USGS	2300500	5/21/1977	3	2.17	372
USGS	2300500	5/22/1977	3	2.16	417
USGS	2300500	5/23/1977	4	2.17	399
USGS	2300500	5/24/1977	4	2.18	402
USGS	2300500	5/25/1977	4	2.21	400
USGS	2300500	5/26/1977	5	2.26	393
USGS	2300500	5/27/1977	5	2.24	570
USGS	2300500	5/28/1977	2	2.14	570
USGS	2300500	5/29/1977	3	2.17	570
USGS	2300500	5/30/1977	6	2.29	215
USGS	2300500	6/8/1977	4	2.26	218
USGS	2300500	6/9/1977	4	2.26	212
USGS	2300500	6/10/1977	8	2.37	210
USGS	2300500	6/11/1977	10	2.41	193
USGS	2300500	6/13/1977	4	2.23	196
USGS	2300500	6/14/1977	2	2.16	193
USGS	2300500	6/15/1977	2	2.16	174
USGS	2300500	6/16/1977	24	2.92	195
USGS	2300500	6/20/1977	106	3.88	154
USGS	2300500	6/21/1977	21	2.69	180

USGS	2300500	6/22/1977	5	2.35	173
USGS	2300500	6/23/1977	7	2.38	170
USGS	2300500	6/24/1977	2	2.22	169
USGS	2300500	6/25/1977	1	2.11	160
USGS	2300500	6/28/1977	8	2.4	146
USGS	2300500	7/1/1977	15	2.58	148
USGS	2300500	7/2/1977	13	2.53	154
USGS	2300500	7/3/1977	12	2.51	153
USGS	2300500	7/4/1977	18	2.72	177
USGS	2300500	7/5/1977	78	3.77	182
USGS	2300500	7/6/1977	206	4.87	185
USGS	2300500	7/7/1977	209	4.9	160
USGS	2300500	7/8/1977	118	4.05	160
USGS	2300500	7/9/1977	71	3.5	158
USGS	2300500	7/10/1977	52	3.24	159
USGS	2300500	7/26/1977	201	4.82	149
USGS	2300500	7/27/1977	142	4.3	148
USGS	2300500	8/1/1977	171	4.55	175
USGS	2300500	8/2/1977	177	4.6	180
USGS	2300500	8/3/1977	135	4.22	174
USGS	2300500	8/4/1977	178	4.61	166
USGS	2300500	8/7/1977	101	3.84	164
USGS	2300500	8/8/1977	92	3.74	165
USGS	2300500	8/9/1977	95	3.78	168
USGS	2300500	8/11/1977	171	4.54	124
USGS	2300500	8/13/1977	699	8.34	124
USGS	2300500	8/14/1977	699	8.36	125
USGS	2300500	8/15/1977	733	8.59	123
USGS	2300500	8/16/1977	577	7.7	132
USGS	2300500	8/17/1977	284	5.54	137
USGS	2300500	8/18/1977	167	4.51	138
USGS	2300500	8/19/1977	122	4.08	200
USGS	2300500	8/20/1977	102	3.86	201
USGS	2300500	8/21/1977	91	3.74	202
USGS	2300500	8/23/1977	301	5.7	200
USGS	2300500	8/24/1977	306	5.71	150
USGS	2300500	8/25/1977	592	7.71	150
USGS	2300500	8/26/1977	480	7.02	150
USGS	2300500	8/27/1977	212	4.96	150
USGS	2300500	8/28/1977	148	4.33	148
USGS	2300500	8/29/1977	89	3.71	148
USGS	2300500	8/30/1977	151	4.37	153
USGS	2300500	8/31/1977	169	4.55	138
USGS	2300500	9/1/1977	134	4.22	137
USGS	2300500	9/2/1977	137	4.23	136
USGS	2300500	9/3/1977	454	6.83	170
USGS	2300500	9/4/1977	451	6.81	168
USGS	2300500	9/5/1977	875	9.22	168
USGS	2300500	9/6/1977	968	9.61	119
USGS	2300500	9/7/1977	832	9.03	119
USGS	2300500	9/8/1977	595	7.72	168
USGS	2300500	9/9/1977	369	6.19	114

USGS	2300500	9/11/1977	198	4.81	112
USGS	2300500	9/12/1977	127	4.14	113
USGS	2300500	9/14/1977	119	4.28	112
USGS	2300500	9/15/1977	167	4.52	79
USGS	2300500	9/16/1977	97	3.82	79
USGS	2300500	9/18/1977	173	4.61	78
USGS	2300500	9/19/1977	848	9.15	78
USGS	2300500	9/20/1977	775	8.79	78
USGS	2300500	9/21/1977	516	7.21	78
USGS	2300500	9/22/1977	638	7.96	91
USGS	2300500	9/23/1977	1250	10.61	91
USGS	2300500	9/25/1977	546	7.36	92
USGS	2300500	9/26/1977	361	5.88	79
USGS	2300500	9/27/1977	255	4.94	78
USGS	2300500	9/28/1977	651	8.21	76
USGS	2300500	9/29/1977	727	8.52	82
USGS	2300500	9/30/1977	441	6.56	92
USGS	2300500	10/12/1977	56	2.58	225
USGS	2300500	10/18/1977	38	2.29	236
USGS	2300500	10/24/1977	31	2.12	182
USGS	2300500	10/30/1977	30	2.13	245
USGS	2300500	11/1/1977	28	2.08	244
USGS	2300500	11/7/1977	38	2.28	195
USGS	2300500	11/11/1977	30	2.12	300
USGS	2300500	11/28/1977	71	2.83	245
USGS	2300500	1/6/1978	58	2.61	141
USGS	2300500	1/18/1978	176	4.09	118
USGS	2300500	1/26/1978	155	3.72	118
USGS	2300500	2/2/1978	76	2.7	165
USGS	2300500	2/17/1978	402	6.14	150
USGS	2300500	3/8/1978	199	3.74	119
USGS	2300500	3/14/1978	186	3.6	310
USGS	2300500	3/15/1978	169	3.4	134
USGS	2300500	3/24/1978	92	2.66	374
USGS	2300500	3/28/1978	72	2.45	230
USGS	2300500	5/7/1978	259	5.14	263
USGS	2300500	5/16/1978	39	2.58	170
USGS	2300500	5/22/1978	44	2.7	320
USGS	2300500	5/28/1978	37	2.53	154
USGS	2300500	6/5/1978	67	3.14	154
USGS	2300500	6/17/1978	39	2.57	146
USGS	2300500	6/25/1978	133	3.91	140
USGS	2300500	6/29/1978	94	3.47	137
USGS	2300500	7/7/1978	122	3.81	95
USGS	2300500	7/14/1978	302	5.51	88
USGS	2300500	7/21/1978	431	6.42	85
USGS	2300500	7/25/1978	192	4.14	101
USGS	2300500	7/31/1978	415	6.27	86
USGS	2300500	8/7/1978	884	9.19	67
USGS	2300500	8/14/1978	1560	11.51	58
USGS	2300500	8/22/1978	212	4.38	85
USGS	2300500	8/29/1978	64	2.57	127

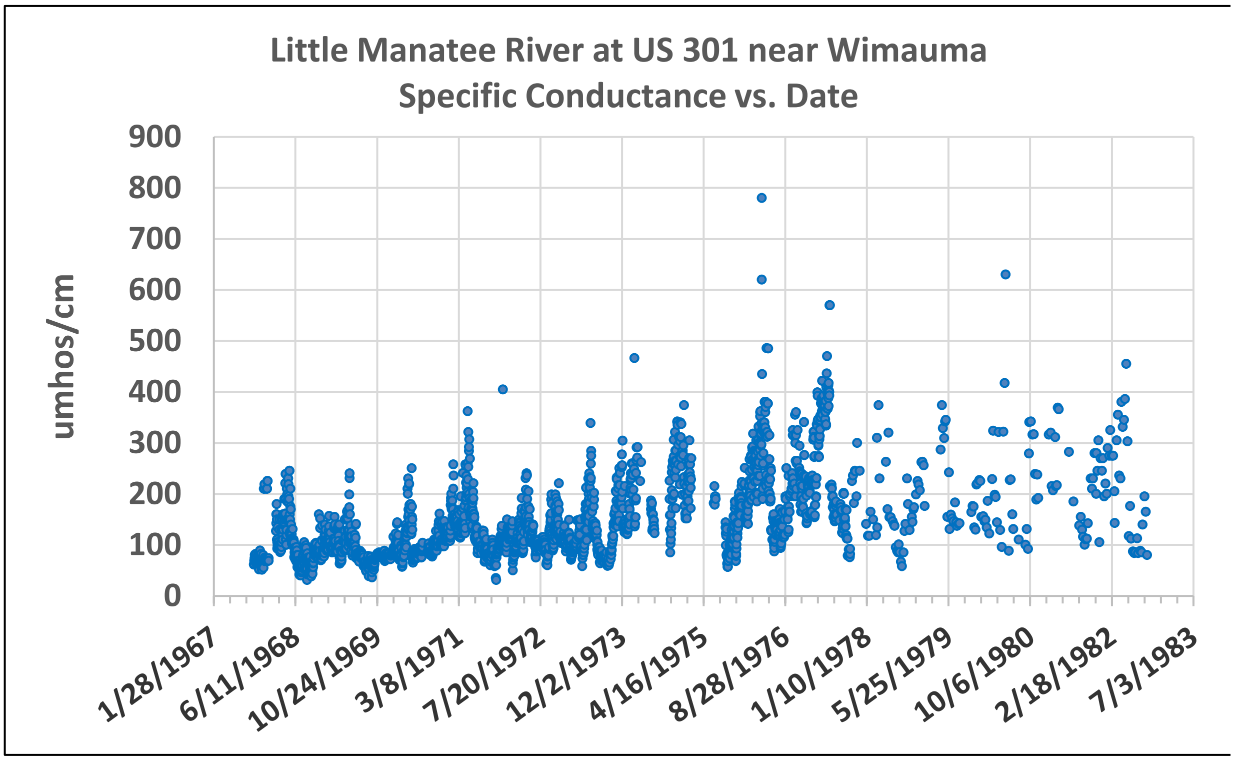
USGS	2300500	9/4/1978	46	2.28	141
USGS	2300500	9/14/1978	40	2.24	230
USGS	2300500	9/20/1978	31	1.98	180
USGS	2300500	9/30/1978	81	2.85	129
USGS	2300500	10/12/1978	46	2.28	155
USGS	2300500	10/16/1978	56	2.46	145
USGS	2300500	10/22/1978	36	2.14	170
USGS	2300500	10/27/1978	28	2.02	174
USGS	2300500	11/8/1978	26	2.07	199
USGS	2300500	11/18/1978	22	2	225
USGS	2300500	11/23/1978	23	2.03	218
USGS	2300500	11/30/1978	22	2	207
USGS	2300500	12/10/1978	26	2.08	262
USGS	2300500	12/17/1978	27	2.1	263
USGS	2300500	12/24/1978	35	2.24	256
USGS	2300500	12/31/1978	56	2.62	176
USGS	2300500	4/8/1979	25	2.43	287
USGS	2300500	4/15/1979	24	2.51	374
USGS	2300500	4/22/1979	19	2.51	329
USGS	2300500	4/29/1979	22	2.62	309
USGS	2300500	5/5/1979	20	2.57	342
USGS	2300500	5/9/1979	155	4.31	345
USGS	2300500	5/18/1979	68	3.15	155
USGS	2300500	5/28/1979	14	2.2	242
USGS	2300500	6/1/1979	70	3.17	131
USGS	2300500	6/9/1979	26	2.44	159
USGS	2300500	6/17/1979	19	2.3	152
USGS	2300500	6/24/1979	35	2.62	146
USGS	2300500	7/5/1979	30	2.52	183
USGS	2300500	7/12/1979	47	2.82	144
USGS	2300500	7/17/1979	55	2.96	137
USGS	2300500	7/26/1979	60	3.04	141
USGS	2300500	7/31/1979	16	2.24	142
USGS	2300500	10/13/1979	97	2.8	164
USGS	2300500	10/20/1979	128	3.24	176
USGS	2300500	10/26/1979	66	2.28	175
USGS	2300500	10/31/1979	53	2.06	134
USGS	2300500	11/7/1979	75	2.46	130
USGS	2300500	11/13/1979	58	2.19	218
USGS	2300500	11/19/1979	50	2.08	221
USGS	2300500	11/30/1979	49	2.1	227
USGS	2300500	12/6/1979	49	2.12	225
USGS	2300500	12/13/1979	58	2.29	155
USGS	2300500	12/24/1979	58	2.32	156
USGS	2300500	12/31/1979	51	2.27	146
USGS	2300500	1/7/1980	54	2.31	149
USGS	2300500	1/14/1980	96	2.94	134
USGS	2300500	1/20/1980	65	2.49	186
USGS	2300500	1/30/1980	136	3.47	122
USGS	2300500	2/16/1980	197	4.18	229
USGS	2300500	2/22/1980	112	3.19	324
USGS	2300500	3/3/1980	197	4.21	198

USGS	2300500	3/10/1980	70	2.56	194
USGS	2300500	3/17/1980	60	2.4	144
USGS	2300500	3/27/1980	50	2.25	321
USGS	2300500	4/6/1980	124	3.32	129
USGS	2300500	4/16/1980	259	4.82	96
USGS	2300500	4/26/1980	42	2.24	322
USGS	2300500	5/3/1980	34	2.11	417
USGS	2300500	5/10/1980	64	2.58	630
USGS	2300500	5/28/1980	750	8.6	88
USGS	2300500	6/4/1980	54	2.44	227
USGS	2300500	6/10/1980	33	2.08	228
USGS	2300500	6/19/1980	27	1.96	160
USGS	2300500	6/26/1980	77	2.77	131
USGS	2300500	7/28/1980	174	3.93	110
USGS	2300500	9/8/1980	306	5.25	100
USGS	2300500	9/15/1980	390	6.03	131
USGS	2300500	9/24/1980	97	3.06	92
USGS	2300500	9/30/1980	53	2.47	279
USGS	2300500	10/1/1980	83	2.84	341
USGS	2300500	10/11/1980	44	2.31	342
USGS	2300500	10/20/1980	36	2.2	316
USGS	2300500	10/29/1980	31	2.15	317
USGS	2300500	11/6/1980	26	2.07	239
USGS	2300500	11/13/1980	22	2.02	189
USGS	2300500	11/19/1980	41	2.38	238
USGS	2300500	11/25/1980	33	2.21	192
USGS	2300500	1/29/1981	48	2.27	316
USGS	2300500	2/9/1981	561	7.44	320
USGS	2300500	2/16/1981	90	2.96	215
USGS	2300500	2/23/1981	58	2.5	207
USGS	2300500	3/9/1981	44	2.31	311
USGS	2300500	3/12/1981	44	2.32	215
USGS	2300500	3/18/1981	41	2.3	217
USGS	2300500	3/25/1981	48	2.48	369
USGS	2300500	3/31/1981	39	2.36	366
USGS	2300500	6/2/1981	55	2.65	282
USGS	2300500	6/29/1981	108	3.28	185
USGS	2300500	8/3/1981	391	6.06	138
USGS	2300500	8/13/1981	171	3.92	155
USGS	2300500	8/20/1981	272	4.68	130
USGS	2300500	8/26/1981	1100	10.45	116
USGS	2300500	9/5/1981	298	5.17	100
USGS	2300500	9/12/1981	321	5.42	111
USGS	2300500	9/20/1981	191	4.13	112
USGS	2300500	9/25/1981	158	3.77	142
USGS	2300500	10/12/1981	54	2.35	230
USGS	2300500	10/20/1981	46	2.36	210
USGS	2300500	10/26/1981	44	2.33	230
USGS	2300500	11/5/1981	40	2.3	280
USGS	2300500	11/14/1981	39	2.25	200
USGS	2300500	11/16/1981	45	2.36	280

USGS	2300500	11/23/1981	38	2.22	245
USGS	2300500	11/28/1981	37	2.22	305
USGS	2300500	12/5/1981	51	2.46	105
USGS	2300500	12/12/1981	40	2.28	270
USGS	2300500	12/20/1981	42	2.32	245
USGS	2300500	12/27/1981	66	2.69	270
USGS	2300500	1/3/1982	47	2.38	195
USGS	2300500	1/10/1982	45	2.35	220
USGS	2300500	1/18/1982	62	2.62	200
USGS	2300500	1/24/1982	61	2.64	290
USGS	2300500	2/3/1982	48	2.42	275
USGS	2300500	2/10/1982	52	2.48	325
USGS	2300500	2/18/1982	258	4.79	275
USGS	2300500	2/26/1982	80	2.75	275
USGS	2300500	3/6/1982	548	7.31	205
USGS	2300500	3/9/1982	615	7.72	143
USGS	2300500	3/20/1982	91	2.91	305
USGS	2300500	3/29/1982	388	6.03	355
USGS	2300500	4/5/1982	101	3.04	236
USGS	2300500	4/12/1982	69	2.59	230
USGS	2300500	4/19/1982	54	2.36	380
USGS	2300500	4/26/1982	356	5.71	331
USGS	2300500	5/4/1982	72	2.64	345
USGS	2300500	5/11/1982	49	2.27	386
USGS	2300500	5/18/1982	45	2.2	455
USGS	2300500	5/26/1982	364	5.79	303
USGS	2300500	6/2/1982	750	8.58	117
USGS	2300500	6/11/1982	70	2.6	176
USGS	2300500	6/16/1982	302	5.22	112
USGS	2300500	6/28/1982	569	7.47	87
USGS	2300500	7/6/1982	377	5.91	84
USGS	2300500	7/14/1982	362	5.77	86
USGS	2300500	7/23/1982	471	6.64	113
USGS	2300500	7/30/1982	483	6.83	84
USGS	2300500	8/12/1982	416	6.27	88
USGS	2300500	8/21/1982	491	6.89	85
USGS	2300500	8/26/1982	111	3.17	140
USGS	2300500	9/6/1982	64	2.51	195
USGS	2300500	9/14/1982	134	3.48	165
USGS	2300500	9/22/1982	1770	11.99	80

Mean	143
Maximum	780
Minimum	31

See highlighted rows 2873 to 2882 for dates near dates with high EPC sp



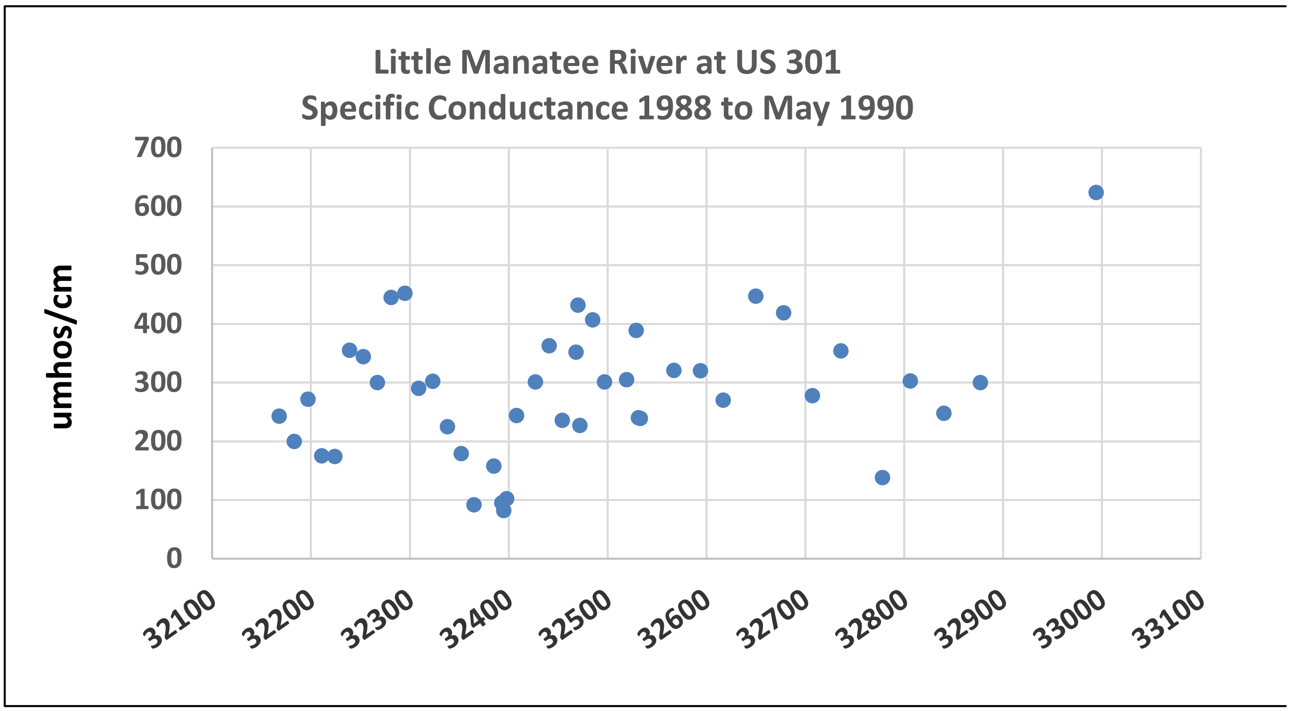
EPC value 9,283 umhos/com on September 10

