From: Angel Martin
To: Kristina Deak
Subject: Upper Peace River Peer Review Kickoff Proposed Minimum Flows-Jan. 16, 2026
Date: Friday, January 16, 2026 1:16:44 PM

Concerning the subject Upper Peace River proposed minimum flows kickoff meeting, the following summarize my comments.

1. Some additional explanation is needed concerning the selection of the three index gaging stations. Are the period of available flow and stage record the same for all three stations? It appears that the USGS has changed and modified the technology for measuring streamflow during the period of record. This record should be examined in order to determine and appreciable changes in the record and whether the record from each gaging station can be directly compared or whether any adjustments need to be considered.
2. One of the items discussed near the end of the presentation concerned the "Monitoring Network". Some discussion is needed concerning the possible addition and/or modifications to the present network. For example, would additional streamflow or stage stations be needed for determination/verification of proposed minimum flows.
3. Additional discussion is needed concerning the groundwater/surface-water interaction of the Upper Peace River. Are there river segments that lose more flow to groundwater system than other segments? How do river segments with varying gain/loss characteristics affect proposed minimum flows?

Thank you for the opportunity to comment on the proposed minimum flows for the Upper Peace River. Please contact me if you need any clarification concerning these comments or additional information.

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S. Flannery #1 - Technical input prepared for the January 23rd meeting of the scientific review panel for the draft Upper Peace River minimum flows report

Submitted by Sid Flannery

<u>Overview</u>

Similar to my verbal comments to the scientific review panel on January 16th, 2026, this memo starts by discussing mathematical uncertainties in the modeling approach used to determine whether the Upper Peace River is currently meeting the proposed minimum flows. It also discusses how some graphics and tabular information presented in the draft District report, do or do not, indicate the proposed minimum flows for the Upper Peace River are currently being met. As will be discussed, it appears to me that the proposed minimum flows are not being met for much of the time at the Bartow and Ft. Meade gages. However, I suggest there is a technically sound approach for the minimum flows that can be pursued that would make water supplies available while minimizing impacts to the ecology of the Upper Peace River.

Mathematical approaches used in the modeling of baseline flows in the Upper Peace River that would result from reductions in groundwater withdrawals.

The Upper Peace River is a very complex system for the modeling of groundwater interactions with streamflow, in large part because of the extensive physical alterations to its watershed, particularly widespread phosphate mining as mined lands currently comprise 25% of upper river basin. Much of these mined lands are in very close proximity to the river, including large areas of clay setting ponds which have very little recharge to the Floridan aquifer and also disrupt localized groundwater flow to the river.

There have been large changes in groundwater use in the upper river basin, much of which occurred when water use records were not nearly as complete as today. Given these factors, for the modeling of changes in groundwater interactions with the river and the calculation of baseline flows, the Upper Peace River represents one of the most complex basins in the District.

The consultants who worked on the Peace River Integrated Model (PRIM2) made a series of assumptions and mathematical estimates that could be applied in the modeling process to estimate baseline flows. Section 5.4 in the District report describes three steps that were taken to facilitate the modeling used to estimate baseline flows the Upper Peace River corrected for the effects of groundwater withdrawals.

1. The PRIM2 model was run for existing groundwater pumpage rates and a 50 percent reduction in groundwater pumpage for the years 2003 to 2018. Daily streamflow values generated by the modeling were then averaged to monthly flow values within each of the simulation years.

2. The monthly differences in flows between these two scenarios where then doubled to estimate flows for no withdrawal conditions.

> Comment – It seems odd to assume that the effect on river flow between the 100% groundwater pumping scenario (existing withdrawals) and the 50% pumpage reduction scenario would be the same as the effect between the 50% reduction scenario and a complete elimination of withdrawals. The District claims the relationship between groundwater levels and streamflow is linear, but it seems that as groundwater levels become much higher with a complete elimination of withdrawals, in some areas rising above the bed of the river, the rate of streamflow increase would rise.

3. Because the PRIM2 model was only run for the years 2003 to 2018, adjustments were needed to simulate baseline flows for the desired period of 1975 to 2022. So, yearly adjustment rates were determined by dividing the estimated total groundwater use in each of the baseline years to average water use for the 16-year PRIM2 modeling period. These yearly adjustments were then applied to the average monthly adjustment factors for the PRIM2 modeling period, then these final factors were applied to the daily gaged record of the river to estimate daily baseline daily flows for the 1975 – 2022 period.

I don't know why the District wanted to have such a long period of baseline flows for the minimum flows analysis, as other minimum flows assessments have used shorter periods of record. Although it may have some attributes, the estimation of baseline flows going back nearly fifty years poses challenges which calls for some assumptions and adjustments. I think the three types of adjustments described above have considerable mathematical uncertainty and potential error, and the estimated long-term baseline flows using this method should be viewed as approximations.

The streamflow estimates for the 2003 to 2018 period that were directly modeled should be more accurate, but the Upper Peace River basin has experienced large physical alterations, including to its near surface geology in some areas, for which the effects on streamflow could be difficult to simulate.

As I said on January 16th, for evaluating the effects of human caused changes to flows in the Upper Peace River, these modeled changes in flows should be considered along with the data we have for flow trends in the river, the occurrence of karst features in the both the river channel and its floodplain, and the large physical alterations of the watershed including the widespread clay settling ponds many of which are very near the river. Declining flows in the Upper Peace River have been described by many studies, and all of these factors should be considered to determine if flows in the Upper Peace River have sufficiently rebounded from previous impacts and are now within the proposed minimum flows for the upper river.

The District report does provide some useful graphics of the modeled baseline flows versus the gaged flow records for the river that are helpful for assessing this question. A hydrograph for the Ft. Meade gage taken from Figure 5-9 in the draft District report is reprinted below, showing median flow values for each day of the year for both the modeled baseline flows and the gaged flows for the river at that site.

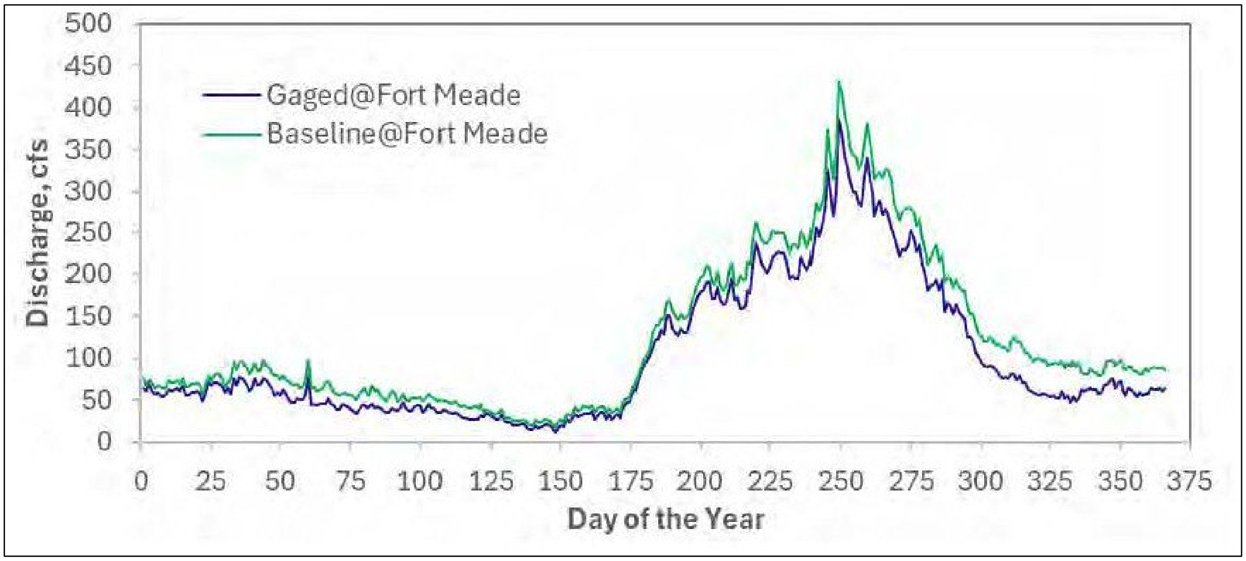

Figure 1. Median daily flows for the baseline flows and the gaged flows for the Peace River at Ft. Meade gage calculated for the years 1975-2022. Taken from Figure 5-9 in the draft District report.

From this graphic it appears that at least for daily median flow conditions, the gaged flows at Ft. Meade are already below the baseline flows more than the proposed minimum flows would allow for much of the year. For example, the proposed minimum flows at Ft. Meade allow for a 12% flow reduction at flows between 21 and 120 cfs, and a 10% reduction at flows between 120 and 529 cfs. For many of the days it appears the difference between the daily median baseline flows and the median gaged flows exceed these percentages.

Text continues on the following page

Other useful graphics in the draft District report are flow duration curves for baseline flows and gaged flows. Figure 6-6 for the Ft. Meade gage taken from the District report is shown below. The Y axis is on a semi-log scale, so additional tic marks and cross hatching in the figure would be helpful to identify the flow quantities. However, for much of the flow range it appears that gaged flows are less than the baseline flows by amounts exceeding the percentages allowed by the proposed minimum flows. In my final review of the report, I am going to request that the scale for the Y axis in this figure be improved and flow percentiles values for these two flow scenarios be reported in a table in five percentile increments.

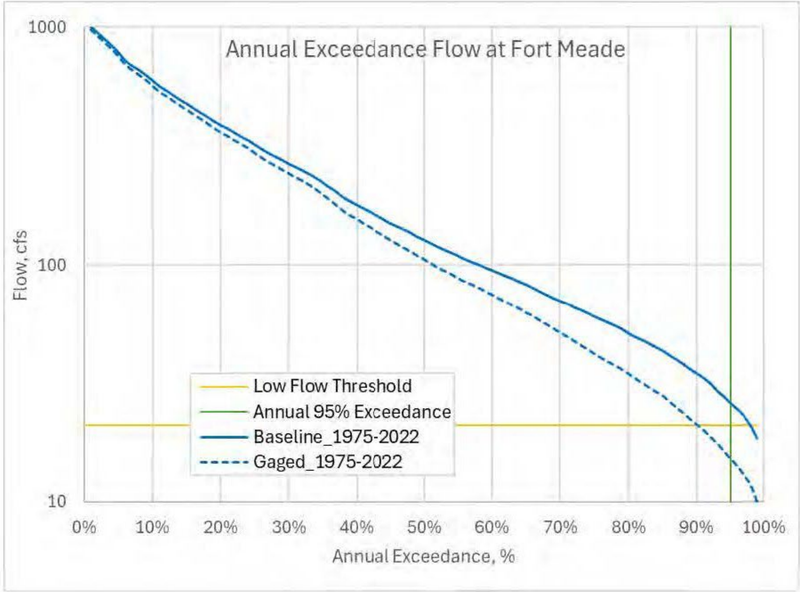

Figure 6-6. Annual exceedance flow for the USGS Peace River gage at Fort Meade for the periods 1975-2022, comparing baseline and gaged flows in relation to the low flow threshold.

Given these results and what is widely known about the physical alterations and impacts to flows in the Upper Peace River that have been reported in previous studies, I think the statement by the District that the Upper Peace River is meeting its minimum flows at the Bartow and Ft. Meade gages is not supported by the material presented in the report.