EPC value 22,175 umhos/com on October 15. 1980

EPC value 2,876 umhos/com on November 13, 1980

Agency	Station	Date_number	Date	Specific Conductance
SWFWMD	US 301	32168	26-Jan-88	243
SWFWMD	US 301	32183	10-Feb-88	200
SWFWMD	US 301	32197	24-Feb-88	272
SWFWMD	US 301	32211	09-Mar-88	175
SWFWMD	US 301	32224	22-Mar-88	174
SWFWMD	US 301	32239	06-Apr-88	355
SWFWMD	US 301	32253	20-Apr-88	344
SWFWMD	US 301	32267	04-May-88	300
SWFWMD	US 301	32281	18-May-88	445
SWFWMD	US 301	32295	01-Jun-88	452
SWFWMD	US 301	32309	15-Jun-88	290
SWFWMD	US 301	32323	29-Jun-88	302
SWFWMD	US 301	32338	14-Jul-88	225
SWFWMD	US 301	32352	28-Jul-88	179
SWFWMD	US 301	32365	10-Aug-88	92
SWFWMD	US 301	32385	30-Aug-88	158
SWFWMD	US 301	32393	07-Sep-88	95
SWFWMD	US 301	32395	09-Sep-88	82
SWFWMD	US 301	32398	12-Sep-88	102
SWFWMD	US 301	32408	22-Sep-88	244
SWFWMD	US 301	32427	11-Oct-88	301
SWFWMD	US 301	32441	25-Oct-88	363
SWFWMD	US 301	32454	07-Nov-88	236
SWFWMD	US 301	32468	21-Nov-88	352
SWFWMD	US 301	32470	23-Nov-88	432
SWFWMD	US 301	32472	25-Nov-88	227
SWFWMD	US 301	32485	08-Dec-88	407
SWFWMD	US 301	32497	20-Dec-88	301
SWFWMD	US 301	32519	11-Jan-89	305
SWFWMD	US 301	32529	21-Jan-89	389
SWFWMD	US 301	32531	23-Jan-89	240
SWFWMD	US 301	32533	25-Jan-89	239
SWFWMD	US 301	32567	28-Feb-89	321
SWFWMD	US 301	32594	27-Mar-89	320
SWFWMD	US 301	32617	19-Apr-89	270
SWFWMD	US 301	32650	22-May-89	447
SWFWMD	US 301	32678	19-Jun-89	419
SWFWMD	US 301	32707	18-Jul-89	278
SWFWMD	US 301	32736	16-Aug-89	354
SWFWMD	US 301	32778	27-Sep-89	138
SWFWMD	US 301	32806	25-Oct-89	303
SWFWMD	US 301	32840	28-Nov-89	248
SWFWMD	US 301	32877	04-Jan-90	300
SWFWMD	US 301	32994	01-May-90	624

Mean	285
Maximum	624
Minmum	82



Agendy	Date	Flow (cfs)	Gage Ht.	Sp. Conductance	
USGS	01-Mar-88	91	3.04		
USGS	02-Mar-88	76	2.93		
USGS	03-Mar-88	91	3.04		
USGS	04-Mar-88	71	2.94		
USGS	05-Mar-88	96	3.16		
USGS	06-Mar-88	282	5.97		
USGS	07-Mar-88	413	7.07		
USGS	08-Mar-88	429	7.06		
USGS	09-Mar-88	323	5.93	175	
USGS	10-Mar-88	314	5.92		
USGS	11-Mar-88	298	5.75		
USGS	12-Mar-88	258	5.32		
USGS	13-Mar-88	200	4.5		
USGS	14-Mar-88	250	5.37		
USGS	15-Mar-88	258	5.22		
USGS	16-Mar-88	194	4.44		**EPC value 24,400**
USGS	17-Mar-88	170	4.11		
USGS	18-Mar-88	138	3.65		
USGS	19-Mar-88	340	6.07		
USGS	20-Mar-88	420	6.91		
USGS	21-Mar-88	359	6.31	174	
USGS	22-Mar-88	265	5.37		
USGS	23-Mar-88	184	4.61		
USGS	24-Mar-88	164	4.22		
USGS	25-Mar-88	157	3.94		
USGS	26-Mar-88	145	3.75		
USGS	27-Mar-88	132	3.55		
USGS	28-Mar-88	116	3.42		
USGS	29-Mar-88	102	3.33		
USGS	30-Mar-88	82	2.99		
USGS	31-Mar-88	72	3.11		

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Yonas Ghile; Kristina Deak; Jordan D. Miller; Xinjian Chen; Chris Zajac; Randy Smith; Gabe I. Herrick
Subject:	Data that support a qualifying statement for three erroneous high salinty values reported by the EPCHC that are mentioned in the Little Manatee minimum flows report.
Date:	Thursday, November 9, 2023 12:09:29 PM
Attachments:	EPC 133, reduced, sorted by salinity.xlsx LMR at US 301, Conductivity_flow_stage.xls

Hello Kym and staff,

I have looked at additional specific conductance data for the Little Manatee River at the US 301 bridge that strongly indicates the three salinity values reported by the EPC that are mentioned on page 161 in the District draft minimum flows report are erroneous or anomalous data. As described in my recent editorial review of the report, there needs to be a qualifier in the report that these data may be erroneous. On further consideration, as described below, it should say they are probably erroneous or anomalous data. Or, better yet, simply not mention those values and end the last sentence on page 161 with "salinities were nearly exclusively zero at the US Highway 301 bridge."

The opinion that these values "appear anomalous" was described by JEI on pages 3-24 in the 2018 draft report for the lower river (JEI 2018b, Appendix B), along with a table on page 3-25 of that report that includes the words "potential anomalous salinity values".

Two EXCEL files are attached which are informative in this regard. The first are data that are reduced from the EPCHC data at the USGS 301 bridge (Station 113). The data are sorted by values for salinity and specific conductance. As you can see, there were three values from 1980 and 1988 that had salinity values of 5.1 to 14.7 psu salinity. Note there were a total of 564 observations at this station, but there were only five dates with salinity values greater than 0.7 psu. The two values of 1.1 and 1.4 in 1983 and 1980 could possibly be due to very mineralized groundwater entering the river from agricultural operations, but as described below that is very unlikely. In that same regard, the salinity values of 5.1 to 14.7 psu are implausible.

There are data from two other sources that support this conclusion. See the worksheet called *LMR at 301, conductivity_flow_stage.* The USGS periodically measured conductivity (specific conductance) at this site between October 1967 and September 1982. Worksheet #2 has the data for the 2,948 days when the USGS measured salinity. The mean conductivity was 143 and the maximum value was 780 umhos/cm.

Scroll down to rows 2873 to 2882 in worksheet #2 to see values recorded by the USGS near when the EPC reported very high values. First, when the EPC reported a value of 2,876 umhos/com on November 13, 1980, the USGS reported a value of 189 <u>for that same day</u>. Also, the USGS recorded much lower and more plausible values (100 to 316 umhos/cm) near the sampling dates of September 10 and October 15, 1980, when the EPC reported very high values (9,283 and 22,175 umhos/cm).

Values for 1988 and 1989 from the SWFWMD watershed study that is cited in the minimum flows report are listed in worksheets #3 and #4. The very high conductivity value of 24,400 umhos/com recorded by the EPC in March of 1988 was during this study. See worksheet #4, the conductivity recorded at US 301 station by the SWFWMD was 175 and 174 umhos/cm seven days before and five days after the high EPC value.

In both the 1980 USGS data and the 1988 SFWMD data, the stage and flow data do not indicate there were any storm tides that could have affected these extremely high values.

It is important that strong qualifiers be put on these three EPC salinity values on page 161 in the MFL report, or do not mention them at all. There is no real evidence that oligo- to mesohaline salinities may be possible at this location.

Sid

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Chris Zajac; Randy Smith; Yonas Ghile; Xinjian Chen; Kristina Deak; Jordan D. Miller; Gabe I. Herrick; krisina.deak@swfwmd.state.fl.us
Subject:	Change in boundary between the upper and lower sections of the Little Manatee River
Date:	Wednesday, November 22, 2023 1:20:46 PM

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and staff,

A few days ago, I noticed the District has posted a final draft of the minimum flows report for Little Manatee River that is dated November 2023. Notably, this report changes the boundary between the upper and lower sections of the river, moving it from the US 301 bridge to the location of station 1616 monitored by the Environmental Protection Commission of Hillsborough County that is located near river kilometer 16.4.

Early next week, either by Monday afternoon or Tuesday morning, I will submit a brief technical assessment of this change in the boundary between the upper and lower river. Preliminarily, I think that moving the boundary to a location in that section of the lower river not far from Station 1616 could be justifiable or even desirable. However, there are a few sections of the report that need some revision to support, or at least not be technically contradictory, to this move.

Also, there are some serious practical water management considerations as to how this move could affect where a water supply intake could be located and comply with the minimum flow rules for either the upper or lower river.

I expect many of you may be taking today or this afternoon off as part of the holidays, but I want to give you a heads up on this now.

Happy Thanksgiving!

Sid

November 28, 2023

TO: SWFWMD staff associated with the draft minimum flows report for the Little Manatee River

FROM: Sid Flannery, retired, formerly Chief Environmental Scientist with the SWFWMD minimum flows program

SUBJECT: Recent change in the boundary for the determination of minimum flows for the upper and lower sections of the Little Manatee River

Summary

Last week I noticed that the most recent draft minimum flows report for the Little Manatee River (dated November 2023) changed the boundary for the establishment of minimum flow rules for the upper and lower sections of the Little Manatee River. This move shifted the boundary downstream about 8 kilometers (approximately five miles) from the US 301 bridge near river kilometer 24.5 to the location of a water quality station monitored by the Environmental Protection Commission of Hillsborough County (EPCHC) near kilometer 16.4. This is a major shift in technical approach, as several previous draft reports published over a considerable length of time, the most recent in August 2023, used the 301 bridge as the boundary between the upper and lower sections of the river.

Moving the boundary to, or preferably slightly upstream of, the location of the EPCHC station at kilometer 16.4 may be temporarily desirable as it is oriented to providing more conservative protection of riverine forests in what is predominantly the tidal freshwater section of the river. However, some revisions to the minimum flows report are needed to technically support, or at least not contradict, this change in the boundary between the upper and lower river.

Also, if a revised boundary between the upper and lower river is kept in the report and adopted in rule, the minimum flows for the Lower Little Manatee River should be re-evaluated as soon as practical with the limited purpose of modeling and assessing of the inundation requirements of riverine wetlands in the tidal freshwater reach of the river, as they are probably not as sensitive to the effects of flow reductions as much as the wetlands upstream of US 301 on which the proposed minimum flows for the upper river are based on during the high flow block.

In the meantime, if this revised boundary is as adopted as part of minimum flow rules for the Little Manatee River, some flexibility should be applied as to which set of rules (upper or lower) should be applied to a new withdrawal from the river depending on its location in the section of the river between US 301 and the EPCHC station at kilometer 16.4. I have never advocated for moving the boundary between the upper and lower river away from US 301, and still think it may not be necessary depending on where a new intake might be located.

The schedule for adoption of minimum flows for the Little Manatee River calls for adoption in 2023. However, the next Governing Board meeting is very soon on December 12th. If consideration of these factors and the needed revisions to report can be accomplished before then, possibly the adoption of the rule in 2023 can be achieved. However, if postponement of the adoption of the minimum flow rule for the Little Manatee River to January 2024 or a subsequent month is needed, that should be pursued as it poses no real problem for regulatory or water supply planning in the region.

Better characterization is needed of the salinity characteristics of the lower river to support the movement of the boundary between the upper and lower river

The upstream extent of brackish water in a tidal river in the dry season is a primary factor to be considered in determining separate minimum flow rules for the freshwater reaches of creeks and rivers versus downstream tidal estuarine reaches. In that regard, the upstream extent of brackish water in the Little Manatee River in the dry season needs more elaboration and clarification, as the minimum flows report is either unclear or misleading in few places, which is problematic for justifying a revised boundary for separating the upper and low sections of the river.

The District chose the location of EPCHC water quality station 1616 near kilometer 16.4 to delineate the boundary between the upper and lower river, but no salinity data for this station are clearly presented in the report. The EPCHC has measured water quality profiles (salinity, dissolved oxygen, pH) at 16 stations in the river on over 200 dates during two separate periods ranging from 2000 to 2006 and from 2009 to present. The draft report for the lower river that was prepared in 2018 (JEI, 2018 included as Appendix E to the report) showed a map of these stations and discussed that data from them was used to develop the empirical salinity model of the river used in the EFF fish habitat modeling.

Although this extensive and important data base was readily available, other than two figures of salinity zones predicted by the EFDC model, two plots of predicted vs. observed salinity using empirical models, and a generated contour plot of observed values, the only other observed salinity data shown for the lower river in the recent minimum flows report is a box plot of salinity at four EPCHC stations where they also measure full water quality, including nutrients. The upstream and downstream extents of these four stations are near kilometers 1.8 and 13.7, respectively. It is therefore important to show salinity data outside this geographic range, especially when the District is proposing a boundary between the lower and upper river at kilometer 16.4. Also, when an agency such as the EPCHC spends so much time and effort collecting such data, it would be valuable to present it in the minimum flows report as it is critical to understanding the salinity characteristics of the Lower Little Manatee River.

Three months after the second draft minimum flows report for the Little Manatee was published in September 2021, I submitted to the District a Supplemental Analyses report (SA report) I prepared that summarized additional data for the river. The SA report recommended that data from all the EPCHHC vertical profile station should be presented in the report, and presented a box plot of mean water column salinity at the 16 EPCHC vertical profile stations, which is reprinted on the following page, with the figure number and legend reprinted from that report.

Text continued on the next page

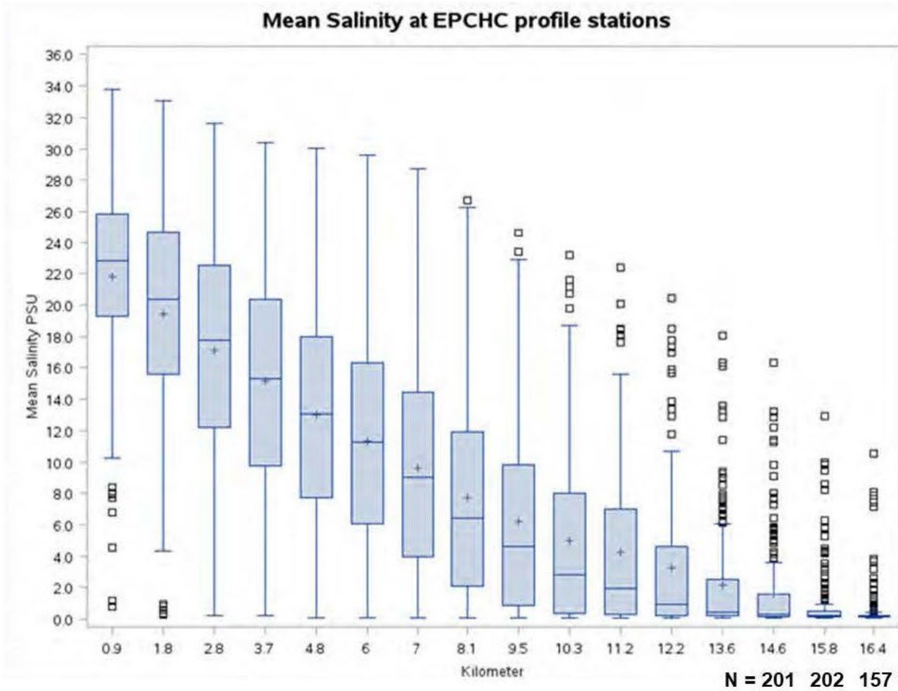


Figure 17. Box plot of mean water column salinity values at EPCHC vertical profile stations. The + symbols are means, the horizontal lines the medians, with the whiskers extending to 1.5 times the inter-quartile range. Outliers are shown for above the whiskers, but not below as freshwater outliers (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

This box plot shows that the median and mean salinity at kilometer 16.4, which is Station 1616, are near zero, but mean salinity values between 7.2 and 10.6 psu occurred on five sampling dates, with salinity between 1 and 3.9 psu occurring on 13 other dates. Clearly, brackish water can migrate to this section of the river during prolonged dry periods. Thus, based on salinity characteristics, the revised boundary between the upper and lower sections of the river can occurs in what is frequently the oligohaline and sometimes low-mesohaline section of the river. As stated in my SA report, I again suggest that a discussion of the EPC vertical profile stations be presented in minimum flows report, including a box plot of salinity at all the EPCHC vertical profile stations similar to the one shown above.

Salinity data in the lower river were also collected by the District on 59 dates during two separate two time periods in the mid to late 1980s. A box plot of those data was also presented in the SA report, but it stated the EPCHC data should be emphasized due to its extensive spatial distribution which is still ongoing.

Text continued on the next page

The SA report also showed informative plots of means salinity values at stations upstream of kilometer 16.4 on days when sampling by either the EPCHC or the District went farther upstream during very dry periods. A figure from the SA report is reprinted below using the figure number and legend in that report. These show that brackish water does not typically extend of kilometer 17 to 18 in during very low flows, which is similar to the conclusions of other researchers (Fernandez 1985, Peebles and Flannery 1992, JEI 2018).

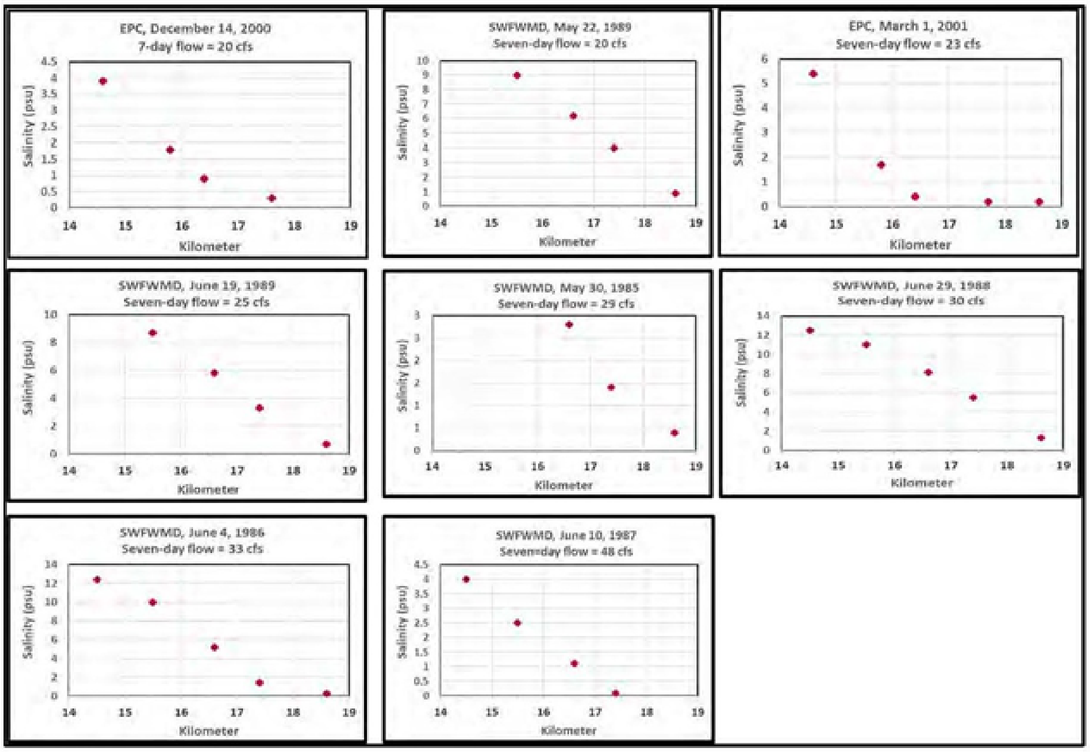


Figure 19. Mean water column salinity at upper stations in the lower river when sampling extended upstream of kilometer 16.6 by either the EPCHC or the District. The preceding seven-day average flow for each sampling date is listed on graphs.

I again reiterate that the upstream penetration of brackish water in the dry season is a fundamental parameter that should be used to establish boundaries for minimum flow rules for freshwater vs. tidal estuarine sections of rivers, as they are fundamentally different types of ecosystems. Given the relationships shown the in two figures reprinted from the SA report, it would make more sense to move boundary between the upper and lower river to near kilometer 18, as it more truly represents the tidal freshwater part of the river, as opposed to kilometer 16.4.

However, even though I repeatedly informed the District here is tidal freshwater zone below US 301, I have never suggested that moving the boundary between the upper and lower river away from US 301 is necessary. As will be discussed in later sections, I think that still may be the case, but appreciate that the District is trying to be cautious with the zone of the river immediately downstream of US 301. As will be discussed further, if the boundary is moved, the minimum flows for the lower river should be re-evaluated with a limited focus as soon as practical. Secondly, some flexibility should be applied in the near term on which rules (upper or lower should be applied to a new withdrawal depending on the location of the intake below US 301

As related to a suitable location for a upper/lower river boundary, the morphology of the river has a tidally affected loop attached to the river channel near kilometer 17.2 (see figure below adapted from the November 2023 draft minimum flows report). If the boundary between the upper and lower river is to be moved downstream from US 301, it would be best to keep the boundary upstream of that morphological feature, as the river is largely confined to a narrow single channel upstream from there. Also, as will be discussed on a page 8, a water level recorder was operated by the USGS near kilometer 17.2 from October 2004 to August 2006. Water level relationships with flow are fundamentally different there than at US 301, and there is no physical or hydraulic reason to extend the boundary between the upper and lower river any further downstream than kilometer 18.

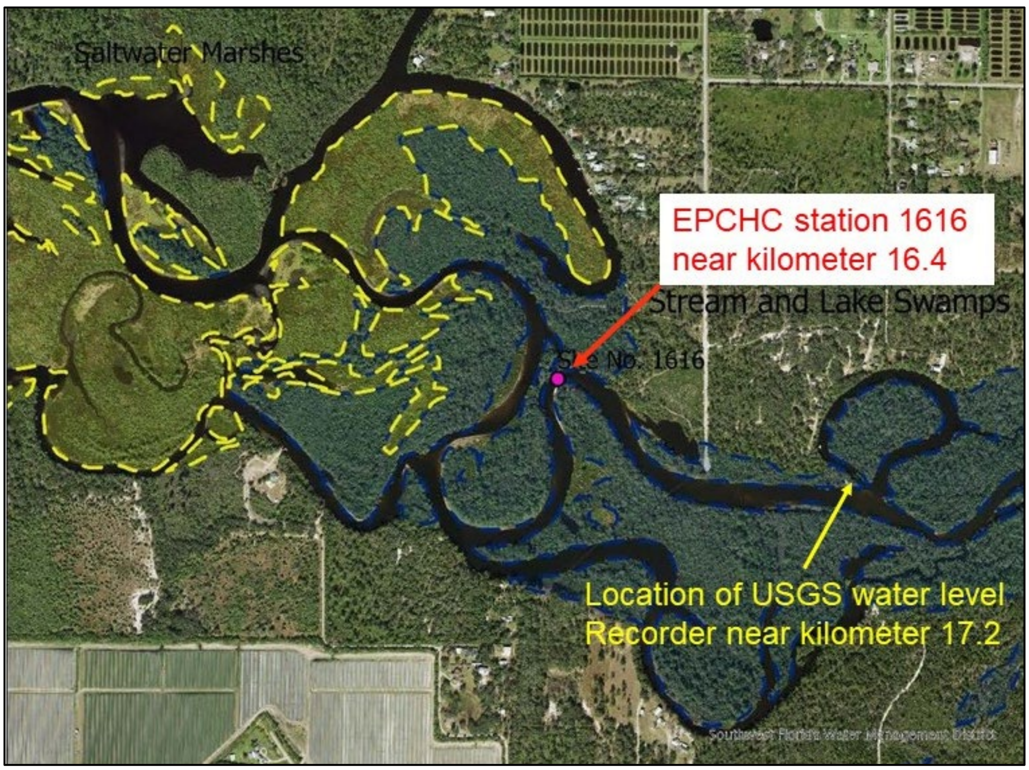


Figure above adapted from Figure 6-23 in the minimum flows report, adding the location of the tidal loop near kilometer 17. The yellow line (placed by the District) denotes saltwater marsh shorelines according to the FLUCCS code system while the blue line (which is hard to see) designated stream and lake swamps, bottomlands by FLUCCS. As will be discussed on page 8, a water level recorder ran for over 22 months at kilometer 17.2.

There are other sections of the minimum flows report where the text needs to be revised to better reflect salinity characteristics of the river and better support moving the upper/lower river boundary downstream from US 301. At present, some of the text seems to contradict the rationale for moving the boundary downstream from US 301.

On October 30, 2023, I sent a series of editorial changes to the District I suggested be incorporated to make the text more clear, without changing the findings or conclusions of the report. Those edits were based on the August 2023 draft, and they are even more critical now that the District is proposing to move the upper/lower boundary eight kilometers downstream.

The first important edit in that regard is in the last sentence on page 161 in the November 2023 draft that states "salinities were nearly exclusively near zero at the US Highway 301 bridge, although three data points existed which showed oligo- to low-mesohaline salinities may be possible at this station." This is misleading, for there is clear evidence that these three salinity values, which were recorded by the EPCHC in 1980 and 1980, are erroneous. In the first draft report for the lower river (JEI 2018), the authors described that these values "appear anomalous" or are "potential anomalous". However, this important characterization was omitted in more recent drafts of the minimum flows reports.

I have accessed specific conductance data from the river at this same site from the USGS website and the District study in 1988, that show that no salinity values anywhere near the very high EPCHC values occurred in the river near those dates (salinity is calculated from specific conductance). There is also no evidence that very high storm tides affected salinity at US 301 on those dates. I sent the District the data I based this conclusion on, and maintain that the statement that oligo- or low-mesohaline salinities may be possible at US 301 should be removed from the minimum flows report or be highly qualified, as it is based on erroneous or anomalous values.

This is case of the text in the current draft technically contradicting the movement of the upper/lower river boundary downstream to kilometer 16.4. Do you really want to suggest that you are moving the boundary 8 kilometers downstream from US 301 when oligo- to low-mesohaline salinities may be possible at US 301. Again, removal or qualifying reference to the clearly erroneous salinity data at US 301 is in order.

There is another section of the report that is contradictory to the concept of moving the upper/lower river boundary downstream to kilometer 16.4. Even before this shift was proposed, my editorial comments suggested this section of the report be revised as it mischaracterizes the river between Interstate between Interstate-75 and the 301 bridge. The report does a decent job of characterizing two zones of the river between the mouth and I-75, but then says there is one ecological zone of the lower river between I-75 and US 301. I pointed out this is false, as the river changes from a distinct, braided estuarine zone with abundant oligohaline marshes to a single channel with tidal freshwater wetlands around kilometer 17.

If you want to establish a boundary between the upper and lower river at kilometer 16.4, do you want to erroneously claim that the river between Kilometer 12.5 and 24.5 is one ecological zone? I provided some fairly simple text to the District to describe that there two distinct ecological zones between I-75 and US 301, which at this time would go along with supporting a boundary somewhere in the range between 16.4 and 18. However, that language has not yet been incorporated in the report.

I also submitted a number of other editorial changes to the District that are technically correct and valuable, which I suggest they incorporate in the next version of the minimum flows report.

The recent emphasis on tidal freshwater wetlands for delineation of the upper and lower river

The inundation of riverine wetlands is a primary factor the District has used to assess minimum flows for non-tidal freshwater rivers, such as the upper reaches of the Alafia, Peace and Myakka Rivers. Freshwater biological communities, including riverine wetlands, can also occur in tidally affected areas that remain fresh but where water levels and current velocities are affected by tides.

The justification for moving the boundary for the upper and lower river appears solely in one paragraph on page 191 in the November 2023 draft report. From this paragraph, it appears the District has chosen to move the boundary between the upper and lower river farther downstream primarily to better protect tidal freshwater forests that extend between US 301 and kilometer 16.4.

This is supported by Figure 6-23 on page 192 in the most recent draft report, which shows the delineation between FLUCCS codes that show a shift from "stream and lake swamps, bottomlands" to "saltwater marshes" near kilometer 16.4, where the EPCHC has a water quality monitoring station that the District has chosen to delineate the upper and lower sections river (see figure on page 5 of this memorandum).

The switch in vegetation communities in the tidal section of the Little Manatee river has been documented for quite some time, as the report by Fernandez (1985) described vegetation gradients in the river in relation to salinity. Peebles and Flannery (1992) also described such gradients in salinity and vegetation, including a tidal freshwater zone upstream of kilometer 16 to 18. A thorough study of vegetation communities in the tidal reach of the Little Manatee was conducted by the Florida Marine Research Institute (1997), which showed the transition between saltmarshes dominated by black needlerush (*Juncus roemerianus*) to oligohaline marshes dominated by freshwater plants such as cattails (*Typha* sp.) and sawgrass (*Cladium jamaicense*) that are tolerant of low salinity.

The maps presented in the FMRI study support the transition from marshes to tidal freshwater forests near the boundary proposed by the District, but the oligohaline marshes near that transition point are not well characterized by the general saltwater marsh label used in the FLUCCS codes shown in Figure 6-23 in the minimum flows report. I have repeatedly expressed to the District that they should at least cite the FMRI (1997) study in their minimum flows report, but that has not yet happened.

It is commendable that the District wants to protect the riverine forests associated with the tidal freshwater section of the Little Manatee River. However, as will be described on page 8, water level relationships to flow can be considerably different over relatively short distances between non-tidal and tidal freshwater reaches of a river. In a recent report for the Lower Peace River, the District (2021) modeled and evaluated the inundation of freshwater forests associated along the tidal freshwater reach of that river.

However, no similar modeling or assessment of changes in the inundation of tidal freshwater wetlands are presented in the most recent draft report for the Little Manatee. I have suggested that that it could be temporarily okay to move the boundary for the upper and lower river to, or preferably slightly upstream of, the recently proposed boundary near river kilometer 16.4. However, this should be subject to further analyses in a limited re-evaluation of minimum flows for the lower river as soon as practical,

with the focus on the inundation relationships of tidal freshwater wetlands between this boundary and US 301.

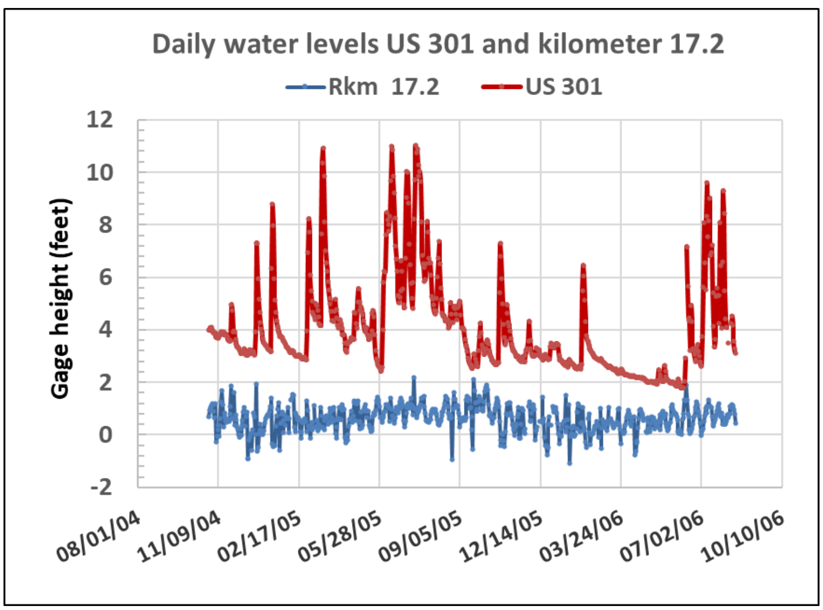
As will also be further discussed, some flexibility should be applied as to which minimum flows rules should apply (upper or lower river) in the evaluation of any new water withdrawal sites that are being considered from near US 301 to several kilometers farther downstream.

Water level relationships with flow in tidal freshwater systems

It is commendable that the District wants be conservative and move the upper/lower river boundary to kilometer 16.4 to better protect the riverine wetland forests between US 301 and that location, as the allowable flow reductions for the upper river are much less than for the lower river.

However, all the data collection to examine the inundation of riverine wetlands presented in the minimum flows report is upstream of US 301, and the relationships of water levels to flow will change dramatically the farther you go downstream of US 301.

As previously mentioned, the USGS operated a water level recorder the Little Manatee River near Ruskin gage (# 02300532) between October 2004 and August 2006 as part of the development of the EFDC hydrodynamic model of the river. That recorder was located at kilometer 17.2 (see figure on page 5). A plot of water levels at this location and the US 301 gage is below, with the caveat the values for 301 are mean daily values while the data for km 17.2 are maximum water levels each day, as only daily minimum and maximum values were readily available for at the time of this writing. Although not shown, there is considerable tidal variation in water levels at this site with a mean diurnal tide range of 2.0 feet, while diurnal tidal water level fluctuations at US 301 are typically less than one or two inches.



It is clear that the response of water levels to variations in flow are much less at 17.2 than at US 301, as the range of maximum daily levels was only 3.2 feet at kilometer 17.2, while the levels ranged over 9 feet at US 301. It is again reiterated that the inundation results that were used to develop the minimum flows for the upper river were all above US 301. Clearly, these findings would not be applicable to the river at kilometer 17.2, but could possibly be more applicable to sites that are closer to US 301.

If the District wants to develop minimum flows are appropriate for the tidal freshwater wetlands downstream of US 301, it should do additional topographic surveys in these wetlands and compare then to modeled surface water elevations at different points between US 301 and various locations farther downriver.   The minimum flows report indicates that the grid for the EFDC model extends up to US 301, but I do not know to what extent if can accurate simulate water levels in the upper part of the lower river or whether another model could be used.

The District did model simulations for the inundations of tidal freshwater wetlands as part of the Lower Peace River minimum flows (SWFWMD 2021). That study found the allowable percent flow reductions based on the inundation of riverine wetlands in the tidal freshwater reach of the river the river were much greater than the allowable percent flow reductions that were determined for the non-tidal part of the river between Zolfo Springs and Arcadia, which were evaluated as part of a separate minimum flows study (SWFWMD 2005).

Need to need to re-evaluate the minimum flows for the lower river as soon as practical if the revised boundary for the upper and lower river is adopted.

Similar to the Lower Peace River, I think it is likely that the modeling of inundation of tidal freshwater wetlands downstream of US 301 on the Little Manatee will also show less sensitivity to flow reductions than wetlands upstream upstream of US 301, with reduced sensitivity most likely at sites father below US 301.

As such, if the new boundary for the upper and lower boundary is adopted, it will be necessary to re-evaluate how far down downstream from US 301 the minimum flows for the upper river should apply.   I think that if that is the case, it may be for a fairly small section of the river below US 301.

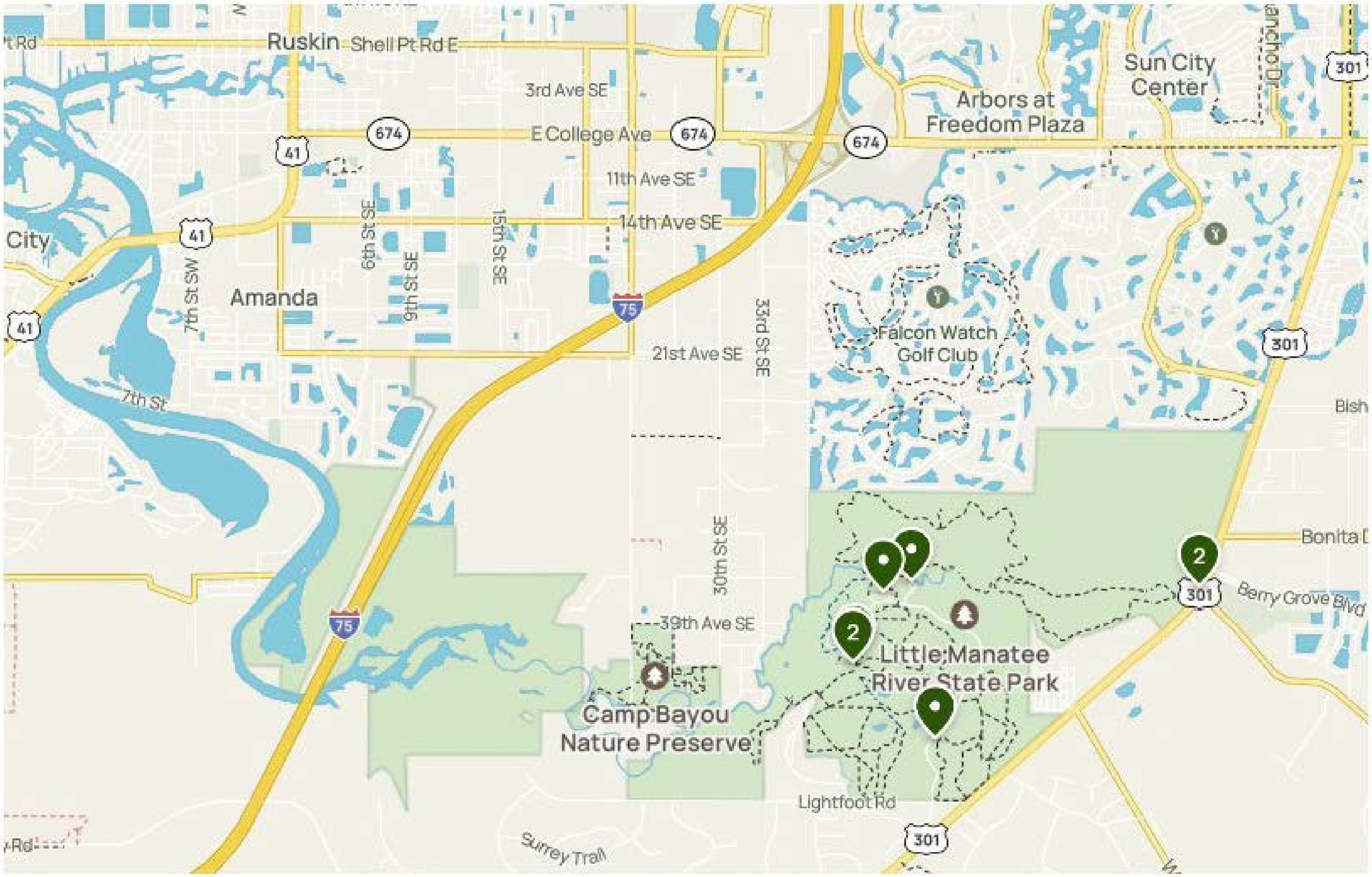
The scope of work for such a re-evaluation of the boundary between the upper and lower river could be limited and focus solely on the modeling and assessment of the inundation of tidal freshwater wetlands between US 301 and kilometer 16.4, as apparently that is what caused the District to move the boundary between the upper and lower river. Such a re-evaluation should be pursued as soon as practical to facilitate water supply planning in the region. Again, if the boundary is moved in the near term prior to a re-evaluation, I think that a location near kilometer 18 is more justifiable than at kilometer 16.4.

Flexibility for the application of minimum flows for the upper or lower river depending on the location of the intake for a proposed withdrawal

Some flexibility should also be applied to whether the rules for the upper or lower river should be applied depending on where the intake for a withdrawal is located. The placement of an intake downstream of US 301 should consider factors near a proposed intake site, including the occurrence of ecologically valuable public park lands, which are generally shown in a map on the following page.

Depending on where an intake is located below US 301, the amount of tidal freshwater wetlands that may be significantly affected may be very small and the minimum flows for the lower river could be applied there with no significant harm to the ecosystem. As such, a number of factors should be evaluated to determine if the minimum flows for the upper or lower river should be applied depending on the location of a proposed intake within several kilometers downstream of US 301.

Unconfirmed location of pubic owned lands along the Little Manatee River between the US Highway 301 bridge and lands along the north bank of the river downstream of Interstate 75. This was taken from an All Trails website, but I know that the Little Manatee River State Park extends a good way downstream of US 301. Also, I believe Hillsborough County ELAPP owns the lands shown closer to Interstate 75.



Procedures for notifying the independent review panel, advisory committees, and interested stakeholders of the change in the upper/lower river boundary location

As with all minimum flows reports published by the District, the minimum flows report was subject to technical review by an independent review panel, which for the Little Manatee was comprised of three experts in the fields of ecology, freshwater hydrology and modeling, and estuarine hydrodynamic modeling. The panel first reviewed he draft report published in September 2021 and then the revised report published in June 2023. The panel then held two sets of meetings after the publishing of each of those reports, in which they interacted with District staff and heard comments from the public.

The two draft reports the panel reviewed had the boundary between the upper and lower river established at the US 301 bridge. As previously mentioned, the movement of the upper/lower boundary was not in a draft report until the November 2023 draft which was posted earlier this month. I believe contract for the review panel expired in August, and do not know if the District has informed the panel that a new draft report has been published that moved that boundary between the upper and lower river sections of the river.

There was also considerable interest in the draft reports published by the District from the public, representatives of public agencies, and staff from the University of South Florida who virtually attended some of the peer review panel meetings. To my knowledge, none of these individuals were made aware that a new draft report for the lower river was published this month and that it shifted the boundary between the upper and lower sections of the river. In the last week, however, I have notified a few individuals that the most recent draft was available from the District website and that it changed the upper/lower river boundary.

Based on the draft report published in August 2023, the District has also presented the findings of the minimum flows work on the Little Manatee at a public workshop and to the District's Public Supply Advisory and Environmental Advisory Committees, the later of which I serve on. I do not believe that any of these groups have been made aware that a more recent version of the draft report has been published that moved the boundary between the upper and sections of the river.

The location of the boundary between the upper and lower river is one of the most important components of a minimum flows analysis, as it affects how much water is available for supply from different sections of a river. It also has important ecological implications, as non-tidal freshwater reaches and tidal estuarine reaches of creeks and rivers are different types of ecosystems. As such, the hydraulic and ecological analyses that determine where the boundary between the upper and lower section of a river is located should be thorough and well described in the minimum flows report.

It may not be standard procedure, but as a professional courtesy the District should consider notifying the peer review panel, the Public Advisory and Environmental Advisory Committees, and key people who attended either the public workshop or the peer review panel meetings that a new draft minimum flows report for the Little Manatee River has been published that proposes moving the location of the boundary between the upper and lower sections of the river from the US 301 bridge to river kilometer 16.4.