In that same regard, the material presented in Chapter 7 (Minimum Flows Status Assessment, Implementation, and Conclusions) is much too brief as this chapter is only two pages long. On page 233 It contains a three-sentence paragraph that states that the recommended minimum flows for the upper river are currently being met, with the first two sentences reprinted below.

> “Table 5-6 presents estimated monthly adjustment flows due to withdrawal-related effects over a 16-year assessment period. Collectively, these findings indicate the recommended minimum flows for the Upper Peace River are currently being met.”

Table 5-6 referred to in this paragraph is reprinted below. First, the heading of the table is unclear and needs to be revised. However, the text on page 179 states these are the monthly adjustment rates for a zero-pumping condition (baseline flows) for the modeling period from 2003 to 2018. As described earlier, these values were based on doubling the differences between the 100% (existing) and 50% pumping reduction scenarios, which I think may underestimate the true adjustment rate.

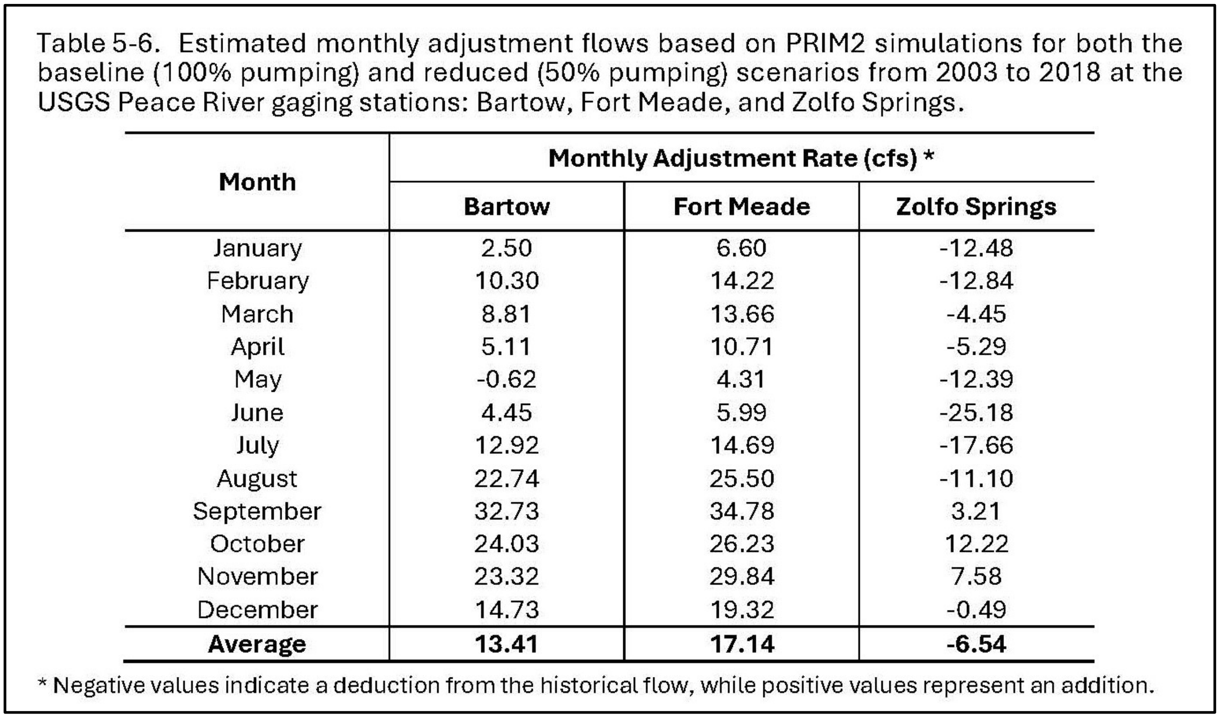

Table 5-6. Estimated monthly adjustment flows based on PRIM2 simulations for both the baseline (100% pumping) and reduced (50% pumping) scenarios from 2003 to 2018 at the USGS Peace River gaging stations: Bartow, Fort Meade, and Zolfo Springs.

Month	**Monthly Adjustment Rate (cfs) ***		
	Bartow	**Fort Meade**	**Zolfo Springs**
January	2.50	6.60	-12.48
February	10.30	14.22	-12.84
March	8.81	13.66	-4.45
April	5.11	10.71	-5.29
May	-0.62	4.31	-12.39
June	4.45	5.99	-25.18
July	12.92	14.69	-17.66
August	22.74	25.50	-11.10
September	32.73	34.78	3.21
October	24.03	26.23	12.22
November	23.32	29.84	7.58
December	14.73	19.32	-0.49
Average	**13.41**	**17.14**	**-6.54**

* Negative values indicate a deduction from the historical flow, while positive values represent an addition.

Whether these are underestimates or not, the values in this table indicate that the minimum flows at the Bartow and Ft. Meade gages are not being met for much of the year. For example, the amount of flow reduction allowed in the medium flow block in the proposed minimum flow rule for the Ft. Meade gage is 12% at flows between 21 and 121 cfs. The median flow at Ft. Meade for this same 16-year period was 70 cfs or midway in this range. How can the yearly average flow adjustment of 17.14 cfs for Ft. Meade at the bottom of Table 5-6, which equals 24% of the median flow for the river at the Ft. Meade gage during that period, not result in flow reductions greater than the minimum flows for much of the year.

Similarly, the median flow for March at Ft. Meade during that period was 30 cfs. How can an average flow adjustment of 13.66 for March not greatly exceed the allowable flow reductions during that month for much of the time. The middle flow range is used as an example, and exceedances of the allowable flow reductions in the higher flow ranges at Ft. Meade (10 and 7 percent) probably frequently occur as well.

In sum, the legend for Table 5-6 is unclear, but more importantly, the rationale that the values in this table support the statement that the Upper Peace River is meeting its minimum flows is either flawed or needs more explanation. At this time, I don't think the results provided in this report indicate the proposed minimum flows for the Upper Peace River are being met at the Bartow and Ft. Meade gages.

Management applications

On a related note, how would the information presented in Table 5-6 be used to regulate new withdrawals from the Upper Peace River and determine new allowable percentage withdrawals that account for the existing flow reductions in the river. As the report points out on page 17, the percent-flow-approach is currently used to regulate large withdrawals on three rivers in the District; the Lower Peace, the Lower Alafia and the Little Manatee Rivers. The percent-of-flow approach has been widely viewed as success, using a progressive method to meet water supply and also protect the environment. By the way, I worked extensively on the ecological and hydrologic justification and regulatory limits for applying the percent-of-flow approach on these rivers.

In all of these of three rivers, the daily withdrawals are based as a percentage of the preceding day's flow at a nearby gage, which as the report correctly points out, is how percent-of-flow approach is supposed to be applied. Based on the findings presented in the draft report, it is unclear how the District would determine allowable percentage withdrawal schedules for new water users based on flows at the Bartow or Ft. Meade gages, but a method could be derived, possibly using a ratio of gaged flows to baseline flows.

An alternative, technically sound plan for the minimum flows and water supply on the Upper Peace River

I believe there is a reasonable, technically sound solution to the determination and application of minimum flows for the Upper Peace River. In 2018, I submitted to the District a report I prepared that evaluates a watershed based approach for obtaining water supplies from the Peace and Alafia Rivers. This report was uploaded to the District minimum flows webboard along with this technical memorandum (S. Flannery #2- Report, Watershed based approach for withdrawal sites on the Peace and Alafia Rivers).

That report points out that as the Peace River progresses downstream from Ft. Meade, the impacts to flows proportionately diminish, the flow regime of the river greatly improves, the morphology of the river and floodplain change, and potential for obtaining water supplies from the river without causing significant environmental harm increases.

The District report cites my report and on pages 64 to 67 presents updated flow statistics for gages on the Upper Peace River similar to the information that I presented. In relation to using the Upper Peace River for water supply, Table 2-9 in the District report lists the median flow at Zolfo Springs at 250 cfs, compared to 78 cfs at Ft. Meade and 56 cfs at Bartow. To maximize both water supply yields and environmental protection, it makes sense to obtain water supplies from the Upper Peace close to Zolfo Springs.

Again, I don't think the data and information presented in the District report indicate the Upper Peace River is meeting the proposed minimum flows at the Bartow and Ft. Meade gages. Knowing the extensive physical changes and impacts in the northern reaches of Upper Peace River, I believe that any new withdrawals should not be allowed in those reaches of the river.

This is supported by what appears to be a technically sound conclusion that the river reaches associated with the Bartow and Ft. Meade gages are not meeting their proposed minimum flows. Conversely, new withdrawals could be considered near the Zolfo Springs gage. I suggest that the findings provided in the District report actually support this conclusion and the report could be revised accordingly, as this would be a much better application of the minimum flows for the Upper Peace River.

SF #2 - Verbal comments planned for the January 23rd meeting of the Upper Peace River minimum flows scientific review panel that was canceled

Submitted by Sid Flannery

Note: To put my documents in one place, the two documents referred to in first sentence below have been included with three new documents made available via a post to the WebBoard on January 30, 2026.

This morning the District uploaded to the minimum flows WebBoard two documents that I hope you can carefully consider. They should appear under the public comments topic for the Upper Peace River minimum flows. The first is a 7-page document I recently prepared with questions and comments pertaining to the District's draft minimum flow report **(Document SF-1 in post on January 30th).**

This document covers four basic topics. As I described last week, the modeling of reductions in baseline flows includes considerable mathematical uncertainty, and when evaluating if the Upper Peace River is now meeting the proposed minimum flows, the District should consider all the information for the upper river including trends in the flow data, the karst features that have formed in the river channel and floodplain, and the large physical alterations to the watershed, particularly the extensive phosphate mining and old clay settling ponds that are in close proximity to the river channel.

Secondly, there are graphics for baseline and gaged flow conditions in the District report that in my view indicate the upper Peace River is not meeting the proposed minimum flows at the Bartow and Ft. Meade gages for much of the time. I reprinted two of those graphics in my document, which I think supports such a conclusion

Also, there is three sentence paragraph in Chapter 7 of the District report that states the minimum flows are being met in the Upper Peace River and refers to Table 5-6 to make this point. I reprinted Table 5-6 in my document and point out that the heading of the table is unclear and needs to be revised, but if that Table shows what the text says it does, it indicates to me that the upper river is not meeting the proposed minimum flows for much of the time at the Bartow and Ft. Meade gages.

Finally, I think there is a technically sound, reasonable solution to the Upper Peace River minimum flows that makes water supplies available and minimizes potential harm to the upper river ecosystem. In 2018 I submitted to the District a report I prepared about a watershed based approach for evaluating potential new surface water withdrawal sites on the Peace and Alfia Rivers. It was also loaded to the minimum flow WebBoard today and I hope you can look at it **(Document SF-3 in post on January 30th).**

That 2018 report makes the point that flows in the Upper Peace River have been highly impacted, but the flow regime of the river improves as you progress downstream. As my recent document states, that 2018 report also concludes that withdrawal sites and obtaining water supplies near Zolfo Springs are feasible, but withdrawals farther upstream in the Upper Peace River should not be allowed.

This plan is supported by what I think is a technically sound conclusion that the Upper Peace River is not meeting the proposed minimum flows at the Bartow and Ft. Meade gages, but is at the Zolfo Springs gage. By the way, with regard to water supply considerations, the median flow at Zolfo Sprigs is 250 cfs, compared to 78 cfs at Ft. Meade at 56 cfs at Bartow. For this and other reasons, such a plan is technically sound, is based on a careful evaluation of the hydrologic and ecological data, and makes a whole lot of sense.