Schedule for the adoption of minimum flows for the Little Manatee River

The yearly minimum flows schedule the District submits to the Florida Department of Environmental Protection calls for minimum flows for the Little Manatee river to be adopted in 2023. I could be wrong, but it appears the minimum flows were not presented to the District Governing Board at their November 2023 meeting. However, it may be that the District is intending to present the minimum flows to the Governing Board at their December 12, 2023 meeting, which is two weeks from the time this memorandum was prepared. Again, until last week I was not aware that a revised minimum flows report was on the District's website that moved the boundary between the upper and lower river.

Given the important implications that the movement of the upper/lower river boundary has for water supply planning and protection of the natural resources of the Little Manatee River, the District should consider moving the adoption of minimum flows to the January 2024 Board meeting, or a subsequent month soon thereafter, if necessary.

As previously discussed, given that this important change in the proposed minimum flow rule was applied so recently, the District should consider notifying the peer review panel, two advisory committees, and key members of local agencies and the public of this change prior to rule adoption, which could take a couple of weeks.

Also, in this memorandum I have presented some technical material that should be added or revised in the minimum flows report to better justify, and not technically contradict, the need to move the upper/lower river boundary from US 301 to a downstream location. I have also raised technical points that the minimum flows for the lower river should be re-evaluated as soon as possible in a limited, focused analysis to examine the inundation characteristics of tidal freshwater wetlands downstream of the US 301 bridge. Similarly, some flexibility should be applied to any new proposed withdrawals downstream of US 301 depending on the location of the intake for that withdrawal. If the minimum flows are presented to the December Governing Board meeting, I expect to attend and discuss these points as part of the public comments.

Possibly the District could address all concerns related to the change in the boundary between the upper and lower river in the next two weeks and adopt minimum flows for the Little Manatee River at their December 12th meeting, if that is their intention. However, if it is necessary to take a bit more time to address all technical and notification factors related to moving the boundary for the upper and lower sections of the river, the District could postpone presenting the minimum flows for the Little Mantee until January, 2024, or a month soon thereafter, as this should leave enough time to address all related factors.

I realize the District likes to keep to their schedule for minimum flows adoption, but for technical and logistical reasons the District sometimes postpones the adoption of minimum flows for a river by a year or more. In the case of the Little Manatee, we are talking about a month or two. This should pose not real delays or problems for water supply plans or natural resource protections strategies in the region. Given the late date at which this important change in the minimum flows was published, such a small postponement for the adoption of the minimum flows for the Little Manatee River would be warranted and beneficial to the water management process and the natural resources of the region.

References

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Peebles. E. B. and M.S. Flannery. 1992. Fish nursery use of the Little Manatee River Estuary (Florida); Relationships with freshwater discharge. Report prepared by the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

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From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Chris Zajac; Randy Smith; Kristina Deak; Yonas Ghile; Jordan D. Miller; Xinjian Chen; Gabe I. Herrick
Cc:	Mike Wessel; rpribble@janickienvironmental.com
Subject:	Change in the boundary of the upper and lower sections of the Little Manatee River for minimum flows
Date:	Tuesday, November 28, 2023 3:43:54 PM
Attachments:	Technical memorandum - Little Manatee River MFLS, change in upper lower river boundary, from Sid Flannery.pdf

Hello Kym and staff,

As I last emailed you last Wednesday, ten days or so ago I noticed that a revised draft minimum flows report for the Little Manatee River (dated November 2023) was posted to the District website. That report identifies a new boundary for delineating the upper and lower sections of the river for the establishment of minimum flows.

As I also mentioned in my previous email, I am now attaching a technical memorandum that addresses certain factors related to changing this boundary. I hope staff can read this fairly soon, for it discusses timely topics with regard to adopting minimum flows with this new boundary. The key points are summarized on page 1, but there are some key graphics and discussion in the body of the memo that staff should review.

I am not opposed to changing the boundary between the upper and lower river, but believe there are some concise revisions to the report and related management factors that need to be considered before a rule corresponding to the recent draft report is adopted by the Governing Board. These are all explained in the attached document.

I'll be happy to address any questions or comments that staff have regarding my technical memorandum.

Thanks as always,
Sid

November 29, 2023

TO: SWFWMD staff associated with the draft minimum flows report for the Little Manatee River

FROM: Sid Flannery, retired, formerly Chief Environmental Scientist with the SWFWMD minimum flows program

SUBJECT: Recent change in the boundary for the determination of minimum flows for the upper and lower sections of the Little Manatee River

Summary

Last week I noticed that the most recent draft minimum flows report for the Little Manatee River (dated November 2023) changed the boundary for the establishment of minimum flow rules for the upper and lower sections of the Little Manatee River. This move shifted the boundary downstream about 8 kilometers (approximately five miles) from the US 301 bridge near river kilometer 24.5 to the location of a water quality station monitored by the Environmental Protection Commission of Hillsborough County (EPCHC) near kilometer 16.4. This is a major shift in technical approach, as several previous draft reports published over a considerable length of time, the most recent in August 2023, used the 301 bridge as the boundary between the upper and lower sections of the river.

Moving the boundary to, or preferably slightly upstream of, the location of the EPCHC station at kilometer 16.4 may be temporarily desirable as it is oriented to providing more conservative protection of riverine forests in what is predominantly the tidal freshwater section of the river. However, some revisions to the minimum flows report are needed to technically support, or at least not contradict, this change in the boundary between the upper and lower river.

Also, if a revised boundary between the upper and lower river is kept in the report and adopted in rule, the minimum flows for the Lower Little Manatee River should be re-evaluated as soon as practical with the limited purpose of modeling and assessing of the inundation requirements of riverine wetlands in the tidal freshwater reach of the river, as they are probably not as sensitive to the effects of flow reductions as much as the wetlands upstream of US 301 on which the proposed minimum flows for the upper river are based on during the high flow block.

In the meantime, if this revised boundary is as adopted as part of minimum flow rules for the Little Manatee River, some flexibility should be applied as to which set of rules (upper or lower) should be applied to a new withdrawal from the river depending on its location in the section of the river between US 301 and the EPCHC station at kilometer 16.4. I have never advocated for moving the boundary between the upper and lower river away from US 301, and still think it may not be necessary depending on where a new intake might be located.

The schedule for adoption of minimum flows for the Little Manatee River calls for adoption in 2023. However, the next Governing Board meeting is very soon on December 12th. If consideration of these factors and the needed revisions to report can be accomplished before then, possibly the adoption of the rule in 2023 can be achieved. However, if postponement of the adoption of the minimum flow rule for the Little Manatee River to January 2024 or a subsequent month is needed, that should be pursued as it poses no real problem for regulatory or water supply planning in the region.

Better characterization is needed of the salinity characteristics of the lower river to support the movement of the boundary between the upper and lower river

The upstream extent of brackish water in a tidal river in the dry season is a primary factor to be considered in determining separate minimum flow rules for the freshwater reaches of creeks and rivers versus downstream tidal estuarine reaches. In that regard, the upstream extent of brackish water in the Little Manatee River in the dry season needs more elaboration and clarification, as the minimum flows report is either unclear or misleading in few places, which is problematic for justifying a revised boundary for separating the upper and low sections of the river.

The District chose the location of EPCHC water quality station 1616 near kilometer 16.4 to delineate the boundary between the upper and lower river, but no salinity data for this station are clearly presented in the report. The EPCHC has measured water quality profiles (salinity, dissolved oxygen, pH) at 16 stations in the river on over 200 dates during two separate periods ranging from 2000 to 2006 and from 2009 to present. The draft report for the lower river that was prepared in 2018 (JEI, 2018 included as Appendix E to the report) showed a map of these stations and discussed that data from them was used to develop the empirical salinity model of the river used in the EFF fish habitat modeling.

Although this extensive and important data base was readily available, other than two figures of salinity zones predicted by the EFDC model, two plots of predicted vs. observed salinity using empirical models, and a generated contour plot of observed values, the only other observed salinity data shown for the lower river in the recent minimum flows report is a box plot of salinity at four EPCHC stations where they also measure full water quality, including nutrients. The downstream and upstream extents of these four stations are near kilometers 1.8 and 13.8, respectively. It is therefore important to show salinity data outside this geographic range, especially when the District is proposing a boundary between the lower and upper river at kilometer 16.4. Also, when an agency such as the EPCHC spends so much time and effort collecting such data, it would be valuable to present it in the minimum flows report as it is critical to understanding the salinity characteristics of the Lower Little Manatee River.

Three months after the second draft minimum flows report for the Little Manatee was published in September 2021, I submitted to the District a Supplemental Analyses report (SA report) I prepared that summarized additional data for the river. The SA report recommended that data from all the EPCHHC vertical profile station should be presented in the report, and presented a box plot of mean water column salinity at the 16 EPCHC vertical profile stations, which is reprinted on the following page, with the figure number and legend reprinted from that report.

Text continued on the next page

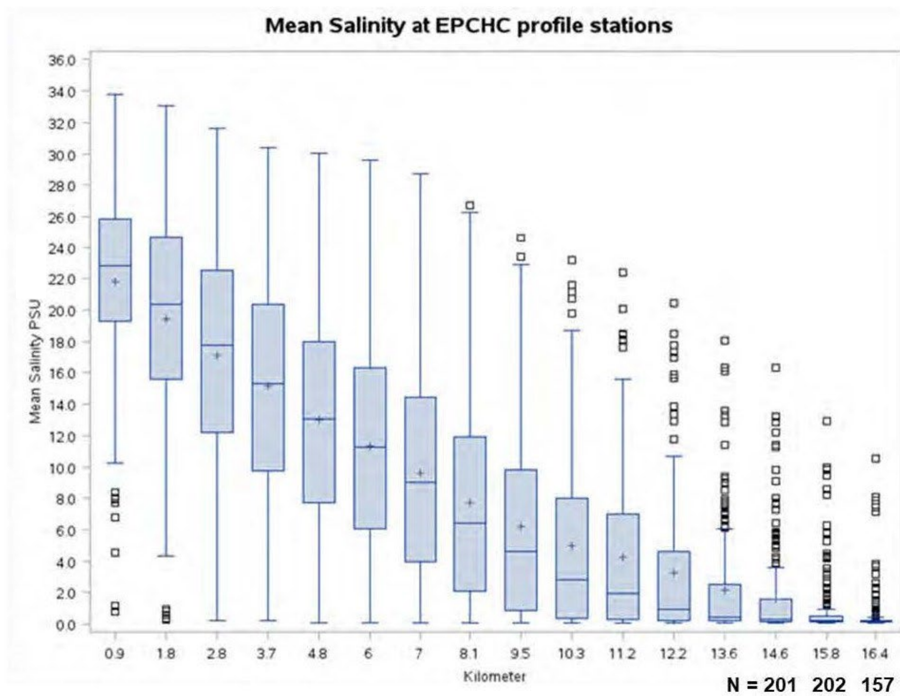


Figure 17. Box plot of mean water column salinity values at EPCHC vertical profile stations. The + symbols are means, the horizontal lines the medians, with the whiskers extending to 1.5 times the inter-quartile range. Outliers are shown for above the whiskers, but not below as freshwater outliers (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

This box plot shows that the median and mean salinity at kilometer 16.4, which is Station 1616, are near zero, but mean salinity values between 7.2 and 10.6 psu occurred on five sampling dates, with salinity between 1 and 3.9 psu occurring on 13 other dates. Clearly, brackish water can migrate to this section of the river during prolonged dry periods. Thus, based on salinity characteristics, the revised boundary between the upper and lower sections of the river can occurs in what is frequently the oligohaline and sometimes low-mesohaline section of the river. As stated in my SA report, I again suggest that a discussion of the EPC vertical profile stations be presented in minimum flows report, including a box plot of salinity at all the EPCHC vertical profile stations similar to the one shown above.

Salinity data in the lower river were also collected by the District on 59 dates during two separate two time periods in the mid to late 1980s. A box plot of those data was also presented in the SA report, but it stated the EPCHC data should be emphasized due to its extensive spatial distribution which is still ongoing.

Text continued on the next page

The SA report also showed informative plots of means salinity values at stations upstream of kilometer 16.4 on days when sampling by either the EPCHC or the District went farther upstream during very dry periods. A figure from the SA report is reprinted below using the figure number and legend in that report. These show that brackish water does not typically extend of kilometer 17 to 18 in during very low flows, which is similar to the conclusions of other researchers (Fernandez 1985, Peebles and Flannery 1992, JEI 2018).

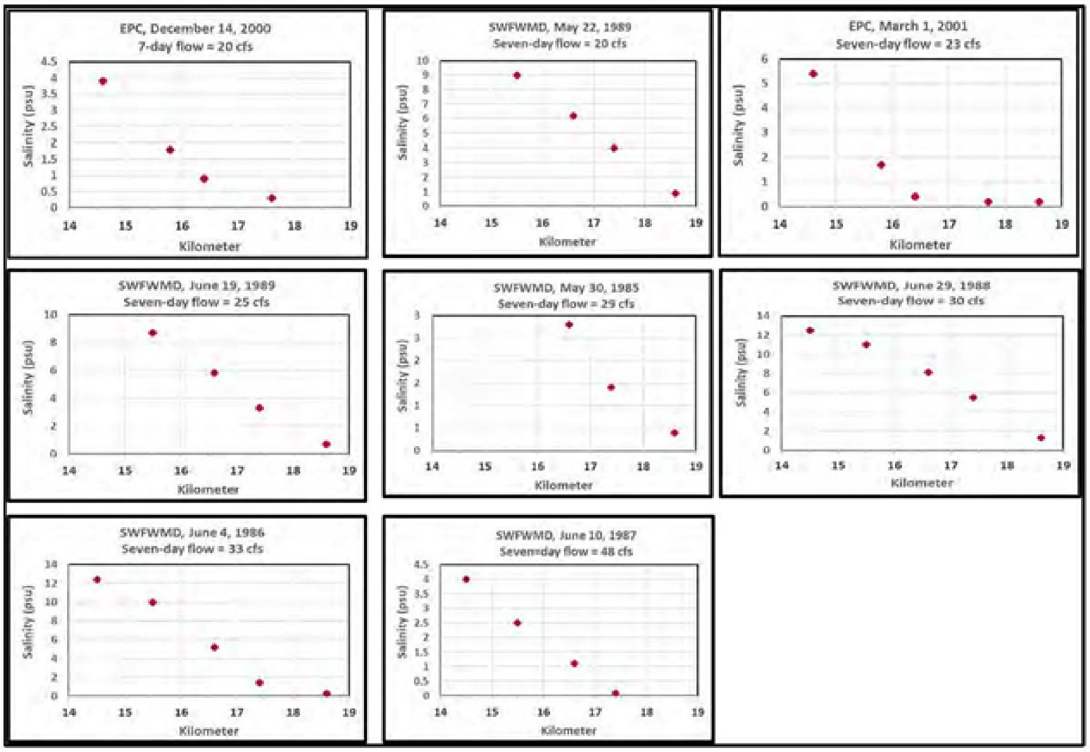


Figure 19. Mean water column salinity at upper stations in the lower river when sampling extended upstream of kilometer 16.6 by either the EPCHC or the District. The preceding seven-day average flow for each sampling date is listed on graphs.

I again reiterate that the upstream penetration of brackish water in the dry season is a fundamental parameter that should be used to establish boundaries for minimum flow rules for freshwater vs. tidal estuarine sections of rivers, as they are fundamentally different types of ecosystems. Given the relationships shown the in two figures reprinted from the SA report, it would make more sense to move boundary between the upper and lower river to near kilometer 18, as it more truly represents the tidal freshwater part of the river, as opposed to kilometer 16.4.

However, even though I repeatedly informed the District here is tidal freshwater zone below US 301, I have never suggested that moving the boundary between the upper and lower river away from US 301 is necessary. As will be discussed in later sections, I think that still may be the case, but appreciate that the District is trying to be cautious with the zone of the river immediately downstream of US 301. As will be discussed further, if the boundary is moved, the minimum flows for the lower river should be re-evaluated with a limited focus as soon as practical. Secondly, some flexibility should be applied in the near term on which rules (upper or lower should be applied to a new withdrawal depending on the location of the intake below US 301

As related to a suitable location for a upper/lower river boundary, the morphology of the river has a tidally affected loop attached to the river channel near kilometer 17.2 (see figure below adapted from the November 2023 draft minimum flows report). If the boundary between the upper and lower river is to be moved downstream from US 301, it would be best to keep the boundary upstream of that morphological feature, as the river is largely confined to a narrow single channel upstream from there. Also, as will be discussed on a page 8, a water level recorder was operated by the USGS near kilometer 17.2 from October 2004 to August 2006. Water level relationships with flow are fundamentally different there than at US 301, and there is no physical or hydraulic reason to extend the boundary between the upper and lower river any further downstream than kilometer 18.

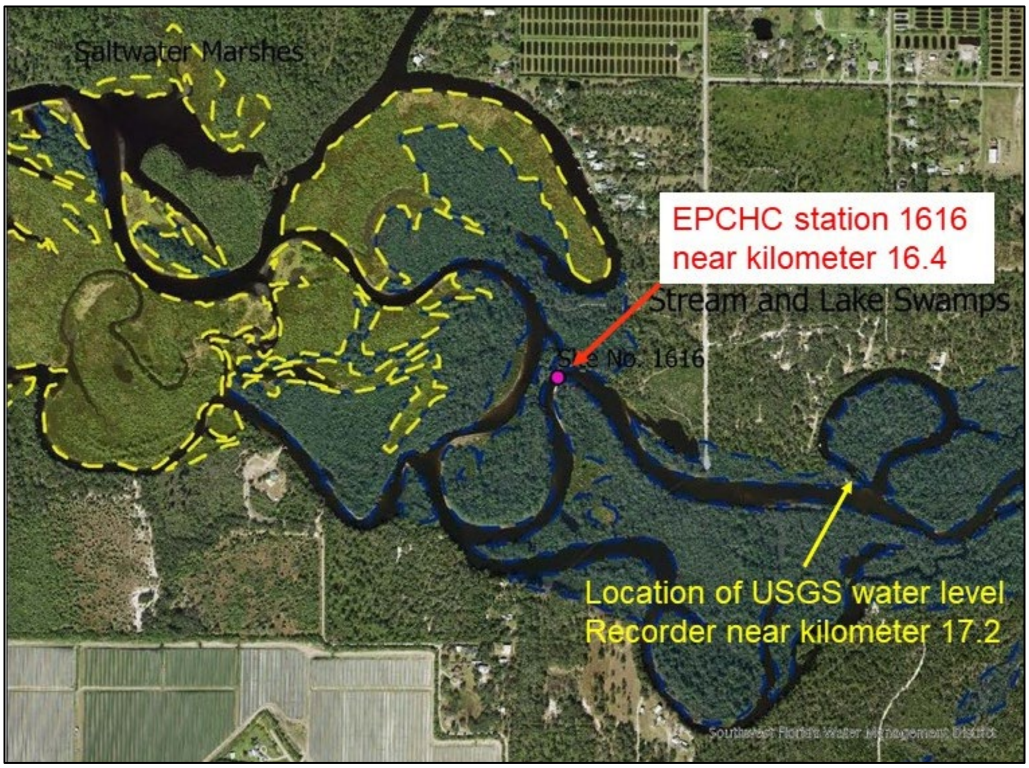


Figure above adapted from Figure 6-23 in the minimum flows report, adding the location of the tidal loop near kilometer 17. The yellow line (placed by the District) denotes saltwater marsh shorelines according to the FLUCCS code system while the blue line (which is hard to see) designated stream and lake swamps, bottomlands by FLUCCS. As will be discussed on page 8, a water level recorder ran for over 22 months at kilometer 17.2.

There are other sections of the minimum flows report where the text needs to be revised to better reflect salinity characteristics of the river and better support moving the upper/lower river boundary downstream from US 301. At present, some of the text seems to contradict the rationale for moving the boundary downstream from US 301.

On October 30, 2023, I sent a series of editorial changes to the District I suggested be incorporated to make the text more clear, without changing the findings or conclusions of the report. Those edits were based on the August 2023 draft, and they are even more critical now that the District is proposing to move the upper/lower boundary eight kilometers downstream.

The first important edit in that regard is in the last sentence on page 161 in the November 2023 draft that states "salinities were nearly exclusively near zero at the US Highway 301 bridge, although three data points existed which showed oligo- to low-mesohaline salinities may be possible at this station." This is misleading, for there is clear evidence that these three salinity values, which were recorded by the EPCHC in 1980 and 1980, are erroneous. In the first draft report for the lower river (JEI 2018), the authors described that these values "appear anomalous" or are "potential anomalous". However, this important characterization was omitted in more recent drafts of the minimum flows reports.

I have accessed specific conductance data from the river at this same site from the USGS website and the District study in 1988, that show that no salinity values anywhere near the very high EPCHC values occurred in the river near those dates (salinity is calculated from specific conductance). There is also no evidence that very high storm tides affected salinity at US 301 on those dates. I sent the District the data I based this conclusion on, and maintain that the statement that oligo- or low-mesohaline salinities may be possible at US 301 should be removed from the minimum flows report or be highly qualified, as it is based on erroneous or anomalous values.

This is case of the text in the current draft technically contradicting the movement of the upper/lower river boundary downstream to kilometer 16.4. Do you really want to suggest that you are moving the boundary 8 kilometers downstream from US 301 when oligo- to low-mesohaline salinities may be possible at US 301. Again, removal or qualifying reference to the clearly erroneous salinity data at US 301 is in order.