A Watershed Based Approach for the Assessment of Potential New Surface Water Withdrawal Sites from the Peace and Alafia Rivers

Document SF - 3 for Upper Peace River minimum flows scientific review

Prepared by: Michael S. Flannery, Retired Chief Environmental Scientist, Springs and Environmental Flows Section, Southwest Florida Water Management District

October 1, 2018

A Watershed Based Approach for the Assessment of Potential New Surface Water Withdrawal Sites from the Peace and Alafia Rivers

Table of Contents

Alafia River

Summary and Dedication

Dedication - *This report is dedicated to the life and work of Ellis Lanquist (1924 – 2006). As a young World War II veteran, Mr. Lanquist studied freshwater biology at the University of Florida. His 1953 Master's Thesis, A Biological Survey of the Peace River, Florida, and contributions to the subsequent reports by the Florida State Board of Health are important documents that describe the ecology of the Peace River and impacts to the river to that point in time (Lanquist, 1953; FSBH, 1955B; 1955C). Mr. Lanquist later served for many years as an admired and highly regarded teacher, coach, and administrator at Bolles High School in Jacksonville, Florida.*

Summary

This report discusses how the hydrologic and ecological characteristics of the Peace and Alafia Rivers are related to obtaining new water supplies from these rivers without causing adverse environmental impacts. A watershed-wide approach is used to identify reaches on each river where water supply availability can be maximized while minimizing the potential for environmental harm. These concepts are also briefly discussed with general application to other rivers in the region.

With regard to flow reductions, the Upper Peace River is one of the most impacted river reaches in Florida with the primary human causes being groundwater drawdowns, cessation or reduction of point sources discharges, and physical alterations of its drainage basin including extensive phosphate mining in close proximity to the river channel, much of which occurred when the regulations for mining were non-existent or not as rigorous as today. The Upper Peace River is currently not meeting minimum low flow rules established by the Southwest Florida Water Management District (SWFWMD) at the Bartow, Ft. Meade, and Zolfo Springs streamflow gages.

The river gains considerable flow and is less impacted farther downstream due to flow contributions from Payne, Charlie, Horse, Joshua and Shell Creeks. The physical and hydrogeologic characteristics of the river basin and the morphology of the river channel and its floodplain change downstream as well. In general, the ability to achieve new water supplies from the Peace River without causing adverse environmental impacts greatly increases progressively downstream.

With the possible exception of the diversion of extremely high flows that cause flooding problems in uplands, this report concludes there should be no new withdrawals from the Peace River or its tributaries above the confluence with Payne Creek. Withdrawals during high flows between Payne Creek and Zolfo Springs could be feasible for purposes of flow restoration of the Upper Peace River. During times of very low flow, flow supplementation of the Peace River just below Bartow would help fill the cavities and voids in the aquifers underneath the upper river that have been caused by groundwater drawdowns and allow the river flow to recover more quickly when surface runoff resumes.

New withdrawals from the Peace River during high flows for water supply should only be considered farther downstream, at least to below Charlie Creek, in order to increase the amount of water supplies that can be obtained without causing environmental harm. Any withdrawals from the river above Arcadia would have to comply with minimum flows for the Middle Peace River, which contain more restrictive flow reduction percentages than the minimum flows for the Lower Peace River farther downstream.

The optimal location for maximizing water supplies from the Peace River while minimizing the potential for adverse environmental impacts is at or near the location of the Peace River Manasota Regional Water Supply (PRMRWSA) facility, located 19 miles upstream of the mouth of the river near Ft. Ogden. Withdrawals at this location, which is in the tidal portion of the river, are in compliance with the adopted minimum flows for the Lower Peace River. Importantly, withdrawals at this location do not affect the upstream freshwater reaches where there have been previous impacts to the river's flow regime. Similarly, any withdrawals from the middle river would have to comply with the cumulative flow reduction limits established by the minimum flows for the Lower Peace River, so it would be better ecologically to make the withdrawals downstream.

The SWFWMD is proposing to reevaluate and possibly adopt revised minimum flows for the Lower Peace River in the year 2020. The existing legal use by the PRMRWSA should have first priority and might require all the allowable flow reductions at low and medium flows to meet their water supply demands. However, on days when the PRMRWSA does not withdraw all their percentage allotments of low and medium flows, withdrawals of the remaining water could be coordinated and implemented for other users on a short-term basis. In addition, pending the reevaluation of minimum flows for the Lower Peace River, there may regularly be additional water available for other users during times of high flow.

Shell Creek is the largest tributary to the Peace River and could be a significant source of new water supplies in the region. Minimum flows for the lower segment of Shell Creek are also proposed for adoption in 2020. Once these minimum flows are adopted, existing permitted withdrawals by the City of Punta Gorda may comprise most or all the allowable flow reductions at low to medium flows. However, there may be considerable water quantities available from Shell Creek for supply at high flows. If it is determined to be necessary for regional water supply needs, consideration could be given to building an interconnection between the Shell Creek reservoir and the location of the PRMRWSA facility in order to transmit raw river water from Shell Creek for transport and use at other locations.

Since there is much more water available for supply in the lower reaches of the Peace River and Shell Creek compared to the upper and middle river, consideration could be given to constructing a pipeline from the lower river to upstream locations if it is necessary to meet regional water supply demands. If new water supplies from the Peace River are truly needed, the expenditure of public funds to transport water from more ecologically resilient downstream locations to upstream water users would be well justified to make such water supplies available without causing further environmental harm to the Peace River. If water from downstream areas is transported upstream for water supply, consideration should be given to using a portion of this water for flow restoration of the Upper Peace River if it is not meeting its low minimum flows.

Flows in the Alafia River are not nearly as impacted as flows the Upper Peace River and existing withdrawals from the Alafia River by Tampa Bay Water (TBW) are below the percent of flow limit contained in the applicable minimum flow rule for the Lower Alafia River. Similar to the PRMRWSA facility on the Peace River, the location of the TBW intake on Alafia River is optimally located to maximize water supply availability while minimizing the potential for environmental harm. Any additional withdrawals for water supplies from the Alafia River should be at or near this location, not from the north or south prongs of the river, which are much smaller streams with less water supply yields and greater sensitivity to ecological harm.

These findings and conclusions for the Peace and Alafia Rivers have broader application to other rivers in the region. In general, new withdrawal sites on rivers should be located as far downstream as practical to just above the tidal reach. The ecological health of both rivers and their receiving downstream estuaries are dependent on a largely natural flow regime that reflects the climate and watershed characteristics of each river. Accordingly, using a percent-of-flow approach, the SWFWMD technically evaluates and adopts minimum flow rules separately for the freshwater and tidal estuarine reaches of each river. Because they are based on ecosystems with different physical and ecological characteristics, the allowable flow reduction percentages contained in minimum flow rules for freshwater rivers are typically more restrictive than for their receiving downstream estuaries. The different minimum flow percentages for the freshwater and estuarine reaches of the Peace and Alafia Rivers are examples of this.

With the exception of the Withlacoochee River, rivers in the region are very short with limited distances on each river channel where freshwater supplies can be obtained. Given the small size of the these rivers, the hydrologic condition that there is generally greater river flow farther downstream and the switch from freshwater to estuarine ecosystems, it makes sense to locate new withdrawals sites as far downstream as practical on each river to near its tidal reach. With this strategy, flows are preserved in upstream freshwater reaches were the natural systems are more sensitive to adverse impacts due to flow reductions.

Given the ecological, aesthetic, and economic importance of Florida's rivers, the expenditure of funds to transport water from downstream river reaches that are more hydrologically and ecologically resilient to upstream water users is money well spent. Factors related to the effects of sea level rise are discussed and strategies suggested if sea level rise threatens the use of a river intake for water supply.

Introduction

This report discusses the hydrologic and ecological characteristics of the Peace and Alafia Rivers and how these factors are related to obtaining new water supplies from these rivers without causing adverse environmental impacts. The Peace and Alafia Rivers are two of the five principal rivers that drain the southern part of the Southwest Florida Water Management District (SWFWMD). With a total length of 106 miles on the main river channel, the Peace is the larger of the two rivers as it flows through four counties with a total watershed area of 2,350 square miles (mi^2). With a watershed area of 422 mi^2 the Alafia River has headwater reaches in western Polk County, but it flows primarily through Hillsborough County to Tampa Bay. The total channel length of the Alafia River including its longest headwater tributary is approximately 50 miles.

Both rivers are currently used for potable water supplies by regional utilities. The Peace River Manasota Regional Water Supply Authority (PRMRWSA) has an intake located approximately 19 miles upstream from the mouth of the Peace River at Charlotte Harbor. Tampa Bay Water (TBW) has an intake on the Alafia River located approximately 12 miles upstream of the mouth of the river at Tampa Bay. The intakes for both of these water supply facilities are located as far downstream as practical, near the beginning of the tidal reach on each river where brackish waters would prohibit freshwater withdrawals much of the time. They are in optimal locations to maximize water supply availability while minimizing the potential for environmental impacts.

The SWFWMD recently received three water use permit applications from the Polk Regional Water Cooperative (PRWC) for new surface water withdrawals from; (1) the Upper Peace River, (2) the Peace Creek Canal (a tributary to the Upper Peace River), and (3) the North and South Prongs of the Alafia River. There is a need for new water supplies in Polk County within the resource planning horizon and it is my understanding the PRWC has concerns that the recent renewal of the water user permit issued for the PRMRWSA facility located near the river mouth might tie up all the available water from the Peace River. Apparently there is a pending legal challenge to the renewal of the PRMRWSA permit because of those concerns. During my nearly 30 years of employment at SWFWMD I did extensive technical work on minimum flows and water supply issues both the Peace and Alafia Rivers, but I did not communicate with either the PRMRWSA, the PRWC, or TBW regarding these recent issues for the Peace or Alafia Rivers prior to the preparation of this technical report.

In both cases, I suggest that a watershed-wide approach be used to assess water supply availability and environmental protection. Hopefully, this approach can be used to prioritize suitable locations for withdrawals or diversions from each river, either for water supply or environmental restoration and evaluate any facilities needed for water storage and/or distribution.

Organization of the report

The Peace River is discussed first and in greater detail as it is the larger of the two rivers and has experienced the most pronounced human impacts to its flows. It is emphasized this report only provides a brief overview of the hydrologic and ecological characteristics of each river as it relates to implementing any new surface water withdrawals. A large number of extensive and informative reports have been published about the Peace and Alafia Rivers and some pertinent findings from those reports are briefly summarized in the following pages. Readers are encouraged to consult the original reports for more detailed discussions of the hydrologic and ecological characteristics of these rivers.

In addition to several other publications, there are five reports that are particularly informative for evaluating the hydrology of the Upper Peace River basin that are referenced in this report. Those reports in chronological order are:

Lewelling, B.R., A.B. Tihansky and J.L. Kindinger. 1998. Assessment of Hydraulic Connection Between Ground Water and the Peace River, West-Central Florida. United States Geological Survey Water-Resources Investigations Report 97-4211. Tallahassee FL.

Southwest Florida Water Management District. 2002. Upper Peace River - An Analysis of Minimum Flows and Levels. Report of the Southwest Florida Water Management District, Brooksville, FL.