There is another section of the report that is contradictory to the concept of moving the upper/lower river boundary downstream to kilometer 16.4. Even before this shift was proposed, my editorial comments suggested this section of the report be revised as it mischaracterizes the river between Interstate between Interstate-75 and the 301 bridge. The report does a decent job of characterizing two zones of the river between the mouth and I-75, but then says there is one ecological zone of the lower river between I-75 and US 301. I pointed out this is false, as the river changes from a distinct, braided estuarine zone with abundant oligohaline marshes to a single channel with tidal freshwater wetlands around kilometer 17.

If you want to establish a boundary between the upper and lower river at kilometer 16.4, do you want to erroneously claim that the river between Kilometer 12.5 and 24.5 is one ecological zone. I provided some fairly simple text to the District to describe that there two distinct ecological zones between I-75 and US 301, which at this time would go along with supporting a boundary somewhere in the range between 16.4 and 18. However, that language has not yet been incorporated in the report.

I also submitted a number of other editorial changes to the District that are technically correct and valuable, which I suggest they incorporate in the next version of the minimum flows report.

The recent emphasis on tidal freshwater wetlands for delineation of the upper and lower river

The inundation of riverine wetlands is a primary factor the District has used to assess minimum flows for non-tidal freshwater rivers, such as the upper reaches of the Alafia, Peace and Myakka Rivers. Freshwater biological communities, including riverine wetlands, can also occur in tidally affected areas that remain fresh but where water levels and current velocities are affected by tides.

The justification for moving the boundary for the upper and lower river appears solely in one paragraph on page 191 in the November 2023 draft report. From this paragraph, it appears the District has chosen to move the boundary between the upper and lower river farther downstream primarily to better protect tidal freshwater forests that extend between US 301 and kilometer 16.4.

This is supported by Figure 6-23 on page 192 in the most recent draft report, which shows the delineation between FLUCCS codes that show a shift from "stream and lake swamps, bottomlands" to "saltwater marshes" near kilometer 16.4, where the EPCHC has a water quality monitoring station that the District has chosen to delineate the upper and lower sections river (see figure on page 5 of this memorandum).

The switch in vegetation communities in the tidal section of the Little Manatee river has been documented for quite some time, as the report by Fernandez (1985) described vegetation gradients in the river in relation to salinity. Peebles and Flannery (1992) also described such gradients in salinity and vegetation, including a tidal freshwater zone upstream of kilometer 16 to 18. A thorough study of vegetation communities in the tidal reach of the Little Manatee was conducted by the Florida Marine Research Institute (1997), which showed the transition between saltmarshes dominated by black needlerush (*Juncus roemerianus*) to oligohaline marshes dominated by freshwater plants such as cattails (*Typha* sp.) and sawgrass (*Cladium jamaicense*) that are tolerant of low salinity.

The maps presented in the FMRI study support the transition from marshes to tidal freshwater forests near the boundary proposed by the District, but the oligohaline marshes near that transition point are not well characterized by the general saltwater marsh label used in the FLUCCS codes shown in Figure 6-23 in the minimum flows report. I have repeatedly expressed to the District that they should at least cite the FMRI (1997) study in their minimum flows report, but that has not yet happened.

It is commendable that the District wants to protect the riverine forests associated with the tidal freshwater section of the Little Manatee River. However, as will be described on page 8, water level relationships to flow can be considerably different over relatively short distances between non-tidal and tidal freshwater reaches of a river. In a recent report for the Lower Peace River, the District (2021) modeled and evaluated the inundation of freshwater forests associated along the tidal freshwater reach of that river.

However, no similar modeling or assessment of changes in the inundation of tidal freshwater wetlands are presented in the most recent draft report for the Little Manatee. I have suggested that that it could be temporarily okay to move the boundary for the upper and lower river to, or preferably slightly upstream of, the recently proposed boundary near river kilometer 16.4. However, this should be subject to further analyses in a limited re-evaluation of minimum flows for the lower river as soon as practical,

with the focus on the inundation relationships of tidal freshwater wetlands between this boundary and US 301.

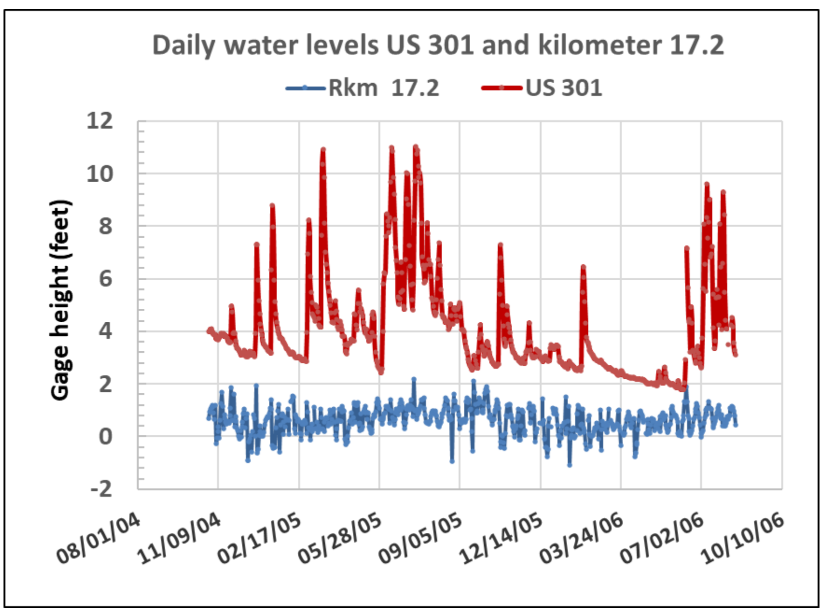
As will also be further discussed, some flexibility should be applied as to which minimum flows rules should apply (upper or lower river) in the evaluation of any new water withdrawal sites that are being considered from near US 301 to several kilometers farther downstream.

Water level relationships with flow in tidal freshwater systems

It is commendable that the District wants be conservative and move the upper/lower river boundary to kilometer 16.4 to better protect the riverine wetland forests between US 301 and that location, as the allowable flow reductions for the upper river are much less than for the lower river.

However, all the data collection to examine the inundation of riverine wetlands presented in the minimum flows report is upstream of US 301, and the relationships of water levels to flow will change dramatically the farther you go downstream of US 301.

As previously mentioned, the USGS operated a water level recorder the Little Manatee River near Ruskin gage (# 02300532) between October 2004 and August 2006 as part of the development of the EFDC hydrodynamic model of the river. That recorder was located at kilometer 17.2 (see figure on page 5). A plot of water levels at this location and the US 301 gage is below, with the caveat the values for 301 are mean daily values while the data for km 17.2 are maximum water levels each day, as only daily minimum and maximum values were readily available for at the time of this writing. Although not shown, there is considerable tidal variation in water levels at this site with a mean diurnal tide range of 2.0 feet, while diurnal tidal water level fluctuations at US 301 are typically less than one or two inches.



It is clear that the response of water levels to variations in flow are much less at 17.2 than at US 301, as the range of maximum daily levels was only 3.2 feet at kilometer 17.2, while the levels ranged over 9 feet at US 301. It is again reiterated that the inundation results that were used to develop the minimum flows for the upper river were all above US 301. Clearly, these findings would not be applicable to the river at kilometer 17.2, but could possibly be more applicable to sites that are closer to US 301.

If the District wants to develop minimum flows are appropriate for the tidal freshwater wetlands downstream of US 301, it should do additional topographic surveys in these wetlands and compare then to modeled surface water elevations at different points between US 301 and various locations farther downriver. The minimum flows report indicates that the grid for the EFDC model extends up to US 301, but I do not know to what extent if can accurate simulate water levels in the upper part of the lower river or whether another model could be used.

The District did model simulations for the inundations of tidal freshwater wetlands as part of the Lower Peace River minimum flows (SWFWMD 2021). That study found the allowable percent flow reductions based on the inundation of riverine wetlands in the tidal freshwater reach of the river the river were much greater than the allowable percent flow reductions that were determined for the non-tidal part of the river between Zolfo Springs and Arcadia, which were evaluated as part of a separate minimum flows study (SWFWMD 2005).

Need to need to re-evaluate the minimum flows for the lower river as soon as practical if the revised boundary for the upper and lower river is adopted.

Similar to the Lower Peace River, I think it is likely that the modeling of inundation of tidal freshwater wetlands downstream of US 301 on the Little Manatee will also show less sensitivity to flow reductions than wetlands upstream upstream of US 301, with reduced sensitivity most likely at sites father below US 301.

As such, if the new boundary for the upper and lower boundary is adopted, it will be necessary to re-evaluate how far down downstream from US 301 the minimum flows for the upper river should apply. I think that if that is the case, it may be for a fairly small section of the river below US 301.

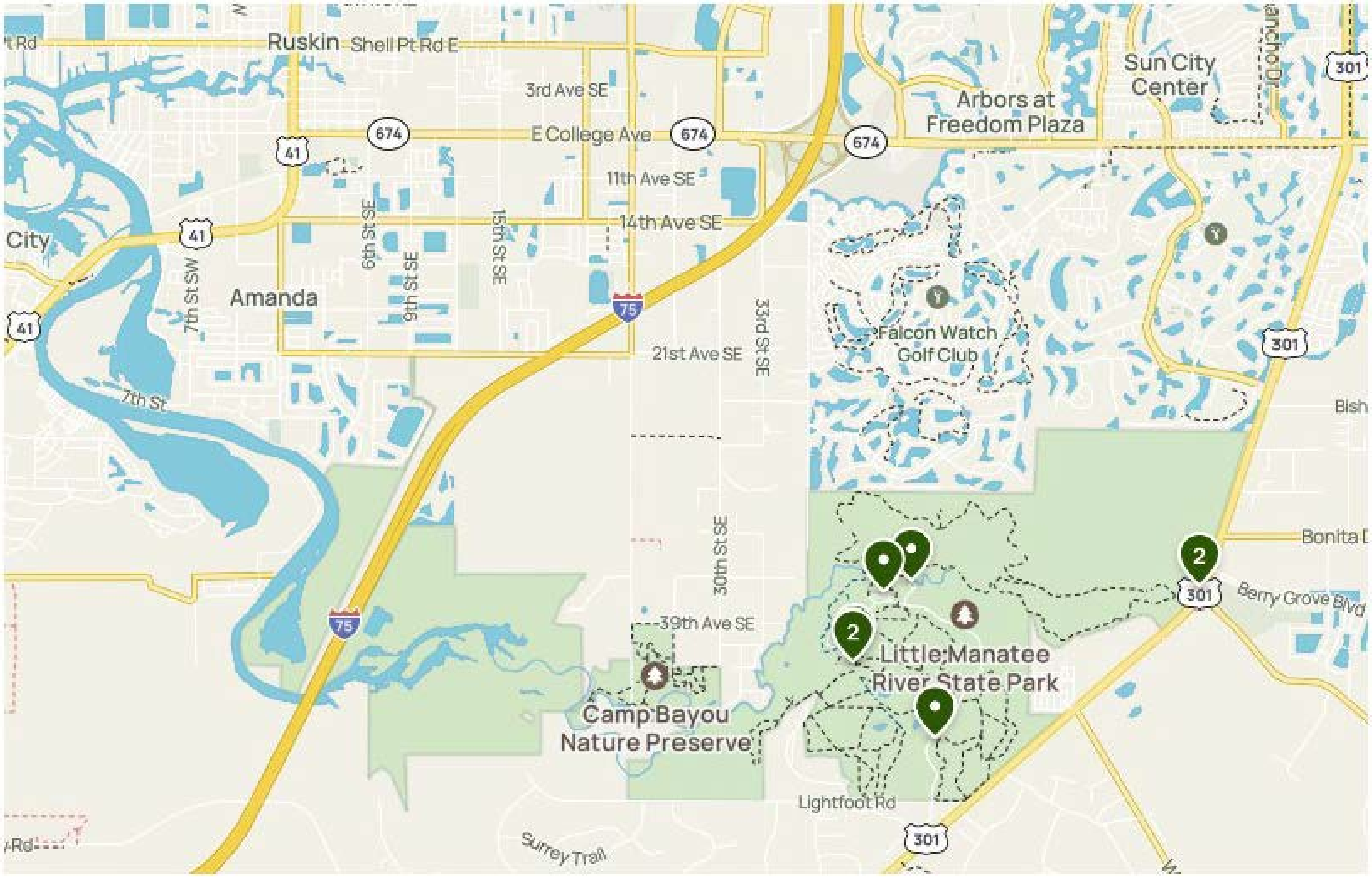
The scope of work for such a re-evaluation of the boundary between the upper and lower river could be limited and focus solely on the modeling and assessment of the inundation of tidal freshwater wetlands between US 301 and kilometer 16.4, as apparently that is what caused the District to move the boundary between the upper and lower river. Such a re-evaluation should be pursued as soon as practical to facilitate water supply planning in the region. Again, if the boundary is moved in the near term prior to a re-evaluation, I think that a location near kilometer 18 is more justifiable than at kilometer 16.4.

Flexibility for the application of minimum flows for the upper or lower river depending on the location of the intake for a proposed withdrawal

Some flexibility should also be applied to whether the rules for the upper or lower river should be applied depending on where the intake for a withdrawal is located. The placement of an intake downstream of US 301 should consider factors near a proposed intake site, including the occurrence of ecologically valuable public park lands, which are generally shown in a map on the following page.

Depending on where an intake is located below US 301, the amount of tidal freshwater wetlands that may be significantly affected may be very small and the minimum flows for the lower river could be applied there with no significant harm to the ecosystem. As such, a number of factors should be evaluated to determine if the minimum flows for the upper or lower river should be applied depending on the location of a proposed intake within several kilometers downstream of US 301.

Unconfirmed location of pubic owned lands along the Little Manatee River between the US Highway 301 bridge and lands along the north bank of the river downstream of Interstate 75. This was taken from an All Trails website, but I know that the Little Manatee River State Park extends a good way downstream of US 301. Also, I believe Hillsborough County ELAPP owns the lands shown closer to Interstate 75.



Procedures for notifying the independent review panel, advisory committees, and interested stakeholders of the change in the upper/lower river boundary location

As with all minimum flows reports published by the District, the minimum flows report was subject to technical review by an independent review panel, which for the Little Manatee was comprised of three experts in the fields of ecology, freshwater hydrology and modeling, and estuarine hydrodynamic modeling.   The panel first reviewed he draft report published in September 2021 and then the revised report published in June 2023. The panel then held two sets of meetings after the publishing of each of those reports, in which they interacted with District staff and heard comments from the public.

The two draft reports the panel reviewed had the boundary between the upper and lower river established at the US 301 bridge. As previously mentioned, the movement of the upper/lower boundary was not in a draft report until the November 2023 draft which was posted earlier this month.   I believe contract for the review panel expired in August, and do not know if the District has informed the panel that a new draft report has been published that moved that boundary between the upper and lower river sections of the river.

There was also considerable interest in the draft reports published by the District from the public, representatives of public agencies, and staff from the University of South Florida who virtually attended some of the peer review panel meetings. To my knowledge, none of these individuals were made aware that a new draft report for the lower river was published this month and that it shifted the boundary between the upper and lower sections of the river. In the last week, however, I have notified a few individuals that the most recent draft was available from the District website and that it changed the upper/lower river boundary.

Based on the draft report published in August 2023, the District has also presented the findings of the minimum flows work on the Little Manatee at a public workshop and to the District's Public Supply Advisory and Environmental Advisory Committees, the later of which I serve on. I do not believe that any of these groups have been made aware that a more recent version of the draft report has been published that moved the boundary between the upper and sections of the river.

The location of the boundary between the upper and lower river is one of the most important components of a minimum flows analysis, as it affects how much water is available for supply from different sections of a river. It also has important ecological implications, as non-tidal freshwater reaches and tidal estuarine reaches of creeks and rivers are different types of ecosystems. As such, the hydraulic and ecological analyses that determine where the boundary between the upper and lower section of a river is located should be thorough and well described in the minimum flows report.

It may not be standard procedure, but as a professional courtesy the District should consider notifying the peer review panel, the Public Advisory and Environmental Advisory Committees, and key people who attended either the public workshop or the peer review panel meetings that a new draft minimum flows report for the Little Manatee River has been published that proposes moving the location of the boundary between the upper and lower sections of the river from the US 301 bridge to river kilometer 16.4.

Schedule for the adoption of minimum flows for the Little Manatee River

The yearly minimum flows schedule the District submits to the Florida Department of Environmental Protection calls for minimum flows for the Little Manatee river to be adopted in 2023. I could be wrong, but it appears the minimum flows were not presented to the District Governing Board at their November 2023 meeting. However, it may be that the District is intending to present the minimum flows to the Governing Board at their December 12, 2023 meeting, which is two weeks from the time this memorandum was prepared. Again, until last week I was not aware that a revised minimum flows report was on the District's website that moved the boundary between the upper and lower river.

Given the important implications that the movement of the upper/lower river boundary has for water supply planning and protection of the natural resources of the Little Manatee River, the District should consider moving the adoption of minimum flows to the January 2024 Board meeting, or a subsequent month soon thereafter, if necessary.

As previously discussed, given that this important change in the proposed minimum flow rule was applied so recently, the District should consider notifying the peer review panel, two advisory committees, and key members of local agencies and the public of this change prior to rule adoption, which could take a couple of weeks.

Also, in this memorandum I have presented some technical material that should be added or revised in the minimum flows report to better justify, and not technically contradict, the need to move the upper/lower river boundary from US 301 to a downstream location. I have also raised technical points that the minimum flows for the lower river should be re-evaluated as soon as possible in a limited, focused analysis to examine the inundation characteristics of tidal freshwater wetlands downstream of the US 301 bridge. Similarly, some flexibility should be applied to any new proposed withdrawals downstream of US 301 depending on the location of the intake for that withdrawal. If the minimum flows are presented to the December Governing Board meeting, I expect to attend and discuss these points as part of the public comments.

Possibly the District could address all concerns related to the change in the boundary between the upper and lower river in the next two weeks and adopt minimum flows for the Little Manatee River at their December 12th meeting, if that is their intention. However, if it is necessary to take a bit more time to address all technical and notification factors related to moving the boundary for the upper and lower sections of the river, the District could postpone presenting the minimum flows for the Little Mantee until January, 2024, or a month soon thereafter, as this should leave enough time to address all related factors.

I realize the District likes to keep to their schedule for minimum flows adoption, but for technical and logistical reasons the District sometimes postpones the adoption of minimum flows for a river by a year or more. In the case of the Little Manatee, we are talking about a month or two. This should pose not real delays or problems for water supply plans or natural resource protections strategies in the region. Given the late date at which this important change in the minimum flows was published, such a small postponement for the adoption of the minimum flows for the Little Manatee River would be warranted and beneficial to the water management process and the natural resources of the region.

References

Fernandez, M.A. 1985. Salinity characteristic and distribution and effects of alternative plans for freshwater withdrawal, Little Manatee River estuary and adjacent areas of Tampa Bay. Water Resources Investigation Report 84-4301. Report of the United States Geological Survey, Water Resources Division. Tallahassee, FL.

Flannery, M. S. 2021. Supplemental analyses, data presentations, and clarifications related to the evaluation of minimum flows for the Little Manatee River. Report prepared by M. S. Flannery

Florida Marine Research Institute. 1997. Development of GIS-based vegetation maps for the tidal reaches of five gulf coastal rivers. Report prepared by the Florida Department of Environmental Protection for the Southwest Florida Water Management District, Brooksville, FL.

Janicki Environmental. 2018. Recommended minimum flows for the Little Manatee River Estuary – Draft report. Report prepared for the Southwest Florida Water Management District. Brooksville Florida.

Peebles. E. B. and M.S. Flannery. 1992. Fish nursery use of the Little Manatee River Estuary (Florida); Relationships with freshwater discharge. Report prepared by the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Southwest Florida Water Management District. 2005. Proposed minimum flows and levels for the middle segment of the Peace River, from Zolfo Springs to Arcadia. Report of the Southwest Florida Water Management District. Brooksville, FL.

Southwest Florida Water Management District. 2021. Recommended minimum flows for the Lower Peace River and Lower Shell Creek. Report of the Southwest Florida Water Management District. Brooksville, FL.

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Chris Zajac; Randy Smith; Kristina Deak; Yonas Ghile; Jordan D. Miller; Xinjian Chen; Gabe I. Herrick
Cc:	Mike Wessel; rpribble@janickienvironmental.com
Subject:	Two corrections to technical memorandum
Date:	Wednesday, November 29, 2023 7:59:48 AM
Attachments:	Technical memorandum - Little Manatee River MFLS, change in upper lower river boundary, from Sid Flannery.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and staff,

Attached is a revised version of the technical memorandum that I sent you yesterday that has two small corrections.   This version has the FMRI (1997) study added to the References and the words upstream and downstream have been reversed on page 2.

This version has the same title but has the date November 29, 2023 in the heading on the first page. Please discard the November 28th version that I sent you yesterday.

Sid

From:	Sid Flannery
To:	Kym Holzwart; Randy Smith
Cc:	Chris Zajac; Doug Leeper; Kristina Deak; Yonas Ghile; Jordan D. Miller; Xinjian Chen; Gabe I. Herrick; Mike Wessel; rpribble@janickienvironmental.com
Subject:	Two items - LIttle Manatee RIver minimum flows
Date:	Tuesday, December 5, 2023 11:14:54 AM
Attachments:	Editoral Review of Little Manatee River MFL report from Sid Flannery.pdf Technical memorandum - Little Manatee River minimum flows, change in upper lower river boundary, from Sid Flannery, 12 4 2023.pdf

Hello Kym, Randy, and staff,

As expected, I see where the adoption of minimum flows for the Little Manatee River is going to be presented to the Governing Board on the 12th of this month. I think the flow blocks and percent flow reductions in the minimum flows for the lower river are technically sound and congratulate the District on all the hard work you have done on this river. However, there are two items I do want to bring up at this time.

1. The title page for Appendix I3 to the minimum flows report says it contains a compilation of public and stakeholder comments from July through October 2023. Accordingly, would the District please include the document I submitted on October 31st that provided editorial comments on the August 2023 draft minimum flows report. That document is attached again for convenience.

I also hope that Appendix I3 can be updated to include my technical memorandum regarding moving the boundary between the upper and lower river that I first submitted on November 28th and resubmitted with two edits on November 29th. **Given that this major change in the proposed minimum flows was not made public until November, comments received after October should be considered for inclusion in Appendix I3.** I have gone through that technical memorandum and made some grammatical edits and added some short phrases for better clarification of a few topics. The final version of my memorandum is attached, which in the date at the top describes it contains edits of a memo originally submitted on November 28th.

2. I genuinely do not want to address the Governing Board at their meeting on Dec. 12th. I am not planning to do so at this time, but that could change. In that regard, I think there is one important issue regarding the minimum flows that needs consideration. That is, can some flexibility be applied to which rules (upper or lower river) can be applied to a proposed water supply intake that is located between kilometer 16.4 and US 301. There are many factors that would go into optimizing the location of an intake in that region, and the best location for an intake could possibly be located about one to four kilometers upstream of the proposed

upper/lower river boundary near kilometer 16.4. If that is the case, I think the minimum flows rule for the lower river could be applied to that withdrawal without causing significant harm to the lower river.

Could Randy please give me a call at the number below to discuss this topic. I will be available anytime starting tomorrow (Wednesday) morning, with the sooner the better if possible.

Thanks as always,
Sid
813-245-0331

October 30, 2023

Editorial review of the draft minimum flows report for the Little Manatee River dated August 2023, submitted by Sid Flannery

Note – Suggestions concerning on the application of these proposed edits to the draft report were contained in an email sent to District staff on October 31, 2023

Cover - Rotate slightly the photo of the mouth of the river so that the horizon is not slanted – see adjusted photograph below. BTW- I took this photo from a helicopter in 1989.

P ii to iii – Table of contents – Some indentations are needed after the section numbers for consistent format in the Table of Contents

P 2 – last sentence in second paragraph - Change "The estuarine portion………" to "The tidal, largely estuarine portion……..". This might seem trivial, but in a few places the report correctly mentions there is a short tidal freshwater zone below US 301, so this small edit on page 2 is helpful. It is relevant to many findings presented in the report, particularly the descriptions of the channel, vegetation communities along the river, and the findings for the fish sampling by Dutterer (2006).

This clarification still supports the use of US 301 to delineate the upper and lower portions of the river. However, it is misleading to suggest that estuarine conditions occur up to US 301, which can be avoided with some very minor edits.

P 2 – third paragraph - The City of Palmetto and the community of Terra Ceia are not in the Little Manatee River watershed. Also, "Sun City" should be changes to "Sun City Center".

P 2 – bottom of page - Change "available" to "favorable" as this more accurately describes the findings of the Environmental Favorability Function (EFF) fish habitat modeling.

P 3 - third paragraph, line 6 - Again change "available" to "favorable".

P 5 – third paragraph, second sentence – Delete "….(e.g., the freshwater portion extends downstream of the US 301 bridge, Peebles and Flannery 1992)…". That report did not say that, and this might be an accidental miswording. It is simple enough in this sentence to just say "……the Upper Little Manatee River starts at the headwaters near Ft. Lonesome and ………gage is located (Figure 1-1)."

Later in the report it is described that minor tidal water level fluctuations can extend up to US 301 and there is more technical description of the delineation of the upper and lower river. Thus, a simple description of the delineation of the upper and lower river is sufficient on page 5.

P 5 - last paragraph -- Similar misquote of Peebles and Flannery (1992) , which can be deleted as above. Instead, the report could read "For purposes of minimum flows development, the lower or tidal, largely estuarine portion of the Little Manatee River begins at the US 301 bridge………"

P 6 - last paragraph or top of page 7 – Somewhere the report should mention the new Appendices that were added to the report. I believe there are at least two: (1) a new Appendix that includes the other plots used to evaluate the flow blocks for the lower river; and (2) the sensitivity analyses of the EFDC model. It necessary, the margins on page 6 or 7 could be expanded to keep the pagination the same, or alternately Figure 1-1 on page 6 could be reduced, or cropped down from the top, to allow for another line or two about these two Appendices on page 7 without affecting the pagination.

P 11 – third paragraph, last sentence. This point may seem picky, but I think taking out one word can fix it. I have never been a proponent of calendar-based seasonal blocks without some flow-based thresholds, as flows can be uncharacteristically low in seasonal blocks 2 and 3 for prolonged periods of time. As written, this sentence mentions seasonal blocks (possibly implying calendar based) in the same sentence as Flannery et al. (2002). The abstract for that paper says "Ongoing efforts are oriented refining percentage among seasons and flow ranges to account for shifts in responsiveness of estuarine resources…."

As such, a general application for seasonal and/or flow-based blocks can easily be referenced in the last sentence of paragraph 3 by replacing "This seasonal, building block approach………" with "A building block approach………" The District has established that a building block approach can be applied to both seasonal blocks and flow-based blocks, which is explained in paragraph 5 on this page. Thus, a generic reference to building block approach at the end of paragraph 3 works fine and does not erroneously attribute the calendar-based seasonal block approach to the 2002 journal article. BTW – using flow-based blocks effectively implements lower withdrawal rates in the ecologically sensitive spring dry season.

P 13 – second or third paragraph – As it was the foundational paper for the percent of flow method ("percent-of- flow approach" is in the title of the paper) the Flannery et al. (2002) reference would be appropriate at either one of two spots in paragraphs 2 or 3. Optimally, it could be added to the end of the second paragraph as the abstract of the paper expresses this same concept.

Alternately, It could be added after Lower Peace River in the first sentence of the third paragraph as "Lower Peace River (Flannery et al. 2002) and has………" as that paper described how the percent-of-flow approach has been applied to the Lower Peace, Little Manatee, and Alafia Rivers.

P 13 – last paragraph first sentence Has the percent of flow approach (or method) actually been implemented for "numerous" permitted surface withdrawals? I would like to think so and would be great if that is the case, but I know of only three at this time which are mentioned in the sentence. The percent of flow method has been applied to rules for numerous rivers, but actually implementing them in water use permits to date has been much less, but that could increase as it gets applied on other water courses in the District. If there only a few permits where the percent of flow method has been applied, simply taking out the word "numerous" in the first sentence could remedy this situation, unless there are other water use permits I don't know about.

Page 15 – third paragraph, last sentence. The City of Palmetto and the community of Terra Ceia are not in the Little Manatee River watershed. Also, change "Sun City" to "Sun City Center."

Page 17. Figure 2-3. There are three other USGS gages where flow was measured as part of the DEP funded watershed study conducted by the District, which were important for demonstrating the excess flow the river was receiving in the late 1980s. The names, numbers, and period of record for (as month/year) flow at those gages are below. Note that flows were measured at the Cypress Creek gage for eleven years, which included the watershed study.

Cypress Creek nr. Wimauma, (0200530), 10/1980 to 9/1991
Dug Creek nr. Wimauma, (0200430), 10/1987 to 1/1989
Carlton Branch nr. Wimauma, (10/87 to 1/1989)

The location of these gages could be added to Figure 2-3 and mentioned in the figure caption. Lat-long information for these sites can be obtained from the USGS website, or their locations can graphically approximated from the dots at the bottom of sub-basins 6, 7, and 8 from the Flannery et al. (1999) article as shown on the next page.

If additional room is needed on page 17, Figure 2-3 could be cropped at the top without losing any critical information or the top margin of that page reduced to make more space for text.

P17 – first paragraph – no correction needed as the third sentence in this paragraph does a good extrapolation of the extent of the tidal freshwater zone of the river as described by Peebles and Flannery (1992). As discussed elsewhere in this review, this is a very important ecological zone of the river which needs to be recognized.

P 17 – first paragraph, fourth sentence - It would be helpful to point out in this sentence that the tidal water level fluctuations at US 301 are small, with added words shown here in italics as in "upstream of the US 301 bridge crossing (Fernandez 1985*), but tidal water level fluctuations at US 301 are small.* In that same regard, page 86 in the District report accurately says "with minor fluctuations extending upstream towards the US Highway 301 Bridge Crossing."

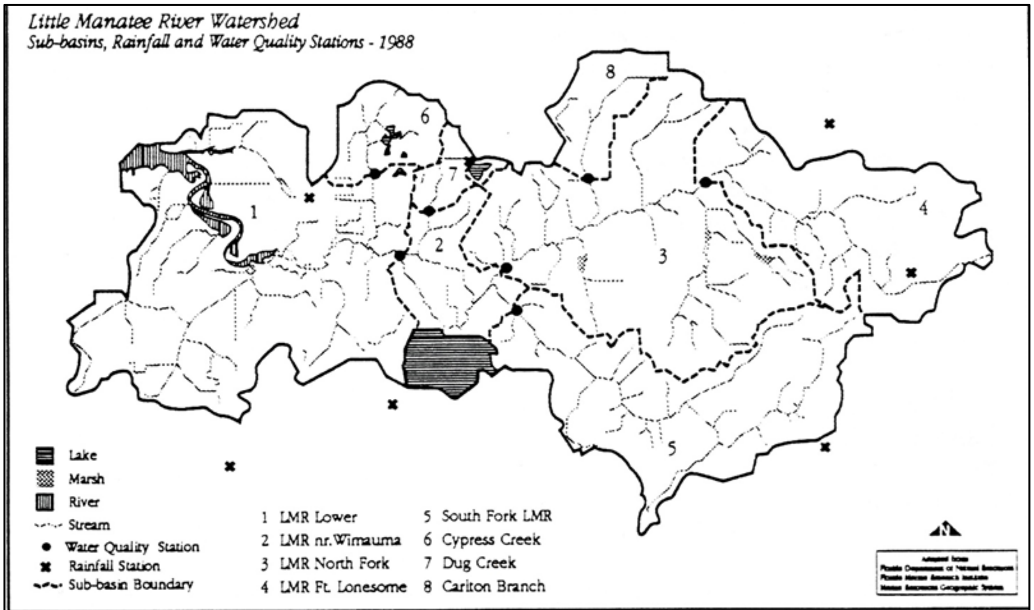


Figure 2. Subbasins, rainfall and water quality stations monitored during the first year of study.

Page 40 – first paragraph, first sentence. To clarify the use of the term "Historically", this sentence should describe the excess agricultural flows became pronounced in the mid-1970s, which was described in the Flannery et al. (1999) paper and on page 124 in the baseline flow section of the District report. The last part of the first sentence could be expanded to read "due to spring and vegetable farming, the effects of which became apparent in the flow records for the river in the mid-1970s (Flannery et al. 1991, JEI (2018b) in Appendix E)."

On a related note, the next sentence says "These practices were attributed to historical flow-field irrigation practices". Our 1991 paper did not go into that level of detail, so it might be better to just say "These practices were due *to* historical flow-field irrigation practices".

Page 42 - first sentence. The statement that "these flows decreased to zero after 2000" is not correct. As described on page 125 in the report, it could say "….beginning in 1978, but with excess flows trending toward zero after 2000 because of decreases ……………………………."

Page 42 – second paragraph - I don't believe the USGS has measured flow at the Little Manatee River at Ruskin and Little Manatee River at Shell Point near Ruskin gages, but I could be wrong. They did do some tidal discharge measurements in the lower Peace and Myakka Rivers years ago, and currently measure tidal discharge at Rowlett Park gage in the Lower Hillsborough River. District staff should check with the USGS or the consultant if there are any historical flow measurements at the two gages in the Little Manatee River mentioned above, but I doubt it. If they have not, these gages should not be mentioned in this paragraph.

This same paragraph, which references Figure 2-3, should mention the three additional gages I described for page 17, especially Cypress Creek which has 11 years of record. If extra space is needed for this wording, Figure 2-27 on this page could be reduced to a smaller size.

P65 - third paragraph Reference to this paper should also mention increased nutrient enrichment as that was a key finding of the study, which was mentioned in the title of the paper, and the sentence correctly mention increasing trends in nitrate-nitrite. The sentence could read "………..Little Manatee river indicated increasing *nutrient enrichment* and mineralization of the system………"

Page 71 There is room on page 71 to briefly mention and cite the previous studies of phytoplankton, chlorophyll *a* concentrations, and nutrients in the Little Manatee River. This will not change the conclusions of the report, but will alert readers to other valuable information for this river. Two short paragraphs are suggested below which could follow paragraph 1 and before the paragraph about dissolved oxygen that is currently paragraph 2. If additional space is needed, the top margin of this page could be reduced a bit.

"The findings of a two-year study of chlorophyll *a* concentrations, phytoplankton populations, and nutrient relationships in Lower Little Manatee River are presented in two reports by Vargo (1989; 1991) These studies found that long-term growth and biomass of phytoplankton populations in the lower river were nitrogen limited based on bioassays of natural phytoplankton populations.

The findings from the first year of the Little Manatee study were compared to data collected in the Lower Peace River and Lower Alafia Rivers, which used a similar sampling design that employed moving salinity-based stations. The Little Manatee was different that the other two rivers in that peak chlorophyll a concentrations typically occurred at the lowest salinity zone (0.5 psu), whereas the highest chlorophyll *a* concentrations typically occurred at 6 and 12 psu zones in the Lower Peace Lower Alafia Rivers (Vargo et al. 2004)."

The references for these studies are as below.

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Vargo, G.A. 1991. Phytoplankton studies in the Little Manatee River and Tampa Bay: Species Composition, Size Fractionated Chlorophyll, Primary Production, and Nitrogen Enrichment Studies. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

Page 83 – third paragraph, last sentence. Biological Oxygen Demand should be referred to as Biochemical Oxygen Demand

P84 - second sentence, last sentence Since the upper river is described in the section below this paragraph, this sentence should say "…………the benthic macroinvertebrate community of the Lower

Little Manatee River is described in Section 4.4.2, and the lower river fish and nekton community is summarized in Section 4.3.2 using data from the FWC's long-term …………"

Note that the use of "fish and nekton" is this sentence is not technically correct, as nekton includes both fish and larger free-swimming invertebrates. It is okay on this page, but as will be described for Page 104, better clarification should be presented there.

Pages 85 and 86 – The description of the Little Manatee River being estuarine up to US Highway 301 is the most misstated in this section of the report, but it can be fixed fairly easily.

It is true that the river is tidally affected up to US 301, but a described earlier in the report, a tidal freshwater zone extends about 5 to 7 kilometers below US 301, which stays fresh throughout the year. This was discussed by: (1) Peebles and Flannery (1992); (2) the supplemental analysis document I submitted to the District; and last but not least, (3) the first draft report for the lower river prepared by Janicki Environmental (JEI 2018b in Appendix E).

Also, the current draft minimum flows report briefly discusses the masters thesis by Dutterer (2006), which was oriented to a freshwater fish species (spotted sunfish) that is found in the tidal freshwater part of the river, with those stations shown in Figure 4-8 in the District report. The minimum flows report states describes that study found obligate freshwater fish in this part of the plus some estuarine fish that can penetrate into freshwater (e.g., snook).

The tidal freshwater section also has distinctly different morphological characteristics which is described in the second on page 86 which states "…… to a point where the channels converge and constrict near RKm 17, progressing to the US Highway bridge as a singular, narrow winding river channel (Figure 4-2)". Precisely, this is largely why this section of the river stays fresh.

The tidal freshwater part of the river is also clearly apparent Figure 4-2 on page 87, which shows major vegetation communities along the river channel with stream and lake swamps identified for this section of the river.

In that regard, the caption for Figure 4-2 should say "distribution of major vegetation communities along the Lower Little Manatee River". It currently says major shoreline types, but the coverages extend back from the river, vegetation communities are identified, and shoreline types (e.g., seawall) are not shown. The discussion of major shoreline types is discussed in Section 5.4.6 of the report and shown in Figure 5-18, so it is better to describe vegetation types for figure 4-2 and shoreline types for Figure 5-18.

As a result, I think it is important to adjust the language on pages 85 and 86. The first paragraph in Section 4.1.2 should say "The tidal portion of the Little Manatee River is long (15 miles or 24 km), narrow…….. and sinuous". As second sentence could read "Estuarine water (greater than 0.5 psu salinity) can extend up to near Rkm 17 in dry periods, with a tidal freshwater zone extending approximately 5 to 7 kilometers upstream to the US 301 bridge." The next sentence could say "The *tidal, largely* estuarine conditions that extends 15 miles from Tampa Bauy …………………. can be appropriately divided into ***four*** main sections based on ……………."

I can't emphasize enough how there are four, not three, sections to the river between Tampa Bay and the 301 bridge. This was discussed in detail by Peebles and Flannery (1992,) who described three zones in their study area and a fourth upstream above kilometer 16 where the river largely returns to one channel and freshwater aquatic vegetation becomes more common (the kilometer system has been revised slightly since that paper was published). This is a very important part of the lower river which needs to be identified. Again, since it is tidally affected, identification of this zone does not contradict the delineation of the upper and lower sections of river at US 301. This correction to the sections of the river can easily be fixed on page 86. Substitute these two paragraphs, the first of which tracks the original text, for the second paragraph on page 86.

"The third section of the Lower Little Manatee River extends upstream from the Interstate 75 bridge, where the river begins a series of braided but well defined channels snaking across the landscape to a point near Rkm 17, where the channel converge to single, narrow winding channel that extends further upstream. Vegetation in this braided section of the river is characterized by brackish oligohaline marshes that contain some scattered black needlerush mixed with stands of freshwater plants that are tolerant of low salinity, such as cattails *(Typha* sp.), giant leather fern (*Acrostichum danaeifolium*), and sawgrass (*Cladium jamaicense*) and interspersed mixed wetland forest. Tidal water level fluctuations are pronounced up to where the braided channels constrict, with minor fluctuations extending upstream towards the US Highway 301 bridge crossing."

"An inventory of plant species found in this and other sections of the Lower Little Manatee River was presented by Clewell et al. (2002), who sampled plant species composition at 78 sites adjacent to the lower river channel between RKms 4.6 and 17.2. That report also contains maps of the areal coverage of major vegetation communities along the lower river prepared by the Florida Marine Research Institute (1997), based on detailed interpretation of aerial photography from 1990 accompanied by subsequent ground truthing and plant identification at the river."

Note – As described in previous correspondence, I don't see where the vegetation in this part of the river was discussed by Hood et al. (2011 in Appendix A). The reference to Figure 4-2 in this report in the first paragraph on page 86 is erroneous, so all references to this report on page 86 should be removed. Alternately, the references to Clewell et al (2002) and FMRI (1997) should be cited, as these District funded studies included detailed information for the Lower Little Manatee that should be referenced. The FMRI study maps show coverage of the plant species communities (cattail, sawgrass) that are mentioned by the District on pages 86 and 133.

In that same regard, it is much more accurate and informative to describe the marshes above I-75 as oligohaline or brackish marshes that occur in low salinity areas. Such marshes and the aforementioned plant species that are common in them are identified on page 86 and again on page 133 of the District report where the study by Clewell et al. (2002) is discussed. The term saltmarshes typically applies to marshes in somewhat higher salinity zones, which are typically dominated by black needlerush in our part of the state, which the report accurately describes for the section of the river between US 41 and Interstate 75 on page 85. However, the term saltmarsh is improperly used in the second paragraph on page 86, so my suggested text uses brackish oligohaline marshes instead.

The map of vegetative communities on page 87 that uses the FLUCCS codes shows the same saltmarsh coverage for the marshes both downstream and upstream of I-75. This is very misleading as these are different types of marshes. That map should stay in the report, but the text of the report should be more clear regarding the different composition of these marshes, which upstream of I-75 it does. Also, as suggested in my edits, it should also quickly reference the FMRI (1997) study, as it was a detailed effort that showed informative maps of this section of the river. The reference for the FMRI study is below.

Florida Marine Research Institute. 1997. Development of GIS-based vegetation maps for the tidal reaches of five gulf coastal rivers. Report prepared by the Florida Department of Environmental Protection for the Southwest Florida Water Management District, Brooksville, FL.

The tidal freshwater part of the river that occurs in the previously defined single channel can quickly characterized on page 86 by breaking the second paragraph into three short paragraphs. As discussed on the previous page, start the first of these paragraphs with “The third section of the Lower Little Manatee extends upstream from the I-75 bridge…”. Again, as previously described, follow this paragraph with a short paragraph concerning the Clewell et al. (2002) and FRMI (1997) studies.

Then start a new paragraph as below, which much better captures the true character of the river upstream of RKm 17 and agrees with the maps shown in Figure 4-22 on page 87.