Basso, R. 2003. Predicted Change in Hydrologic Conditions along the Upper Peace River due to a Reduction in Ground-Water Withdrawals. Hydrologic Evaluation Section. Report of the Southwest Florida Water Management District. Brooksville, FL.

PBS&J, Inc. and other firms. 2007. Final Report of the Peace River Cumulative Impact Study. Report prepared for the Florida Department of Environmental Protection Bureau of Mine Reclamation, Tallahassee, Florida and the Southwest Florida Water Management District, Brooksville, FL.

Metz, P. A., and B.R. Lewelling. 2009. Hydrologic Conditions that Influence Streamflow Losses in a Karst Region of the Upper Peace River, Polk County Florida. United States Geological Survey Scientific Investigations Report 2009-5140. Tallahassee, FL.

All of the previous reports about the Peace and Alafia Rivers are limited to data collected up to a certain date, for example the end of the year 2000 in the SWFWMD report concerning minimum flows for the Upper Peace River (SWFWMD, 2002). In most cases the findings of those reports are still valid today, but where the findings of previous reports need qualification with regard to current hydrologic conditions I attempt to do so. Rainfall and streamflow data updated through 2017 are presented in the following pages, but I felt it was beyond the scope of this report to do an update of recent groundwater levels in the region. The findings of this report can be assessed by others in relation to how recent groundwater conditions in the basins of either the Peace or Alafia Rivers might affect the hydrology of these rivers and their potential to serve as sources of water supply.

The tables presented in this report are embedded in the text, while the figures are presented at the end of the report and also as a separate pdf file. Readers are encouraged either print the text and figures separately or view them simultaneously on a split screen. One solution is to print the text and simultaneously view the color figures on a screen while reviewing the report.

Long-term flow statistics for the Peace River and its major tributaries

The first objective of my analysis was to update streamflow data for the gages operated by the U.S. Geological Survey (USGS) on the main stem of the Peace River and its major tributaries. The location of the gages discussed in the report are shown in Figure 1. A list of other streamflow gages on the Peace River and its tributaries is included in Appendix A, with only the most downstream gage listed if more than one site exists on a specific tributary.

Flow statistics for the gages shown in Figure 1 were calculated beginning with the first year of complete daily records and extending through the end of 2017. There are four long-term gages on the main stem of the Peace River; at Bartow, Ft. Meade, Zolfo Springs and Arcadia. The lengths of flow records for complete years are between 78 and 86 years for three of the gages; beginning in 1932 at Arcadia, 1934 at Zolfo Springs, and 1940 at Bartow. The flow records are shorter at Ft. Meade with the first complete year being 1975. Hydrographs of yearly flows at for the periods of record at these gages are presented and discussed in this report.

In order to compare flow rates over a consistent time period, Table 1 lists mean (average) flows calculated for the 43 years of record since 1975 when flow records for complete years began at Ft. Meade. This allows for a comparison of flows at both of the two gages in the upper river (Bartow and Ft. Meade) to flows at the two river gages located farther downstream (Zolfo Springs and Arcadia). Table 1 also lists the drainage area, the mean area-based runoff for the drainage basin above each gage, and the gage location relative to the origin of the river where Saddle Creek and Peace Creek meet to form the Peace River near Bartow.

It is obvious from Table 1 there is considerable gain in water as the river flows downstream. The average gaged flow near mouth of the river at the confluence with Shell Creek (1,547 cfs) is greater than the mean flow at Ft. Meade (195 cfs) by a nearly a factor of eight. Also apparent is the gain in flow between the Ft. Meade and Zolfo Springs gages, where the mean flow increases by a factor of 2.5 while drainage basin are increases by a factor of 1.7.

Table 1. Drainage areas, gage locations and average values for flow and area-based runoff for four long-term streamflow gages on the main stem of the Peace River and at the confluence with Shell Creek for 1975 to 2017.

	Drainage area and location of gage		Average Flow and Runoff	
USGS gage	Drainage area (mi^2)	Distance from the river origin (miles)	Mean Flow (cfs)	Area Based Runoff (cfs/mi2)
Peace River at Bartow	390	1	168	0.43
Peace River at Ft. Meade	480	14	195	0.41
Peace River at Zolfo Springs	826	37	496	0.60
Peace River at Arcadia	1,367	70	890	0.65
Peace River at Shell Creek confluence*	2,090	97	1,547	0.74

* Sum of draingae areas and gaged flows from the Peace River at Arcadia and Horse, Joshua, and Shell Creeks corrected for withdrawals from Shell Creek by the City of Punta Gorda

Similarly, average rates of area-based runoff expressed as cfs per square mile (cfs/mi^2) increase downstream, with values between 0.60 and 0.74 cfs/mi^2 from Zolfo Springs to the Shell Creek confluence compared to rates of 0.43 and 0.41 cfs/mi^2 at Bartow and Ft. Meade. The hydrologic characteristics of these two upstream sub-basins are complex and will be further discussed later in this report. It is also important to note that the runoff rates listed for the more downstream gages in Table 1 include the drainage area above Ft. Meade, so the average runoff rates in the areas between the Ft. Meade and the Zoflo Springs and Arcadia gages are even higher than the average values listed for the two downstream gages. These average values for flow and areal based runoff show that for obtaining water supplies from the Peace River, there is much more water available progressively farther downstream.

It is also useful to examine flow duration characteristics as these gages. Value for minimum, maximum, and five flow percentiles at these same gages are listed in Table 2. For terminology I use the percentile value above the minimum, for example the P5 flow is a low flow that when ranked among all the daily flows is five percent of the way up from the lowest flow, while P90 is a high flow that is ranked 90 percent of the way up from the lowest flow. The P50 is the median flow.

One thing apparent in Table 2 is the marked increase in low percentile flows between the Ft. Meade and Zolfo Springs gages, as the P5 flows increase from 3 to 35 cfs, the P25 flows increase from 22 to 108 cfs, and the median flows increase from 73 to 244 cfs. It is also important to note that the P5 and P10 flows go down between the Bartow and Ft. Meade gages, for as will be discussed later in more detail, the river sometimes loses flow to the groundwater system in the first few miles below the Bartow gage. The large reduction in the maximum daily flow values between Bartow and Ft. Meade is discussed later on page 15. High flows downstream of Ft. Meade show large increases, for example the P90 flow increases from 547 cfs at Ft. Meade to 1,210 cfs at Zolfo Springs to 2,310 cfs at Arcadia. With regard to diverting high flows for water supply or environmental restoration, the percentile flows also show there is much more water available progressively farther downstream in the Peace River.

Table 2. Percentile values for daily flows at four long-term streamflow gages on the main stem of the Peace River and at the confluence with Shell Crek for 1975 to 2017.									
	Flow Percentiles (cfs)								
USGS gage	Minimum	P5	P10	P25	P50	P75	P90	P95	Maximum
Peace River at Bartow	0	6	9	20	51	183	468	758	4,010
Peace River at Ft. Meade	0	3	6	22	73	214	547	871	2,450
Peace River at Zolfo Springs	4	35	53	108	244	564	1,210	1,840	10,300
Peace River at Arcadia	6	56	82	154	376	981	2,310	3,540	21,700
Peace River at Shell Creek confluence*	18	92	140	269	648	1,686	4,036	6,039	37,569

* Sum of gaged flows from Peace River at Arcadia and Horse, Joshua and Shell Creeks corrected for withdrawals by the City of Punta Gorda

Much of the gain in flow at the downstream locations is due to inflow from the tributaries to the river below Ft. Meade. Table 3 lists the drainage areas and relative locations of five major tributaries to the Peace River, along with the mean and median values for flow and area-based runoff. Again for consistency between gages, the values are computed for the years 1975 to 2017, except for Payne Creek where daily records for complete years start in 1980.

Table 3. Drainage areas, gage locations, average values for flow and area-based runoff and median flows for five major tributaries to the Peace River for 1975 to 2017 or as noted.					
USGS gage	Drainage area (mi^2)	Location relative to gages on the river	Mean Flow (cfs)	Area-Based Runoff (cfs/mi^2)	Median Flow (cfs)
Payne Creek nr. Bowling Green *	121	Between Ft.Meade and Zolfo Springs	116	0.96	64
Charlie Creek nr. Garner	330	Between Zolfo Springs and Arcadia	243	0.74	53
Horse Creek nr. Arcadia	218	Downstream of Arcadia	170	0.78	40
Joshua Creek at Nocatee	132	Downstream of Arcadia	112	0.85	34
Shell Creek nr. Punta Gorda**	371	Downstream of Arcadia	368	0.99	146

*** for 1980 to 2017**

**** corrected for withdrawals by City of Punta Gorda**

In comparing the values in Tables 1 and 3, the values for Payne Creek in Table 3 are included in the values for the river at Zolfo Springs in Table 1, while the flows for both Payne and Charlie Creek are included in the values for and Arcadia gage since those gages are located upstream. Horse, Joshua, and Shell Creeks flow into the river below Arcadia and mean values for those tributaries can be added to the mean flow at the Arcadia gage to get a total average gaged flow value for the river of 1,547 cfs for 1975-2017 (Table 1). By comparison, the mean flow at Ft. Meade in the Upper Peace River (195 cfs) is only 12.6 percent of this total gaged flow, although the Ft. Meade sub-basin comprises 23 percent of the total gaged area of the Peace River watershed.

With regard to location, Payne Creek is the most upstream tributary listed in Table 3 as it flows into the river about nine miles south of the Ft. Meade gage. With a mean flow of 116 cfs and a comparatively high rate of area-based runoff (0.96 cfs/mi^2) , flow contributions from Payne Creek are very important to the flow gains observed at the downstream Zolfo Springs gage.

Charlie Creek has the second largest tributary sub-basin in the Peace watershed and flows to the river between Zolfo Springs and Arcadia. The mean flow for Charlie Creek for the 1975-2017 (243 cfs) is equal to 27% of the mean flow at the Arcadia gage (890 cfs) for this same period. The Charlie Creek sub-basin is considered to be one of the least altered major tributary sub-basins in the Peace River watershed (SWFWMD, 2005A; PBS&J and others, 2007; Lee et al., 2010).

Horse Creek flows into the Peace Rive about 15 miles below the Arcadia gage. It is also a relatively lightly altered sub-basin and has a mean area-based runoff values (0.78 cfs/mi^2), similar to that for Charlie Creek (0.74 cfs/mi2). As will be discussed later, these two creeks also have very similar long-term flow trends. Joshua Creek flows into the Peace River about six miles below the Arcadia gage. It has a relatively large average rate of area-based runoff (0.85 cfs/mi^2) and previous studies have concluded that agricultural land use and irrigation have resulted in increasing flow trends in Joshua Creek (Flannery and Barcelo, 1998; PBS&J and others, 2007; SWFWMD, 2010A).

Shell Creek, which flows into the tidal estuarine reach of the Peace River, has the highest mean flow of any of the tributaries (368 cfs), equivalent to 41% of the flow at the upstream Arcadia gage. The median flow for Shell Creek is more than twice as great as for any other tributary. Shell Creek also has comparatively high rate of area-based runoff (0.99 cfs/mi^2), due in part to agricultural land use and irrigation in its drainage basin.