“The fourth, most upstream segment of the Lower Little Manatee River extends upstream from near Rkm 17, where the river becomes confined to a single channel. Estuarine water (> 0.5 psu salinity) rarely penetrates above this point, resulting in tidal freshwater zone that extends upstream to the US 301 bridge crossing. Shoreline vegetation communities along this most upstream section of the lower river are largely stream and lake swamps with some upland forests on bluffs that occur along the river (Figure 4-2). Some freshwater aquatic plants such as spatterdock (*Nuphar luteum)* and water pennywort (*Hydrocotyle umbellata)* also are common in the channel in this section of the river.”

This last sentence in this suggested paragraph is valuable, but could be dropped if a lack of space on page 86 is an issue. However, to save space, Figure 4-1 could be cropped at the top with no loss of important information. Also, the margins on pages 85 and 86 could be adjusted to accommodate more text. A photograph of this section of the river is below.

Page 88 – third paragraph, fourth sentence - This sentence should be edited to say "Selected information from these studies of benthic macroinvertebrates in the lower river is summarized in Section 4.2.2" as the information directly below that paragraph is for the upper freshwater part of the river.

Page 104. Nekton refers to free-swimming organisms not carried by currents that include fishes and larger free-swimming invertebrates such as blue crab and pink shrimp. Accordingly, the term nekton is typically used by FWC and others to refer to all of these organisms. As such, the use Fish and Nekton in the heading for Section 4-3 and is technically incorrect, but is more problematic in the second sentence under heading 4.3 that reads "The fish (and nekton, e.g., crabs, shrimp) community of the Lower Little Manatee River" which implies that the nekton is comprised only of invertebrates.

I realize the District wants to emphasize fish, and many readers won't immediately know what nekton means, but this terminology issue could be quickly clarified. The title for Section 4.3 could read "Fish and other Nekton". The second sentence could read "The fish and larger free-swimming invertebrates (e.g., crabs, shrimp) that comprise the nekton community of the Lower Little Manatee River is well characterized as a result ………………"

Page 109 – first paragraph - No change needed, but want again to point out the discussion of the study by Dutterer (2006) on this page supports the identification of the upper portion of the Lower Little Manatee River as a distinct tidal freshwater zone as previously discussed for pages 85 and 86.

Pages 114 and 115 – Table 4-8 is a case where the margins of page 114 could be adjusted to get the entire table on one page.

Page 119 - Again modify page margins to get all of Table 4-10 on one page. As with some other tables, the fonts or spacing in the headings for Table 4-10 could be adjusted to not have words broken between lines of text (e.g., Capture, Abundance)

Page 123 or 124 - Somewhere on either of these two pages the new Appendix that contains the other plots the District examined to develop the flow blocks for the lower river should be referenced in the text of the report.

Pages 156 end of first paragraph just above Table 5-6. – The report should also reference the new Appendix that contains the sensitivity analysis of the EFDC model the District conducted to address the peer review comments, as I believe the District has prepared a new Appendix that presents those results.

Page 158 – first sentence The initials for EFF shous be defined here as "The Estuarine Favorability Function (EFF) analysis………." It is defined only once in the report on page 134, but that was 24 pages back and it needs to be repeated on page 158 for clarity.

Page 161 last sentence - I have looked that EPC data for station 113 and it is very likely the three data points that show "oligohaline to low-mesohaline salinities" at this stations are highly questionable. Among the 564 observations I have for that station, there are three with salinity values of 5.1, 13.3, and 14.7 psu recorded in September or October of 1980 and March of 1998 (35 to 43 years ago!).

This station is fresh water and these more likely are erroneous data entries, for if these three resulted from storm tides, they would have flooded half of downtown Tampa. Possibly there could have been sort of point source release, but that is equally implausible.

It is okay to acknowledge the presence of these three high values, but it should be more qualified rather than indicating the oligohaline or low mesohaline salinity can occur at this station. Alternate language in the last sentence could read "…at the US Highway 301 bridge. There were three data points that showed oligo- to low-mesohaline salinities occurred at this station in 1980 and 1988, but these could be erroneous data." BTW- this was discussed in more detail in the first draft report for the lower River (JEI 2018b, in Appendix E)

Page 180 -third paragraph One of the most important clarifications needed in the report is the analytical method by which net percent changes in both salinity zones and favorable fish habitats were calculated within a flow block for each flow reduction scenario. As described in previous correspondence, JEI used the Normalized Area Under the Curve (NAUC) method to calculate net percent changes in predicted model values within blocks in other District minimum flows reports (e.g., see description in Lower Myakka report).

There are different ways to calculate net percent differences in predicted model values within a flow block for a specific flow reduction scenario, so whatever method they used needs to be mentioned in this section, which should not take more than one or two sentences. If space is needed, the top margin of page 180 could be adjusted to keep the pagination the same.

Page 183 – first sentence The changes in percent reduction in salinity zone habitats between two flow scenarios in five percent increments may not be a linear relationship. In other words, the percent change in a salinity zone between a 10 and 11 percent flow reduction may not be the same as the percent reduction between 14 and 15 percent flow reduction. Thus, the word "exact" in the first sentence should be dropped so the sentence reads "……………..can be interpolated to *calculate* the percentage of flow reduction from baseline conditions that would result in the 15 percent reduction of salinity habitats………."

Page 185 - No changes needed here, but in keeping with the comment for pages 2 and 3, as described on page 185, the EFF modeling analysis predicts changes favorable habitats, not available habitats

Page 186 - The presentation of percent changes in favorable habitats predicted by EFF models in Tables 6-6 through 6-8 were for flow reduction scenarios in five percent increments. However, the results presented in Table 6-9 are for values that were interpolated from the results in Table 6-6 to 6-8. As such, the interpolation step needs to be mentioned in the discussion of the values presented in Table 6-9.

December 4, 2023 ***(has corrections and clarifications to a version submitted on Nov. 28, 2023)***

TO: SWFWMD staff associated with the draft minimum flows report for the Little Manatee River

FROM: Sid Flannery, retired, formerly Chief Environmental Scientist with the SWFWMD minimum flows program

SUBJECT: Recent change in the boundary for the determination of minimum flows for the upper and lower sections of the Little Manatee River

Summary

Around November 20th or so, I noticed that a revised final draft minimum flows report for the Little Manatee River (dated November 2023) had been posted by the District that changed the boundary for the establishment of minimum flow rules for the upper and lower sections of the Little Manatee River. This move shifted the boundary downstream about eight kilometers (approximately five miles) from the US 301 bridge to the location of a water quality station monitored by the Environmental Protection Commission of Hillsborough County (EPCHC) near kilometer 16.4. This is a major shift in technical approach, as several previous draft reports published over a considerable length of time, the most recent in August 2023, used the 301 bridge as the boundary between the upper and lower sections of the river.

Moving the boundary to, or preferably slightly upstream of, the location of the EPCHC station at kilometer 16.4 may be temporarily desirable as it is apparently oriented to providing more conservative protection of riverine forests in what is predominantly the tidal freshwater section of the river. However, some revisions to the minimum flows report are needed to technically support, or at least not contradict, this change in the boundary between the upper and lower river.

Also, if a revised boundary between the upper and lower river is kept in the report and adopted in rule, the minimum flows for the Lower Little Manatee River should be re-evaluated as soon as practical with the limited purpose of modeling and assessing of the inundation requirements of riverine wetlands in the tidal freshwater reach of the river, as they are probably not as sensitive to the effects of flow reductions as much as the wetlands upstream of US 301, on which the proposed minimum flows for the upper river are based during the high flow block.

In the meantime, if this revised boundary is as adopted as part of minimum flow rules for the Little Manatee River, some flexibility should be applied as to which set of rules (upper or lower) should be applied to a new withdrawal from the river depending on its location in the section of the river between US 301 and the EPCHC station at kilometer 16.4. I have never advocated for moving the boundary between the upper and lower river away from US 301, and still think it may not be necessary depending on where a new intake might be located.

The schedule for adoption of minimum flows for the Little Manatee River calls for adoption in 2023. However, the next Governing Board meeting is very soon on December 12th. If consideration of these factors and the needed revisions to report can be accomplished before then, possibly the adoption of the rule in 2023 can be achieved. However, if postponement of the adoption of the minimum flow rule for the Little Manatee River to January 2024 or a subsequent month is needed, that should be pursued as it poses no real problem for regulatory or water supply planning in the region.

Better characterization is needed of the salinity characteristics of the lower river to support the movement of the boundary between the upper and lower river

The upstream extent of brackish water in a tidal river in the dry season is a primary factor to be considered in determining separate minimum flow rules for the freshwater reaches of creeks and rivers versus their downstream tidal estuarine reaches. In that regard, the upstream extent of brackish water in the Little Manatee River in the dry season needs more elaboration and clarification, as the minimum flows report is either unclear or misleading in few places, which is problematic for justifying a revised boundary for separating the upper and low sections of the river.

The District recently chose the location of EPCHC water quality station 1616 near kilometer 16.4 to delineate the boundary between the upper and lower river, but no salinity data for this station are clearly presented in the report. The EPCHC has measured *in situ* water quality profiles (e.g., salinity, temperature, dissolved oxygen, pH) at 16 stations in the river on over 200 dates during two separate periods ranging from 2000 to 2006 and from 2009 to present. The draft report for the lower river that was prepared in 2018 (JEI, 2018 included as Appendix E to the report) showed a map of these stations and discussed that data from them was used to develop the empirical salinity model of the river used in the EFF fish habitat modeling.

Although this extensive and important data base was readily available, other than two figures of salinity zones predicted by the EFDC model, two plots of predicted and observed salinity values using empirical models, and two contour plots of observed and LOESS regression predicted values vs. flow, the only other salinity data shown for the lower river in the recent minimum flows report is a box plot of salinity at four EPCHC stations where they also measure full water quality, including nutrients. The downstream and upstream extents of these four water quality stations are near kilometers 1.8 and 13.8, respectively. It is therefore important to show salinity data outside this geographic range, especially when the District is proposing a boundary between the lower and upper river at kilometer 16.4. Also, when an agency such as the EPCHC spends so much time and effort collecting such data, it would be valuable to present it in the minimum flows report as it is critical to understanding the salinity characteristics of the Lower Little Manatee River.

Three months after the second draft minimum flows report for the Little Manatee was published in September 2021, I submitted to the District a Supplemental Analyses report (SA report) I prepared that summarized additional data for the river (Flannery 2021). The SA report recommended that data from all the EPCHC vertical profile stations should be presented in the report, and presented a box plot of mean water column salinity at the 16 EPCHC vertical profile stations, which is reprinted on the following page, with the figure number and legend reprinted from that report.

Text continued on the next page

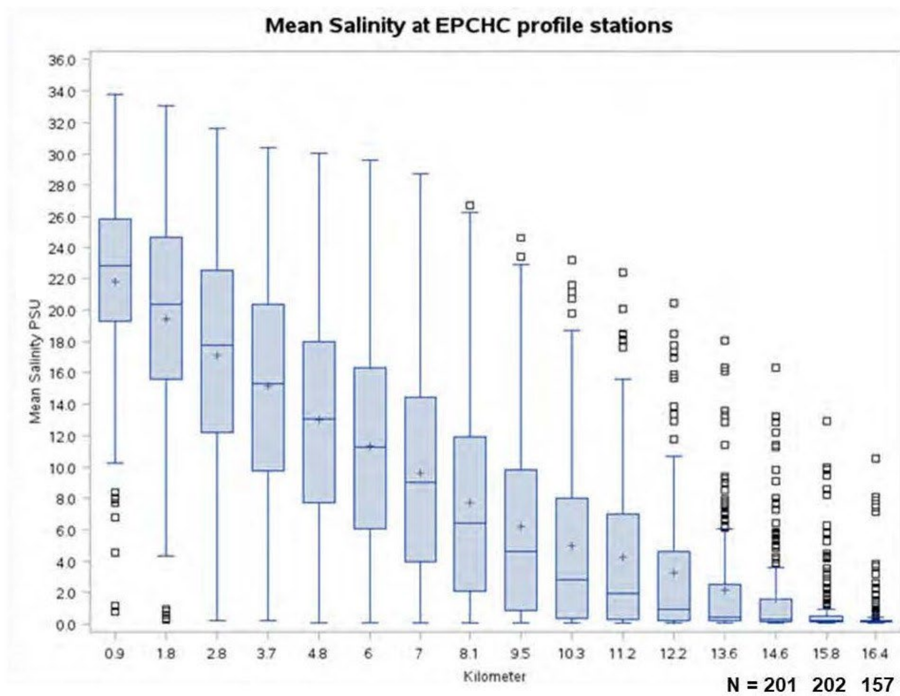


Figure 17. Box plot of mean water column salinity values at EPCHC vertical profile stations. The + symbols are means, the horizontal lines the medians, with the whiskers extending to 1.5 times the inter-quartile range. Outliers are shown for above the whiskers, but not below as freshwater outliers (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

This box plot shows that the median and mean salinity at kilometer 16.4, which is Station 1616, are near zero, but mean water column salinity values between 7.2 and 10.6 psu occurred on five sampling dates, with salinity between 1 and 3.9 psu occurring on 13 other dates. Clearly, brackish water can migrate to this section of the river during prolonged dry periods. Thus, based on salinity characteristics, the revised boundary between the upper and lower sections of the river can occurs in what is sometimes the oligohaline and even the low-mesohaline section of the river. As stated in my SA report, I again suggest that a discussion of the EPHC vertical profile stations be presented in minimum flows report, including a box plot of salinity at all the EPCHC vertical profile stations similar to the one shown above.

Salinity data in the lower river were also collected by the District on 59 dates during two separate two time periods in the mid to late 1980s. This program involved taking a vertical profile measurement at or near the location of 0.5 psu salinity value in the river on each sampling day. During these two sampling periods the location of 0.5 psu salinity ranged from the mouth of the river during a major flood in September 1988 to near kilometer 18.6 at the end of the spring dry season in 1985, 1988, and 1989. A box plot of the data from the District sampling program was also presented in the SA report, but it stated the EPCHC data should be emphasized due to its extensive spatial distribution which is still ongoing.

The SA report also showed informative plots of mean water column salinity values at stations upstream of kilometer 16.4 on days when sampling by either the EPCHC or the District went farther upstream during very dry periods. A figure from the SA report is reprinted below using the figure number and legend in that report. These show that brackish water (>0.5 psu salinity) does not typically extend upstream of kilometer 17 to 18 during low flows, but can reach near kilometer 18.6 at the end of the dry season, which is similar to the conclusions of other researchers (Fernandez 1985, Peebles and Flannery 1992, JEI 2018).

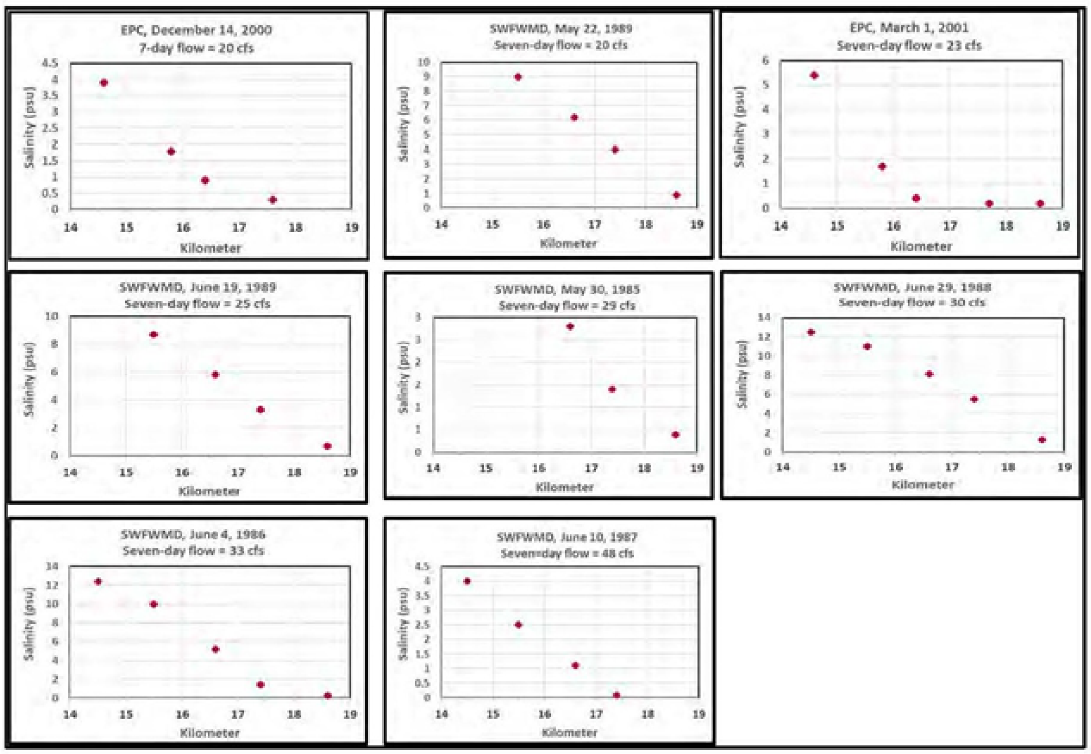


Figure 19. Mean water column salinity at upper stations in the lower river when sampling extended upstream of kilometer 16.6 by either the EPCHC or the District. The preceding seven-day average flow for each sampling date is listed on graphs.

I reiterate that the upstream penetration of brackish water in the dry season is a fundamental parameter that should be used to establish boundaries for minimum flow rules for freshwater vs. tidal estuarine sections of rivers, as they are fundamentally different types of ecosystems. Given the relationships shown the in two figures reprinted from the SA report, it would make more sense to the move the upper/lower river boundary to near kilometer 18 or 19, as it better represents the downstream extent of the tidal freshwater reach of the river during prolonged dry periods, rather than kilometer 16.4.

However, even though I repeatedly informed the District here is tidal freshwater zone below US 301, I have never suggested that moving the boundary between the upper and lower river away from US 301 is necessary. As will be discussed in later sections, I think that still may be the case, but appreciate that the District is trying to be cautious with the zone of the river immediately downstream of US 301. As will be discussed further, if the boundary is moved, the minimum flows for the lower river should be re-evaluated with a limited focus as soon as practical. Secondly, some flexibility should be applied in the near term on which rules (upper or lower) should be applied to a new withdrawal depending on the location of the intake below US 301.

As related to a suitable location for a upper/lower river boundary, the morphology of the river has a tidally affected loop attached to the river channel near kilometer 17.2 (see figure below adapted from the November 2023 draft minimum flows report). If the boundary between the upper and lower river is to be moved downstream from US 301, it would be best to keep the boundary upstream of that morphological feature as the river is largely confined to a narrow single channel upstream from there. Also, a water level recorder was operated by the USGS near kilometer 17.2 from October 2004 to August 2006. As will be discussed on page 8, water level relationships with flow are fundamentally different there than at US 301, and there is no physical or hydraulic reason to extend the boundary between the upper and lower river any further downstream than kilometer 18 or 19.

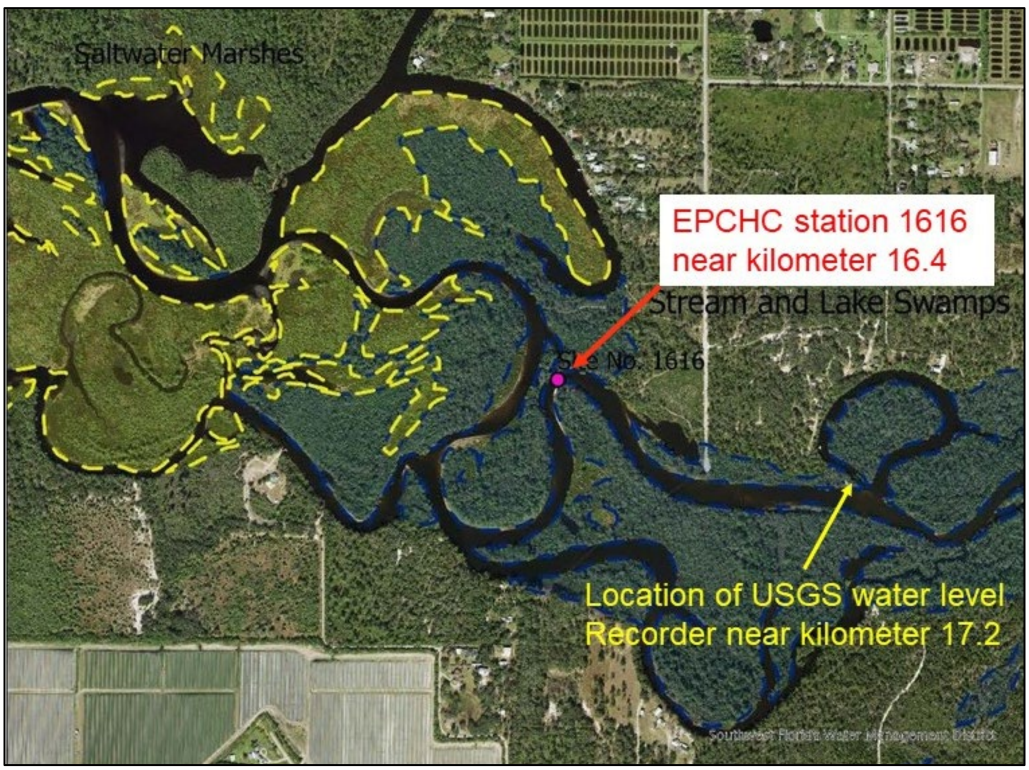


Figure above adapted from Figure 6-23 in the minimum flows report, adding the location of a tidal loop attached to the channel and a previous USGS water level recorder near kilometer 17.2. The yellow line (placed by the District) denotes saltwater marsh shorelines according to the FLUCCS system while the blue line (which is hard to see) designates stream and lake swamps, bottomlands by FLUCCS.