Collectively, these flow statistics for the gages on the Peace River and the five major tributaries show that the river gains considerable flow below Ft. Meade, as the sub-basins in the middle and lower reaches of the river have greater rates of area-based runoff. As will be further discussed, it is well documented that various human factors have contributed to reduced flows in the Upper Peace River sub-basin and the hydrology and ecology of the river tends to recover from these reduced flows progressively farther downstream.

Influence of long-term rainfall patterns

Hydrographs and trend analyses of flows at various gages in the Peace River watershed are presented throughout the remainder of this report. Long-term patterns in regional rainfall have clearly played a major part in the trends in streamflow that will be described. To support that discussion, a general description of long-term, inter-annual patterns of rainfall in the Peace River watershed is presented below.

Long-term rainfall values for the Peace River Watershed were obtained from the website of the Southwest Florida Water Management District (https://www.swfwmd.state.fl.us), which contains yearly data for monthly, seasonal, and annual rainfall totals that can be tabulated by county or by major USGS drainage basin. I downloaded yearly values for annual and seasonal rainfall totals for the Peace River watershed. Based on areal-based averaging of data from the various rainfall stations that have operated over the years, rainfall values for the Peace River watershed are available going back to 1915. I downloaded data from 1930 to 2017 to compare to the longest flow records analyzed in this report.

Based on these data, the average annual rainfall for the Peace River watershed is 52.2 inches. Yearly rainfall totals ranged from a minimum value of 36.6 inches in the year 2000 to a maximum value of 77.9 inches in 1947. Rainfall totals for the four-month summer wet season that runs from June through September average 31.5 inches, while the average rainfall for eight-month dry season that runs from October through May is 20.7 inches.

Yearly deviations from these average values for annual, wet, and dry season rainfall totals were calculated and are presented in Figure 2. There is strong inter-annual variation in yearly rainfall, although sometimes there can be two, three, or more consecutive years with above or below average rainfall (Figure 2A). A number of reports dealing with the hydrology of Peace River (Basso and Schultz, 2003; SWFWMD, 2002; PBSJ and others, 2007; Metz and Lewelling, 2009) have discussed the importance the Atlantic Multidecadal Oscillation (AMO), which is a cyclical pattern in the warming and cooling of ocean temperatures that affects rainfall patterns in North America (Gray and others, 1997; Enfield and others, 2001).

Research suggests that during periods of cooler water temperatures in the North Atlantic Ocean less rainfall occurs in the dry season in peninsular Florida, while warmer temperatures in the North Atlantic produces more summer rainfall (Basso and Schultz, 2003; Kelly, 2004, PBS&J, 2007; Metz and Lewelling, 2009). These authors have discussed a warm AMO phase that extended from 1925 or 1940 through 1969 with typically higher rainfall in peninsular Florida and a cooler phase from 1970 through 1995 or 1999 with typically less rainfall, including in the Peace River basin.

The deviations from yearly average rainfall in Figure 2A largely support these conclusions, but there are significant changes from this pattern within these cycles. For example, two very dry years occurred in 1955 and 1956 during what was predominantly a wet AMO period. Conversely, two very wet years occurred in 1982 and 1983 in what was predominantly a cool, dry AMO period.

Regardless of any possible AMO effects, this report points out some long-term patterns in rainfall for the Peace River watershed that are related to the patterns observed in the streamflow data for the river and its tributaries. The 1950s were generally wet, notably with four successive wet years from 1957 through 1960 when very high flows were observed in the Peace River.

The 1970s were basically dry, with seven years with at least three inches of below average rainfall. Rainfall deficits of 10 and 12 inches occurred in 1989 and 1990 and a severe drought occurred from 1999 to 2001 when the cumulative rainfall deficit was 30 inches, with 21 inches of that deficit occurring in the year 2000. A very prolonged dry period occurred from 2006 to 2013, when there were eight successive years of below average rainfall, with the greatest yearly deficits occurring in 2006 and 2007 (12 and 15 inches, respectively).

There have been some notable wet periods with the last few decades. Rainfall surpluses of 14 and 15 inches occurred in 1982 and 1983. The two-year period of 2004-2005 was also wet, with yearly rainfall surpluses near 11 inches each year. What has been very fortunate for assessing the current status of the Peace River has been four years of average or above average rainfall for four most recent years from 2014 through 2017. The effects of these series of wet and dry years on flow in the river are apparent in the hydrographs and streamflow trends discussed in the following section.

Flow trends in the Upper Peace River

In order to assess the status of flows in the Peace River watershed and the suitability of various locations on the river for obtaining water supplies, hydrographs and trends were examined at the four long-term streamflow gages on the channel of the Peace River plus five of the tributary creeks. The following section focuses on data from the Upper Peace River in Polk County at the Bartow and Ft. Meade gages. Data from the other gages are discussed in more detail later in this report.

Hydrographs of yearly values for mean, median, P5 and P90 flows at the Peace River at Bartow gage are shown in Figure 3 for the years with complete daily records (1940 to 2017). It is visually apparent there has been a declining trend in all these flow parameters, with a shift to generally lower flow values occurring in the 1970's. Prior to 1970 there were no average yearly flows below 100 cfs, but since 1971 there have been 21 years with average flows below that amount. There are also dramatic reductions in the low (P5) and median (P50) flows, again with a shift appearing in the 1970s. However, high values for the P5 and median flows in the 1950s and 1960s may have been partly due to discharges from the phosphate industry, for although they were using large quantities of ground water, much of it was released to the river. Improved water use efficiency and water retention by the phosphate industry in more recent decades has reduced such flows to the river.

The SWFWD has adopted minimum low flows for the Upper Peace River at the Bartow, Ft. Meade, and Zolfo Springs gages (for purposes of minimum flows the SWFWMD identified the Upper Peace as extending to Zolfo Springs). The SWFWMD normally adopts minimum flows using the percent-of-flow approach which covers the entire flow regime of a river, but for the Upper Peace the SWFWMD adopted only a minimum low flow for they could not determine the relative degree that flows in the Upper Peace River had declined due to the effects of groundwater withdrawals versus physical and structural alterations in the watershed. The SWFWMD, however, acknowledges that minimum flows for medium and high flows are important and intends to develop such rules for the Upper Peace River by 2025.

The regulatory rule for minimum low flows at the Bartow, Ft. Meade and Zolfo Springs gages are listed in Appendix B. The minimum low flow for the Bartow gage is a yearly 95% exceedance flow of 17 cfs. This minimum low flow is considered to be met if it is equaled for three years in a row, with provisions for how long the minimum flow must be achieved to be considered in compliance if it goes below 17 cfs for one or more years.

The graph of yearly P5 flows in Figure 3C at the Bartow gage (which are equivalent to yearly 95% exceedance flows) shows that during the 35 years of record prior to 1975 the river met the 17 cfs minimum low flow except for five years (1940, 1943-1945, and 1968). Since 1975, however, the river at Bartow has been below the minimum flow target for 32 of the 43 years. There has been a noticeable rebound in the average and high P90 flows at Bartow since 2014 due to increased rainfall. The median and P5 flow also showed recovery in 2015 and 2016, but returned to low values in 2017 due to low dry season rainfall that year (Figures 2B & 2C).

Climatic trends in rainfall, with a large number of below average rainfall years in the 1970s have clearly played a factor in these declining flows, but as will be discussed later, human factors have also played a role in the flow reductions observed in the Upper Peace River. Also, as discussed below, the relative degree of the declining flow trends observed at Bartow tend to lessen at the long-term gages located farther downstream in the middle and lower reaches of the river.

The declining flows graphically shown for the Bartow gage are confirmed by trend tests on each yearly flow parameter using two techniques; the non-parametric Mann-Kendall test and a linear regression of each flow parameter as a function of year. The results of these tests are listed in Table 4 on the following page along with results from the gages at Zolfo Springs and Arcadia, where flow records go back to the 1930s. For consistency in the comparison of results between gages, the period analyzed for Zolfo Springs and Arcadia were limited to the 1940 to 2017 period that is available for the Bartow gage.

The two statistical tests showed similar results in that the significant declining trends were observed at all three gages in the river, but were most pronounced at the Bartow gage. The Mann-Kendall test is a non-parametric statistical procedure that is frequently used to determine if there is a monotonic trend (doesn't switch between increasing and decreasing) in a time series of values. It generates a Tau statistic, which estimates the degree that adjacent pairs of data are, or are not, identically distributed. The farther the Tau statistic is from zero indicates the strength of either a positive or negative trend. All the Tau statistics listed in Tables 1A are negative, indicating there are trends for declining flows at the long-term gages in the Peace River. Note, however, for all the flow parameters (means, P5, P50, and P90 flows) the Tau statistics are farthest from zero at the Bartow gage, indicating the declining trends are most pronounced in the upper river.

Table 4. Results of trend tests of yearly flow statistics (means, P5, median, and P90 flows) for three long-term gages on the Peace River for the period 1940 to 2017. Results are presented for (A) the non-parametric Mann-Kendall test and (B) linear regression of each yearly flow statisitc as a function of year. P is the probability of type 1 error or that there is no trend. P values less than 0.10 are highlighted in bold.

	A. Mann-Kendall		**B. Linear Regression**			
Gage and yearly statistic tested for trend	**Tau**	**p**	**Slope cfs per year**	**p**	**Slope as % of mean value**	**Slope as % of median value**
Average Yearly Flows						
Bartow (1940-2017)	-0.227	**0.0032**	-2.15	**0.0083**	-1.00%	-1.19%
Zolfo Springs (1940-2017)	-0.197	**0.0108**	-4.31	**0.0113**	-0.72%	-0.81%
Arcadia (1940-2017)	-0.139	**0.0760**	-6.42	**0.0274**	-0.61%	-0.64%
Yearly P5 (Low) Flows						
Bartow (1940-2017)	-0.416	**<0.0001**	-0.57	**0.0008**	-2.05%	-3.20%
Zolfo Springs (1940-2017)	-0.397	**<0.0001**	-1.36	**<0.0001**	-1.35%	-1.55%
Arcadia (1940-2017)	-0.282	**0.0003**	-1.27	**0.0034**	-1.01%	-1.20%
Yearly P50 (Median) Flows						
Bartow (1940-2017)	-0.329	**<0.0001**	-2.02	**0.0003**	-1.64%	-2.23%
Zolfo Springs (1940-2017)	-0.247	**0.0014**	-2.97	**0.0036**	-0.88%	-0.99%
Arcadia (1940-2017)	-0.183	**0.0176**	-4.06	**0.0150**	-0.79%	-0.96%
Yearly P90 (High) Flows						
Bartow (1940-2017)	-0.167	**0.0306**	-3.46	**0.0990**	-0.64%	-0.70%
Zolfo Springs (1940-2017)	-0.134	**0.0828**	-6.85	0.1109	-0.49%	-0.58%
Arcadia (1940-2017)	-0.107	0.1674	-13.50	**0.0896**	-0.50%	-0.57%

P (p) values, which denote the certainty of a statistical test, are also listed in Table 1. P values indicate the probability of incorrectly rejecting the null hypothesis, which in this case would be no trend. A low p value therefore means there is small probability of falsely rejecting the null hypotheses, so the lower the p value the more certainty of the test. Researchers often use a p value of < 0.05 (95% certainty) for identifying a statistically significant result, but I highlighted p values less than 0.1 in Table 4 to identify evidence of trend. Similar to the results for the Tau statistics, the p values tend to be smallest for the Bartow gage indicating the declining trends are most certain there.

Linear least squares regressions were also run to predict each of the yearly flow parameters as a function of year. All slopes are negative, indicating that the flows are generally tending to go down over time. A simple comparison of the magnitude of the slopes between the gages in the upper, middle, and lower reaches of the river can be misleading because they are expressed in cfs per year. Thus, the same relative rate of change (e.g. 2%) would produce a greater slope farther downstream simply because there is more flow in the lower river. To correct for the differences in the quantity of flow between the gages, the slope for each linear regression was divided by the mean and median values for each yearly flow parameter (e.g., the yearly P5 flows) to estimate a relative rate of change of that parameter. Note that the slopes of the regressions expressed as percentages of the mean and median values for each of the flow parameters are greatest at the Bartow gage, again indicating the declining trends are most pronounced there.

At all three gages the relative changes for each of the flow parameters are greatest for the low flows (P5), intermediate for median flows (P50), and least for the high flows (P90). Similarly, the confidence limits of the statistical tests for both the Mann-Kendall and the linear regression are strongest (low p values) for the low flows, intermediate for the median flows and least for the P90 flows. These results indicate the lower end of the flow regime has been most affected at these gages, with intermediate effects in the middle range of flows and less effects at high flows. As will be discussed later, this could mean that some diversions of high flows at various points downstream might be feasible as this component of the river's flow regime has been the least affected.

Although declining trends are reported and rates of change expressed, it is important to note that in actuality the rates of change at these gages has not been constant. It is clear from Figure 3 for the Bartow gage and hydrographs for other gages presented later in this report show there was a large shift in flows beginning in the 1970s. Since the 1970s, flows have been more stable. Other earlier reports have confirmed this by running trend tests beginning in the 1970s and found no significant declining trends for gages in the Peace River since that time (Flannery and Barcelo, 1998; Lewelling and others, 1998; SWFWMD 2002; PBSJ and others, 2007). As will be discussed on page 34, trend tests I ran on data updated through 2017 had similar findings, but there has been a pattern of low P5 flows at the long-term gages since the year 2000 (Figures 3C, 19C and 20C), but the unusually high frequency of years with below average rainfall between 1999 and 2013 has been a major contributing factor (Figure 2A).

Hydrographs and trend tests conducted on flows in other rivers with lightly impacted watersheds (e.g., Hillsborough and Withlacoochee Rivers) have also shown a tendency for declining flows over time periods extending back to the 1930s and 1940s, but no apparent trends since the 1970s. Long-term patterns in rainfall including the influence of the Atlantic Multidecadal Oscillation have clearly played a major role in the observed flow trends for the Peace and other rivers as there was generally more rainfall in the earlier decades.

However, it should not be interpreted that all is well and there are no continued human impacts to flows in the Peace River. When compared to other rivers in the region, the declining flow trends are most pronounced for the Upper Peace River. Also, as described in the next sections of this report, data from recent years clearly show that flows in the upper river have been reduced by hydrologic and physical changes in the upper river sub-basin. To some extent, these human effects on changes on flows in the upper river are manifested father downstream, but become progressively diminished as the river receives flow from less impacted downstream tributaries.

Comparison of flows at the Bartow and Ft. Meade gages, including periodic flow losses

The hydrologic characteristics of the Upper Peace River sub-basin have been the site of intensive study over the last several decades. A topic that has received considerable attention is the periodic occurrence of flow losses between the Bartow and Ft. Meade gages. Time series plots of the same yearly flow parameters shown for Bartow are shown for Ft. Meade in Figure 4. Complete daily flow records for the Ft. Meade gage begin in 1975, so the available data for this gage do not extend to the pre-1970 period when flows tended to be higher in the Peace River. Not surprisingly, the hydrographs for Ft. Meade show no apparent trends, which were confirmed by statistical tests for this period which showed no significant trends.

Rather than having trends over time, the unusual characteristic at the Ft. Meade gage is that the daily flows there are frequently less than the same-day flows at Bartow gage, which is located 13 miles upstream. Graphs of the differences in same-day flows between the Bartow and Ft. Meade gages are shown in Figures 5 A&B. The Bartow flows are subtracted from the Ft. Meade flows, so if the difference is negative that means the flow that day at the Bartow gage was greater. Graphs are shown for the entire period record at the Ft. Meade gage (1975-2017) and for three years from 2014 to 2016 for better visual resolution of the daily patterns.

It is clear from these graphs that daily flows at Ft. Meade are frequently less than at the Bartow gage. For the sake of discussion, the days when there is less flow at Ft. Meade are called flow deficits. On some days this can be a natural phenomenon, as short-term deficits may represent the time lag for an upstream flow pulse to reach the Ft. Meade gage. Flow deficits could result from the storage of water in depressions and floodplain wetlands or evapotranspiration loss between the two gages. Deficits could also be due to errors in the gaged flow estimates at either site, particularly at high flows when the river is out of channel.

Given the possibility of these periodic natural causes, it is notable that deficit flows are very frequent between these two gages and on many days involves large flow quantities. Over the period of record since 1975, daily flows at Ft. Meade were less than the flows at Bartow for 34.7% of the time. If only the flow deficits of greater than 5 cfs are counted, 22.4% of the days have flow deficits. I also examined flow deficits if flows at Ft. Meade were compared to the preceding day flow at Bartow and the number of days of flow deficits were very similar.

Table 5 on the following page provides summary statistics for days per year when there were flow deficits of at least 5 cfs at Ft. Meade. The mean values for days with deficits can be quite large, frequently over 20 to 30 cfs with a maximum value of 442.9 cfs in 2004, which is a special case which will be discussed later. The mean deficits were also expressed as an average rate for the year, calculated by averaging the total quantities during the deficit periods by 365 days. The deficit rates on a yearly basis were smaller, but in excess of 20 cfs in some years.

Table 5. Statistics for days that flow at the Bartow gage exceeded the the flow at the Ft. Meade gage on the Peace River by at least 5 cfs (deficit). The mean deficit for the year is the average deficit between the gages if averaged over the entire year.

Year	Number of days	Mean Deficit	Greatest Daily Deficit	Smallest Daily Deficit	Mean Deficit for Year
	(cfs)				
1975	20	16.4	61	5.6	0.9
1976	22	57.5	185	6.0	3.5
1977	69	14.6	60	6.0	2.8
1978	52	49.5	146	6.0	7.1
1979	108	74.4	320	6.0	22.0
1980	110	36.1	316	6.0	10.9
1981	211	13.5	79	5.8	7.8
1982	117	66.9	420	6.0	21.4
1983	118	72.8	416	6.0	23.5
1984	150	31.6	279	6.0	13.0
1985	122	8.9	25	5.1	3.0
1986	110	31.6	192	6.0	9.5
1987	57	60.7	445	5.2	9.5
1988	34	30.9	89	5.5	2.9
1989	16	58.3	139	7.0	2.6
1990	69	20.3	129	5.0	3.8
1991	94	29.8	338	5.2	7.7
1992	48	60.6	263	6.0	8.0
1993	92	42.3	180	6.0	10.7
1994	120	34.2	178	5.1	11.3
1995	52	45.8	283	5.2	6.5
1996	76	85.1	610	6.0	17.7
1997	123	28.7	166	5.1	9.7
1998	9	11.2	20	6.0	0.3
1999	88	27.1	134	5.1	6.5
2000	135	17.2	51	5.1	6.4
2001	15	17.3	114	5.6	0.7
2002	49	36.2	370	5.1	4.9
2003	33	66.3	240	7.0	6.0
2004	74	442.9	1670	5.3	89.8
2005	34	24.3	56	6.0	2.3
2006	63	9.0	34	5.0	1.6
2007	71	8.3	16	5.1	1.6
2008	145	27.3	175	5.0	10.8
2009	91	7.5	21	5.0	1.9
2010	60	25.2	160	5.0	4.1
2011	104	37.2	527	5.0	10.6
2012	119	11.4	75	5.0	3.7
2013	45	22.2	225	5.0	2.7
2014	101	71.3	562	5.2	19.7
2015	134	79.5	455	5.1	29.2
2016	90	101.9	581	6.0	25.1
2017	75	39.4	236	5.2	8.1

Without attempting to differentiate between natural processes and human influences, differences in daily flow rates between the Bartow and Ft. Meade gages are plotted against the same-day flow at Bartow in Figure 6. As before, the difference is the Ft. Meade flow minus Bartow, so negative values mean less flow (deficit) at Ft. Meade. Graphics are provided for the entire range of flows observed during the 1975-2017 period (Fig. 6A) and flows less than 1,800 cfs at Bartow for better visual resolution (Fig. 6B).

It is clear that there are large values for both flow gains and deficits over the range of flows at Bartow. The string of large flow deficits shown for very high flows at Bartow (> 2,200 cfs) occurred during the passage of three hurricanes over the Peace River watershed in August and September 2004, with the effects continuing into October. **The flow deficits shown during this time are striking, but should be viewed with much caution as there could be errors in the gaged flow estimates at these very high flow rates when water was well outside the river channel**. However, while acknowledging that gaged flow values involve some degree of error, the graph for Bartow flows less than 1,800 cfs shows that both flow gains and deficits are common over a wide range of flows (Figure 6B). As previously discussed, over the period of record there were about one-third of the days when flows were less at the Ft. Meade gage, even though it is located 13 miles downstream of the Bartow gage and represents a 23% gain in drainage area.

Readers are reminded however that these flow deficits were somewhat compensated for on days when the Ft. Meade gage showed a gain in flow. The net average flow at Bartow for 1975 – 2017 was 168 cfs, compared to 195 cfs at Ft. Meade. This represents a 16% increase in average flow at Ft. Meade, although there is a 23% increase in drainage area. There is a net gain in flow at Ft. Meade, but it would be greater if the days with deficits were less frequent.

With regard to compliance with regulatory rules, the SWFWMD adopted a minimum low flow of 27 cfs at the Ft. Meade gage, which is to be exceeded 95% of the time each year. Similar to the minimum low flow for the Bartow gage, the SWFWMD established criteria by which the river at Ft. Meade could meet the minimum flow in subsequent years if it fell below the minimum flow for one or more years. That seems to be a moot point, for in the 43 years of complete daily records since 1975, the low minimum low flow for the Peace River at Ft. Meade has been met only in four years (1983, 2003, 2005, 2016).

As discussed later in this report, the SWFWMD did not establish minimum flows for the entire flow regime of the Upper Peace River because it could not adequately differentiate between the effects of groundwater withdrawals and structural alterations on the declining flows in the upper river. However, based on the declining flow trends at Bartow and the frequent flow deficits observed between the Bartow and Ft. Meade gages, it seems clear that the medium and high flows of the river at the Ft. Meade gage have been impacted. For that reason, with the possible exception of some extremely high flows, no withdrawals should be allowed from the Upper Peace River or its tributaries above Ft. Meade. As will be discussed later in this report, the first point downstream to allow the withdrawal of high flows should be below the confluence with Payne Creek near the town of Bowling Green.

Effects of groundwater drawdowns on streamflow losses in the Upper Peace River

I have used the term flow deficits because some of the daily flow shortages at Ft. Meade could be naturally occurring and involve time lags in flows due to changes in water storage. However, as will be discussed in the following pages, extensive research has shown there are many days where there are losses of water from the Peace River to the underlying aquifers, caused largely by drawdowns in the Upper Floridan and intermediate aquifers due to from extensive groundwater use in the region.