There are other sections of the minimum flows report where the text needs to be revised to better reflect the salinity characteristics of the lower river and better support moving the upper/lower river boundary downstream from US 301. At present, some of the text seems to contradict the rationale for moving the boundary downstream from US 301.

On October 31, 2023, I sent a series of editorial changes to the District I suggested be incorporated to make the text more clear without changing the findings or conclusions of the report. Those edits were based on the August 2023 draft, which had the upper/lower boundary at US 301, and they are more critical now that the District is proposing to move the upper/lower boundary eight kilometers downstream.

The first important edit in that regard is in the last sentence on page 161 in the November 2023 draft that states "salinities were nearly exclusively near zero at the US Highway 301 bridge, although three data points existed which showed oligo- to low-mesohaline salinities may be possible at this station." This is misleading, for there is clear evidence that these three salinity values, which were recorded by the EPCHC in 1980 and 1988, are erroneous. In the first draft report for the lower river (JEI 2018), the authors described that these values "appear anomalous" or are "potential anomalous". However, this important characterization was omitted in more recent drafts of the minimum flows reports.

I have accessed specific conductance data from the river at this same site from the USGS website for 1980 and from the District study in 1988 that show that no salinity values anywhere near the very high EPCHC values occurred in the river near those dates (salinity is calculated from specific conductance). There is also no evidence that very high storm tides affected salinity at US 301 on those dates. I sent the District the data I based this conclusion on, and maintain that the statement that oligo- or low-mesohaline salinities may be possible at US 301 should be removed from the minimum flows report or be highly qualified, as it is based on erroneous or anomalous values.

This is case of the text in the current draft technically contradicting the movement of the upper/lower river boundary downstream to kilometer 16.4. Do you really want to suggest that you are moving the boundary eight kilometers downstream from US 301 when oligo- to low-mesohaline salinities may be possible at US 301. Again, removal or qualifying reference to the clearly erroneous three salinity values at US 301 is in order.

There is another section of the report that is contradictory to the concept of moving the upper/lower river boundary downstream to kilometer 16.4. Even before this shift was proposed, my editorial comments suggested this section of the report be revised as it mischaracterizes the river between Interstate-75 and the 301 bridge. The report does a decent job of characterizing two zones of the river between the mouth and I-75, but then says there is one ecological zone of the lower river between I-75 and US 301. I pointed out this is false, as the river changes from a distinct, braided estuarine zone with abundant oligohaline marshes to a single channel with tidal freshwater wetlands around kilometer 17.

If you want to establish a boundary between the upper and lower river at kilometer 16.4, do you want to erroneously claim that the river between I-75 (near kilometer 12) and US 301 (near kilometer 24.5) is one ecological zone. I provided some fairly simple text to the District to describe that there two distinct ecological zones between I-75 and US 301, which at this time would go along with supporting a boundary somewhere in the range between kilometer 16.4 and kilometer 18 or 19. However, that language has not yet been incorporated in the report.

I also submitted a number of other editorial changes to the District that are technically correct and valuable, which I suggest they incorporate in the next version of the minimum flows report.

The recent emphasis on tidal freshwater wetlands for delineation of the upper and lower river

The inundation of riverine wetlands is a primary factor the District has used to assess minimum flows for non-tidal freshwater rivers, such as the upper reaches of the Alafia, Peace, and Myakka Rivers. Tidal freshwater biological communities, including riverine wetlands, can also occur in areas that remain fresh but where water levels and current velocities are affected by tides.

The justification for moving the boundary for the upper and lower river appears solely in one paragraph on page 191 in the November 2023 draft report. From this paragraph, it appears the District has chosen to move the boundary between the upper and lower river farther downstream primarily to better protect tidal freshwater forests that extend between US 301 and kilometer 16.4.

This is supported by Figure 6-23 on page 192 in the most recent draft report, which shows the delineation between FLUCCS codes that show a shift from "stream and lake swamps, bottomlands" to "saltwater marshes" near kilometer 16.4, where the EPCHC has a water quality monitoring station that the District has chosen to delineate the upper and lower sections river (see figure on page 5 of this memorandum).

The switch in vegetation communities in the tidal section of the Little Manatee river has been documented for quite some time, as the report by Fernandez (1985) described vegetation gradients in the river in relation to salinity. Peebles and Flannery (1992) also described such gradients in salinity and vegetation, including a tidal freshwater zone upstream of kilometer 16 to 18. A thorough study of vegetation communities in the tidal reach of the Little Manatee was conducted by the Florida Marine Research Institute (1997), which showed a transition just upstream of I-75 from saltmarshes dominated by black needlerush (*Juncus roemerianus*) to oligohaline marshes dominated by freshwater plants such as cattails (*Typha* sp.) and sawgrass (*Cladium jamaicense*) that are tolerant of low salinity.

The maps presented in the FMRI study support the transition from marshes to tidal freshwater forests near the boundary proposed by the District, but the oligohaline marshes near that transition point are not well characterized by the general saltwater marsh label used in the FLUCCS codes shown in Figure 6-23 in the minimum flows report. I have repeatedly expressed to the District that they should at least cite the FMRI (1997) study in their minimum flows report, but that has not yet happened.

It is commendable that the District wants to protect the riverine forests associated with the tidal freshwater section of the Little Manatee River. However, as will be described on page 8, water level relationships to flow can be considerably different over relatively short distances between non-tidal and tidal freshwater reaches of a river. In a recent report for the Lower Peace River, the District (2021) modeled and evaluated the inundation of freshwater forests associated along the tidal freshwater reach of that river.

However, no similar modeling or assessment of changes in the inundation of tidal freshwater wetlands are presented in the most recent draft report for the Little Manatee. I have suggested that that it could be temporarily okay to move the boundary for the upper and lower river to, or preferably slightly upstream of, the recently proposed boundary near river kilometer 16.4. However, this should be subject to further analyses in a limited re-evaluation of minimum flows for the lower river as soon as practical,

with the focus on the inundation relationships of tidal freshwater wetlands between this boundary and US 301.

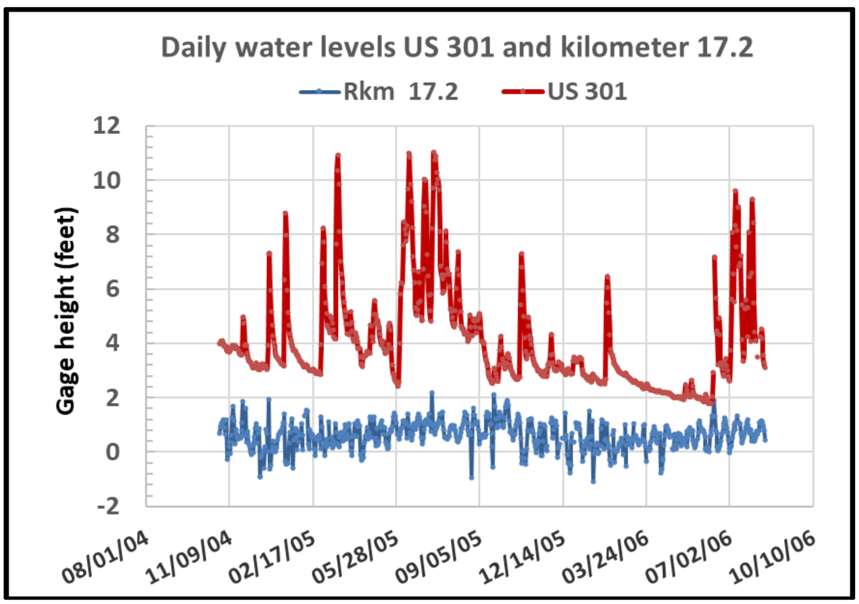
As will also be further discussed, some flexibility should be applied as to which minimum flows rules should apply (upper or lower river) in the evaluation of any new water withdrawal sites that are being considered from near US 301 to several kilometers farther downstream.

Water level relationships with flow in tidal freshwater systems

It is commendable that the District wants be conservative and move the upper/lower river boundary to kilometer 16.4 to better protect the riverine forests between US 301 and that location, as the allowable flow reductions for the upper river at high flows are much less than for the lower river.

However, all the data collection to examine the inundation of riverine wetlands presented in the minimum flows report is upstream of US 301, and the relationships of water levels to flow will change dramatically the farther you go downstream of US 301.

As previously mentioned, the USGS operated a water level recorder the Little Manatee River near Ruskin gage (# 02300532) between October 2004 and August 2006 as part of the development of the EFDC hydrodynamic model of the river. That recorder was located near kilometer 17.2 (see figure on page 5). A plot of water levels at this location and the US 301 gage is below, with the caveat the values for 301 are mean daily values while the data for kilometer 17.2 are maximum water levels each day, as only daily minimum and maximum values were readily available at the time of this writing. Although not shown, there is considerable tidal variation in water levels at this site with a mean diurnal tide range of 2.0 feet, while diurnal tidal water level fluctuations at US 301 are typically less than one or two inches.



The response of water levels to variations in flow are much less at kilometer 17.2 than at US 301, as maximum daily water levels differed by 3.2 feet at km 17.2, while daily mean levels differed by over nine feet at US 301. It is again reiterated that the inundation results that were used to develop the minimum flows for the upper river were all above US 301. Clearly, these findings would not be applicable to the river at kilometer 17.2, but could possibly be more applicable to sites that are closer to US 301.

If the District wants to develop minimum flows that are appropriate for the tidal freshwater wetlands downstream of US 301, it should do additional topographic surveys in these wetlands and compare then to modeled surface water elevations at different points between US 301 and various locations farther downriver.   The minimum flows report indicates that the grid for the EFDC model extends up to US 301, but I do not know to what extent if can accurate simulate water levels in the upper part of the lower river or whether another model should be used.

The District did model simulations for the inundations of tidal freshwater wetlands as part of the Lower Peace River minimum flows analysis (SWFWMD 2021). That study found the allowable percent flow reductions based on the inundation of riverine wetlands in the tidal freshwater reach of the river the river were much greater than the allowable percent flow reductions that were determined for the non-tidal part of the river between Zolfo Springs and Arcadia, which were evaluated as part of a separate minimum flows study (SWFWMD 2005).

Need to need to re-evaluate the minimum flows for the lower river as soon as practical if the revised boundary for the upper and lower river is adopted.

Similar to the Lower Peace River, I think it is likely that the modeling of inundation of tidal freshwater wetlands downstream of US 301 on the Little Manatee will also show less sensitivity to flow reductions than wetlands upstream upstream of US 301, with reduced sensitivity most likely at sites father below US 301.

As such, if the new boundary for the upper and lower boundary is adopted, it will be necessary to re-evaluate how far down downstream from US 301 the minimum flows for the upper river should apply.   I think that if that is the case, it may be for a fairly small section of the river below US 301.

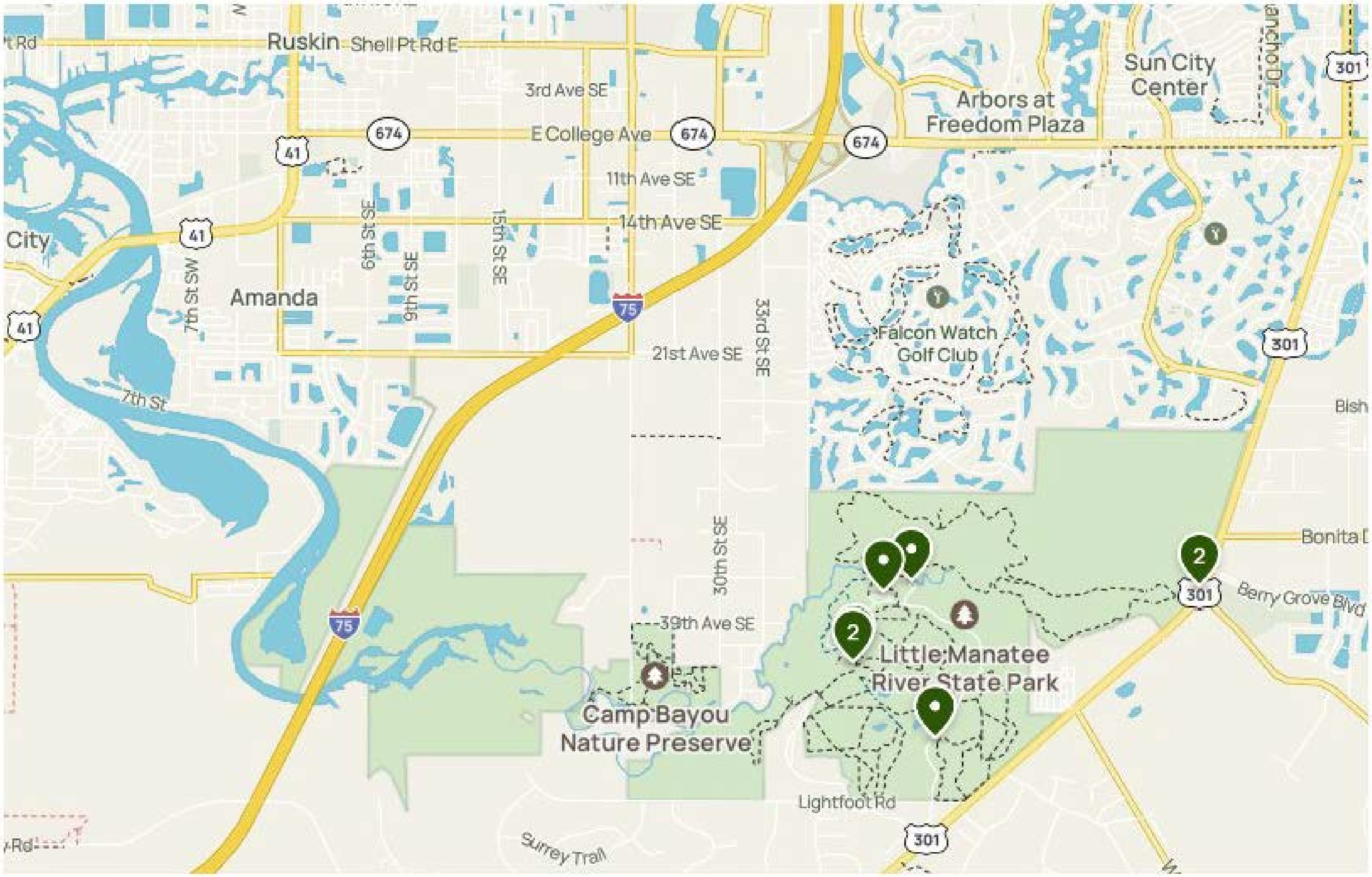
The scope of work for such a re-evaluation of the boundary between the upper and lower river could be limited and focus solely on the modeling and assessment of the inundation of tidal freshwater wetlands between US 301 and kilometer 16.4, as apparently that is what caused the District to move the boundary between the upper and lower river. Such a re-evaluation should be pursued as soon as practical to facilitate water supply planning in the region. Again, if the boundary is moved in the near term prior to a re-evaluation, I think that a location near kilometer 18 or 19 is more justifiable than at kilometer 16.4.

Flexibility for the application of minimum flows for the upper or lower river depending on the location of the intake for a proposed withdrawal

Some flexibility should also be applied to whether the rules for the upper or lower river should be applied depending on where the intake for a withdrawal is located. The placement of an intake site downstream of US 301 must consider several important factors, including the occurrence of ecologically valuable public lands, which are generally shown in a map on the following page.

Depending on where an intake is located below US 301, the amount of tidal freshwater wetlands that may be significantly affected may be very small and the minimum flows for the lower river could be applied there with no significant harm to the ecosystem. As such, a number of factors should be evaluated to determine if the minimum flows for the upper or lower river should be applied depending on the location of a proposed intake within several kilometers downstream of US 301.

Unconfirmed location of pubic owned lands along the Little Manatee River between the US Highway 301 bridge and lands along the north bank of the river downstream of Interstate 75. This was taken from an All Trails website, but I know that the Little Manatee River State Park extends a good way downstream of US 301. Also, I believe Hillsborough County ELAPP owns the lands shown closer to Interstate 75.



Procedures for notifying the independent review panel, advisory committees, and interested stakeholders of the change in the upper/lower river boundary location

As with all minimum flows reports published by the District, the minimum flows report was subject to technical review by an independent review panel, which for the Little Manatee was comprised of three experts in the fields of aquatic ecology, freshwater hydrology and modeling, and estuarine hydrodynamic modeling. The panel first reviewed the draft report published in September 2021 and then the revised report published in June 2023. The panel then held two sets of meetings after the publishing of each of those reports, in which they interacted with District staff and heard comments from the public.

The two draft reports the panel reviewed had the boundary between the upper and lower river established at the US 301 bridge. As previously mentioned, the movement of the upper/lower river boundary was not in a draft minimum flows report until the November 2023 draft. I believe the contract for the review panel expired in August, and do not know if the District has informed the panel that a new draft report has been published that moved that boundary between the upper and lower river sections of the river.

There was also considerable interest in the draft reports published by the District from the public, representatives of public agencies, and staff from the University of South Florida who virtually attended some of the peer review panel meetings. To my knowledge, none of these individuals were made aware that a new draft report for the lower river was published in November that shifted the boundary between the upper and lower sections of the river. In late November, however, I have notified a few individuals that the most recent draft was available from the District website and that it changed the upper/lower river boundary.

Based on the draft report published in August 2023, the District has also presented the findings of the minimum flows work on the Little Manatee at a public workshop and to the District's Public Supply Advisory and Environmental Advisory Committees, the later of which I serve on. I do not believe that any of these groups have been made aware that a more recent version of the draft report has been published that moved the boundary between the upper and sections of the river.

The location of the boundary between the upper and lower river is one of the most important components of a minimum flows analysis, as it affects how much water is available for supply from different sections of a river. It also has important ecological implications, as non-tidal freshwater reaches and tidal estuarine reaches of creeks and rivers are different types of ecosystems. As such, the hydraulic, water quality, and ecological analyses that determine where the boundary between the upper and lower section of a river is located should be thorough and well described in a minimum flows report.

It may not be standard procedure, but as a professional courtesy the District should consider notifying the peer review panel, the Public Advisory and Environmental Advisory Committees, and key people who attended either the public workshop or the peer review panel meetings that a new draft minimum flows report for the Little Manatee River has been published that proposes moving the location of the boundary between the upper and lower sections of the river from the US 301 bridge to near river kilometer 16.4.

Schedule for the adoption of minimum flows for the Little Manatee River

The yearly minimum flows schedule the District submits to the Florida Department of Environmental Protection calls for minimum flows for the Little Manatee River to be adopted in 2023. The District is intending to present the draft November 2023 report and the minimum flow rules proposed in it to the Governing Board at their December 12, 2023 meeting, which is about two weeks from when I submitted the first version of this technical memorandum to the District. Again, I was not aware that a revised minimum flows report that changed the boundary between the upper and lower river had been published until around November 20th.

Given the important implications that the movement of the upper/lower river boundary has for water supply planning and protection of the natural resources of the Little Manatee River, the District should consider moving the adoption of minimum flows to the January 2024 Board meeting, or a subsequent month soon thereafter, if necessary.

As previously discussed, given that this important change in the proposed minimum flow rule was applied so recently, the District should consider notifying the peer review panel, two advisory committees, and key members of local agencies and the public of this change prior to rule adoption, which could take a couple of weeks.

Also, in this memorandum I have presented some technical material that should be added or revised in the minimum flows report to better justify, and not technically contradict, the need to move the upper/lower river boundary from US 301 to a downstream location. I have also raised technical points that the minimum flows for the lower river should be re-evaluated as soon as possible in a limited, focused analysis to examine the inundation characteristics of tidal freshwater wetlands downstream of the US 301 bridge. Similarly, some flexibility should be applied to any new proposed withdrawals downstream of US 301 depending on the location of the intake for that withdrawal. If the minimum flows are presented to the December Governing Board meeting, I may attend and discuss these points as part of the public comments.

Possibly the District could address all concerns related to the change in the boundary between the upper and lower river in the next week and adopt minimum flows for the Little Manatee River at their December 12th meeting, if that is their intention. However, if it is necessary to take a bit more time to address all technical and notification factors related to moving the boundary for the upper and lower sections of the river, the District could postpone presenting the minimum flows for the Little Mantee until January, 2024, or a month soon thereafter, as this should leave enough time to address all related factors.

I realize the District likes to keep to their schedule for minimum flows adoption, but for technical and logistical reasons the District sometimes postpones the adoption of minimum flows for a river by a year or more. In the case of the Little Manatee, we are talking about a month or two. This should pose not real delays or problems for water supply plans or natural resource protections strategies in the region. Given the late date at which this important change in the minimum flows was published, such a small postponement for the adoption of the minimum flows for the Little Manatee River would be warranted and beneficial to water supply planning and the protection of the natural resources in the region.

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