As a result, during very dry periods since the 1980s the channel of the Peace River has gone dry at a number of locations between the Bartow and Ft. Meade gages, whereas in earlier decades it was a perennial stream. Photographs of some of the sites in the Upper Peace River that dried up or had small amounts of ponded water during such dry periods in recent years are shown in Figure 7.

Although the drying of the river in recent years has been obvious, the evidence for the effects of groundwater withdrawals on flows in the Peace River go back much further. Up until the middle part of the 20th century, Kissengen Spring was a major source of flow to the Upper Peace River and was used for recreational purposes for many years . A photograph of Kissengen Spring in 1894 is shown in Figure 8A. The USGS first made flow measurements from Kissengen Spring in 1898 and periodically for years afterwards. Monthly measurements between 1932 and 1936 averaged 29 cfs (Lewelling and others, 1998). However, after those measurements the discharge of the spring progressively declined and ceased flowing in 1950. A report by Peek in 1951 documented this decline and cessation of flow and attributed it to increasing groundwater use in southeastern Polk County, which was "approximately 110 million gallons per day, of which about 75 million gallons per day is used by phosphate companies" (Peek, 1951 as cited by SWFWMD, 2002).

A hydrograph of the declining flows in Kissengen Spring is shown in Figure 8B1. There were temporary periods of flow resumption in 1955 and 1959 due to high water levels in the Upper Floridan aquifer, but permanent cessation of flow occurred in April, 1960 (Lewelling and others, 1998). A photograph of the puddle at the location of the inactive Kissengen Spring is shown in Figure 8C. In addition, artesian wells at the headwaters of the Peace River near Saddle Creek ceased to flow in the 1950s (Stewart, 1966 as cited by Metz and Lewelling, 2009).

The peak of phosphate production in the Upper Peace River basin occurred in the mid-1970s when groundwater pumpage for phosphate mining was estimated to be about 270 million gallons per day (Spechler and Kroening, 2007 as cited by Metz and Lewelling, 2009). There has been some recovery of groundwater levels in the upper Floridan Aquifer near Kissengen Spring since the late 1970s when groundwater levels were at their lowest (Figure 8B2). This increase coincides with the period of time when the phosphate mining industry started water conservation practices. This rise may also be in part due to increased rainfall and improved water conservation by agriculture. Although mining in the Upper Peace River region has declined, an increase in population and agriculture expansion since the 1970s has resulted in a redistribution of some of the pumping stresses (Spechler and Kroening, 2007 as cited by Metz and Lewelling, 2009).

There has been some increase in water levels in the intermediate aquifer system near Kissengen Spring since that the late 1970s (Figure 8B3). This rise is likely the result decreased pumpage from the Upper Floridan aquifer, which in turn causes reduced leakage from the intermediate aquifer system (Knochemus, 2006). Lewelling and others (1998) report that for Kissengen Spring to flow again, a reversal of head gradients near the spring must occur and water levels in the Upper Floridan aquifer near the spring must rebound to above 83.55 feet, which is the elevation of the spring outflow control structure. Water levels briefly reached near that elevation in a nearby Upper Florida aquifer monitor well (WMIS 670300) at the end of the wet season in 2015 and 2016.

It is widely accepted that groundwater drawdowns have resulted in flow reductions in the Upper Peace River (Lewelling and others, 1998; SWFWMD; 2002, Basso 2003; PBSJ and others, 2007; Metz and Lewelling, 2009). Various reports by SWFWMD and other have mapped groundwater levels in the region. For this report I have reprinted maps from Metz and Lewelling (2009) that show estimated drawdowns of the potentiometric surface of the Upper Floridan aquifer from predevelopment conditions to recent years. Figure 9A shows drawdowns in the Southern Groundwater Basin in from estimated pre-development conditions to May 1975, while Figure 9B shows drawdowns from pre-development conditions to May 2007. Comparison of these two maps shows substantial drawdowns in the region, exceeding 50 feet in some areas, but the region of maximum drawdowns has shifted west with some reductions in drawdowns in Polk County.

Figure 10 shows drawdowns in the Upper Peace River sub-basin for May and September 2007, with May representing the end the dry season and September the end of the wet season. The map for May shows that drawdowns in excess of 50 feet occurred in the region of the Peace River between Bartow and Ft. Meade, while the September map shows the drawdowns of between 30 and 40 feet in this region. The years 2006 and 2007 were very dry, and I suspect that groundwater levels may be higher now, for as discussed on page 11 there has been average to above average rainfall for the last four years.

Although there has been some recovery in groundwater levels since the mid-1970s, groundwater drawdowns continue to impact the flow in the Upper Peace River. Whereas the potentiometric surface of the Upper Floridan Aquifer was previously above the elevation of the bed of the river channel, it is now below the channel which causes a tendency for the river to lose water as downward seepage to the underlying aquifers (recharge). Further downstream, the potentiometric surface is above the bed of the river and there is upward seepage to the river.

This spatial relationship is shown in Figure 11, which shows the change in the potentiometric surface from pre-development conditions to average conditions in May for 1988 to 1990 (Basso, 2003). Whereas the potentiometric surface was above the river channel in Polk County during pre-development conditions, it now is below the river channel until near the Polk – Hardee county line and near the surface of the river bed in Hardee county, albeit for dry springtime conditions. Maps are not shown for the intermediate aquifer, but lowering of the Upper Floridan aquifer acts to lower the surface of the intermediate aquifer as well.

Using a variety of methods, the USGS has done extensive studies of the hydrogeology of the region and relationships between groundwater levels and streamflow in various reaches of the Peace River (Lewlling and others, 1998; Metz and Lewelling, 2009). Those reports should be consulted for detailed information on these topics, which I do not cover in detail here. As expected, the interactions of groundwater levels and flow in the river can change with climatic conditions, as water levels in both the river and the intermediate and Upper Floridan aquifers respond to changes in rainfall during wet and dry periods.

Some characteristics, however, are generally true for the Peace River with important implications for water supply planning and natural resource management. Lewelling and others (1998) described three distinctive hydrogeologic areas along the Peace River: (1) the Upper Peace River near Bartow where groundwater recharge occurs; (2) the middle Peace River near Bowling Green where reversals of hydraulic gradients occur; and the lower Peace River near Arcadia where groundwater discharge to the river occurs. Changes in these hydrogeologic relationships contribute to the higher rates of area-based runoff for the gages in the middle and lower reaches of the river compared to runoff rates for the upper river gages that are listed in Table 1.

A distinctive characteristic of the Upper Peace River has been the formation of sinks, crevasses, and other karst features in the channel and floodplain of the Peace River between Bartow and Homeland, which is about 5 river miles north of the Ft. Meade gage. Based work conducted between 1979 and 1981, Patton (1981) and Patton and Klein (1989) identified approximately 90 actual and/or probable solution features and discussed sinkhole formation and its effect on the hydrology of the Peace River. Patton and Klein conclude that the increased sinkhole formation was due to extensive groundwater use in the region, and state “that all available data indicate that increased water table drawdown and declining potentiometric levels in the aquifers in the Upper Peace River basin have led to intensified solutional activity and increased collapse.”

They also made the important finding that the sinkholes were not only in the river channel, but occurred in the river floodplain as well. They state that these sinks and other solutional conduits act as influent channels into the Upper Floridan aquifer, and due to the number of these features they are capable of affecting flow in the Peace River during times of both low and high water levels in the river. They furthermore suggested that the greatest loss of flow from the river occurs during high water levels in the river, resulting in a reduction in the amplitude and duration of high water flow.

In more recent years, extensive studies of the effects of the sinks and other karst features on flows in the river have been conducted by the Water Resources Division of the U.S. Geological Survey, notably the studies by Lewelling and others (1998) and Metz and Lewelling (2009). These researchers used a variety of techniques to examine the interactions of these karst features with the hydrogeology surrounding the river and the river’s flow, including aquifer tests, dye studies, isotope analyses, seismic reflection, and a series of seepage runs in which flows were measured at many stations along the river during various flow conditions.

Figure 12 shows a map of the principal karst features along reaches 1 and 2 of the upper river identified by Metz and Lewelling (2009). These two reaches, which extend for about two miles starting about one mile below the Bartow gage, include some of the largest karst features in the river and is where most of the flow losses have been observed. Photographs of karst features in the channel of the Peace River in reaches 1 and 2 are shown in Figure 13. At very low flows during droughts, the entire flow of the Peace River can flow into the ground through karst features such as these.

Figure 14 shows karst features located in the floodplain of the river in this same region, including two of the largest features, Gator Sink and Dover Sink. Water flows into these sinks at higher river stages via distributary channels that extend off of the main channel of the Peace River. Two photographs are shown of Dover Sink, one during low river stages and one when the sink is inundated by river water during a period of high flows and levels. The authors point out that an extensive network of cavities exist beneath the walls of Dover Sink which can store large volumes of water. During the dry season, large unfilled cavities exist, but when the rainy season begins, river water flows into Dover Sink and fills these void spaces in the underlying aquifers. Because the conduit system near Dover Sink is very large, it can accommodate a large proportion of flow from the river at multiple river stages (Metz and Lewelling, 2009).

Both of these USGS studies performed seepage runs in which flow in the river was measured at many locations in the river over a period of just a few days, usually with no rainfall, to measure areas of flow gains and losses in the river. The study by Lewelling and others (1998) included two base-flow seepage runs over a 74 mile reach of Peace River between Bartow and Nocatee, while a third high-flow seepage run focused on the upper river between Bartow and Ft. Meade. The later study by Metz and Lewelling (2009) focused strictly on streamflow losses in the upper river between Bartow and Ft. Meade.

Figure 15 shows areas of streamflow losses and gains in reaches 1 and 2 for seven seepage runs conducted between June 2002 and March 2006 in the study by Metz and Lewelling (2009). The area of highest streamflow loss was between site 7 (located 1.8 miles below the Bartow gage) to site 11 (3.7 miles below Bartow gage). The average total seepage loss in this reach for these seven was 22.7 cfs, with a minimum value of 11.6 cfs and a maximum value of 49.9 cfs. The results of a low-flow seepage run from May 2003 were compared to a low-flow seepage run conducted during May 1996 during the study of Lewelling and others (2009) with similar results (17.3 and 17.8 cfs).

During high flow periods, large losses of water were observed in reaches 1 and 2 due to floodplain storage rather than losses to karst features. The authors state that in reach 1 water drains to a series of interconnected pit lakes by way eastern ditches along the eastern floodplain. Similarly, during higher flows river water drains to pit lakes along the western floodplain in reach 2. One of these pit lakes has the capacity to store large volumes of river backwater (Metz and Lewelling, 2009). As part of the earlier study, a high-flow seepage run was conducted to measure flow losses from the river channel and floodplain during higher flows in August 1995. Total streamflow losses in a 7.2 mile reach extending from 3.7 to 10.9 miles below the Bartow gage was approximately 10 percent of river flow, or about 118 cfs, but it was noted that the magnitude of most seepage losses calculated during the high-flow run were within the range of discharge measurement error of five to eight percent (Lewelling and others, 1998).

The results from these two USGS studies are provided only as an overview of some findings regarding the Upper Peace River. However, it is emphasized the interactions of groundwater with flows in the Upper Peace River are spatially complex, involving both the intermediate and Upper Floridan aquifers. In that regard, the SWFWMD (Gates, 2009) implemented a series of nested wells to examine relationships of water levels in the surficial, intermediate and Upper Florian aquifer in the vicinity of the Upper Peace River. As with other documents cited in this report, readers are encouraged to obtain the original reports for thorough discussions of the interaction of groundwater with streamflow and other related topics pertaining to the Peace River.

Other factors affecting flows in the Upper Peace River

Four of the reports that are listed on page 5 and referenced extensively in this report discuss other factors affecting flows in the Upper Peace River, with the broadest assessments provided by SWFWMD (2002) and PBS&J and others (2007). As previously discussed, long-term changes in rainfall with generally greater yearly rainfall totals in the 1950s and 1960s have been acknowledged as a major factor affecting streamflow trends in the Peace River. As also discussed, groundwater drawdowns have also been an important factor contributing to declining flows in the Upper Peace River. However, there have been physical and structural alterations to the Upper Peace River sub-basin which have also likely played roles in the observed flow trends.

Phosphate mining in the drainage basin of the Upper Peace River - Figure 16 shows the distribution of major land uses within the drainage basin of the Upper Peace River for the year 2005. It is clear that phosphate mining is a major land use with much of the mining in very close proximity to the Upper Peace River, which in Figure 16 extends to the Polk/Hardee County line. Using data from 1999, SWFWMD (2002) reported that 26.2% of the drainage basin above the Zolfo Springs gage (which is located approximately 10 miles south of downstream limit of Figure 16) has been mined, but points out that much of the mined land is above Ft. Meade and also in the Payne Creek sub-basin.

Much of the mining in the drainage basin of the Upper Peace River was done before the state of Florida first required mandatory reclamation of mines lands in 1975, while other areas were mined when the reclamation standards are not what they are today. There are extensive clay setting areas located in very close proximity to the floodplain of the Upper Peace River, which have entirely different physical properties in terms of water storage and transmission than the landscape prior to mining (Brickman and Koening, 2007 as cited by Metz and Lewelling, 2009). Also, many small natural stream channels were mined in the upper river basin.

More thorough descriptions of the history and distribution phosphate mining and its effects on the physical hydrography of the Upper Peace drainage basin are provided by the five reports listed on page 5, plus an earlier USGS report about hydrologic differences between mined and unmined lands (Lewelling and Wylie, 1993). Based on those findings and other work in the region, it is reasonable to conclude that the extensive mining along the banks and in the watershed of the Upper Peace River that was done over many earlier decades has had a significant effect on the river's hydrology.

Reduction or elimination of wastewater discharges - An important factor that could have affected the hydrographs and trends for low and medium flows in the Upper Peace River was the reduction or elimination of wastewater discharges. The report by SWFWMD (2002) claims that beginning around 1985 a number of wastewater discharges to the upper river were either reduced or eliminated, including water used for phosphate mining and processing, discharges from associated chemical plants and several wastewater treatment plants.

As mentioned on page 11, the phosphate industry used to pump more ground water than they do now, but much more of this water made its way to the Peace River and its tributaries. Improvements in water use efficiency, conservation and retention by the industry has reduced these flows to the river. Relatively large reductions in phosphorus and fluoride concentrations in the upper river and at the Arcadia gage indicate that a significant sources related to mining activity were reduced or eliminated around 1985 (SWFWMD, 2002).

The flow of excess water from mining activities may be partially why there were high values for low and medium flows at the Bartow gage in the 1950s and 1960s. A similar rise in low flows was observed in the Alafia River, where extensive mining also occurred during this time (SWFWMD, 2008). It is again reiterated that wet climatic conditions were also a major factor during those decades, which also would resulted in increased flows resulting from mining activity during that time.

Additional reductions in low flows in the Upper Peace River were likely partly due to the removal of point source discharges in the basin. For example, in 1987 approximately 14 to 16 cfs of wastewater from the City of Lakeland's municipal treatment plan was removed from the Stahl Canal, which flowed to upper river system via connections through Banana Lake, Lake Hancock and Saddle Creek (SWFMD, 2002). Although the effects of groundwater withdrawals resulted the Upper Peace River to lose water to the underlying aquifers in the 1950s and 1960s, low flows in the river channel were not as noticeably affected because these losses were partially offset or masked by an increase in wastewater discharges to the river. As these discharges were reduced or eliminated, the reductions in low flows became more apparent.

Other physical alterations of the drainage basin of the Upper Peace River

In addition to extensive phosphate mining there have been other physical modifications of the basin of the Upper Peace River sub-basin. The reports by SWFWMD (2002) and PBS&J and others (2007) provide detailed descriptions of other changes that have occurred over time in the major sub-basins that comprise the Upper Peace River basin. The two major sub-basins that contribute flow to the Upper Peace River at the Bartow gage are the Saddle Creek sub-basin, which includes the inflows and outflows from Lake Hancock, and the Peace Creek sub-basin to the east. These two creeks join about one mile above the Bartow gage to form the Peace River.

Both the Peace Creek and Saddle Creek sub-basins are not typical stream catchments as they do not a well defined dendritic network of streams. Instead, these sub-basins are physically complex with headwater lakes, water control structures, drainage canals and some areas that are internally drained. Groundwater drawdowns have interacted with these physical characteristics to reduce flows contributions to the Upper Peace River.

Modifications to the Peace Creek drainage basin - SWFWMD (2002) describes the creation of several local drainage districts in the Peace Creek drainage basin in the early part of the 20th century and construction of canals as part of the Peace Creek Drainage Canal. These canals allowed for improved drainage and may have lowered groundwater and surface water levels in the region (SWFWMD, 2002). Additionally, Johnson (1960 as cited by SWFWMD, 2002) reported the Peace Creek drainage basin received more drainage from the Green Swamp to the north before construction of the Atlantic Coastline railroad track and U.S. Highway 17&92. Pride and others (1966) also suggested that the construction of levees, ditches, highways and railroad fills and other drainage improvements reduced the drainage from the Green Swamp area to the headwaters of Peace River basin in northern Polk County.

In my opinion, it is difficult to evaluate the net effect of the drainage modifications in the Peace Creek sub-basin, but whatever these effects have been they are reflected in the flows at the Peace River at Bartow gage, which has experienced significant flow declines over the years.

Control structures on headwater lakes - Another significant alteration of the drainage basin of the Upper Peace River include the placement of water control structures and management of water levels on many of the headwater lakes that are occur in the Peace Creek and Saddle Creek sub-basins. While the effects of these modification are uncertain and somewhat speculative, the report by SWFWMD (2002) suggests that there was a considerable loss of lake storage associated with modification of these lakes and the construction and connection with of the Peace Creek Drainage Canal system.

As described later in this report, the SFWWMD has pursued a project in the Saddle Creek sub-basin to raise water levels in Lake Hancock in an effort to release water to the Upper Peace River to help achieve minimum flows.

Alteration of natural stream catchments and channels - In their assessment of cumulative impacts to the Peace River and its watershed, the report by PBSJ and others (2007) includes a section on the loss of natural stream channels throughout Peace River watershed between the 1940s and 1999. They considered the loss of a natural stream channel could result from modifications such channelization, filling, grading, and otherwise altering natural streams. They found that a total of 347 miles of natural stream channels had been lost throughout the Peace River watershed, with the largest losses resulting from mining (101.2 miles), agriculture (64.5 miles) and urban (37.5 miles) land uses.

They state that most of the losses were to smaller first and second order streams rather than to the river channel, although a portion of the Peace River below Lake Hancock has been channelized. They also point out that streams already channelized before the 1940s were not counted, so the estimate of stream segments that were lost are conservative. Since the 1940s, they found that the largest of natural stream channels was in the Lower Coastal Peace sub-basin (77.5 miles), followed by sub-basins in or near the upper river including Payne Creek (66.9 miles), the Peace River at Bartow (57.8 miles) and the Peace River at Zolfo Springs (31.6 miles). Urban land uses resulted in the most natural stream loss in the Lower Coastal sub-basin, while mining resulted in the most stream loss in the sub-basins in the upper river.

The report by Metz and Lewelling (2009) includes maps of the surface drainage network of the Upper Peace River sub-basin for historical (1850-1855) and recent (1985) conditions. They also point out that many stream channels were altered by phosphate mining and agricultural activities. The state that the altered streams previously had dendritic (branched) drainage patterns and channels that were longer than their current configuration.

Relationship of physical and structural alterations to the determination of minimum flows

Minimum flows are intended to manage the effects of water withdrawals on streamflow and natural systems, as Chapter 373.042 defines minimum flows as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." However, in addition to water withdrawals other human modifications to stream catchments can affect the flows of rivers and streams, so Section 373.042(1) F.S. states that when establishing minimum flows the governing board "shall consider changes and structural alterations had had, and the constraints such changes or alterations have placed on the hydrology of the affected watershed, surface water, or aquifer, provided that nothing in this paragraph shall allow significant harm as provided by S. 373.042(1) caused by withdrawals." In essence, the District is to evaluate and account for the effects of previous structural alterations on a watercourse when assessing the potential for withdrawals, whether from ground water or surface water, to cause significant harm to the natural systems of a stream or river.

The combined findings of studies and assessments of the Upper Peace River basin indicate the observed declines in flows in the Upper Peace River are due to a combination of changes in rainfall, groundwater withdrawals in the region, and physical and structural alterations in the upper river's drainage basin. In their minimum flows report for the Upper Peace River, SWFWMD (2002) concluded that while the medium and high flows in the Upper Peace River in recent decades “are not adequate to protect ecological resources across the entire flow regime, the inability to achieve those flows in a quantitative way cannot, at this time, be adequately partitioned among the various controlling factors (rainfall, structural alterations and changes, withdrawals).”

For that reason, minimum flows for medium and high flows were not adopted for the Upper Peace River at that time (2002). However, SWFWMD suggested that the findings of the report could be used to be used to develop strategies to restore components of the rivers flow regime and natural systems by a combination of physical, regulatory, and other water management techniques. They also suggested that a full range of minimum flows could be adopted in the future, but will likely require the development of additional tools such as an integrated ground water / surface water model of the river to better differentiate between the effects of withdrawals versus other changes in the watershed.

Although minimum flows for the entire flow regime of the Upper Peace River have not been adopted at this time, it is clear that the entire flow regime of the river has been affected by human activities. The findings that support this conclusion are the significant declining trends at the Bartow gage, the documented effects of groundwater drawdowns on flow losses in the Upper Peace River, and the frequent flow deficits observed between the Bartow and Ft. Meade gages which occur over a wide range of flows. Considering these findings, it is my conclusion that with the possible exception of some extremely high flows, no withdrawals should be allowed from the Upper Peace River above the confluence with Payne Creek until minimum flows for medium and high flows for the upper river are adopted, as it could well be determined the entire flow regime of the Upper Peace River upstream of Payne Creek is in recovery.

Lake Hancock modifications

As mentioned on page 24, the SWFWMD has pursued a large project on Lake Hancock to improve the quantity and quality of the water flowing from the lake to the Upper Peace River via Saddle Creek. The project has two primary components. The first was to replace the water control structure at the lake in order to raise the operating levels in the lake to reflect more historic water levels. This increases the water storage in Lake Hancock, allowing more water to be released to Saddle Creek and the Upper Peace River in the dry season to help meet the adopted minimum flows for the upper river.

The Lake Hancock project also involved the construction of a 1,000 acre treatment wetland near the outlet of the lake to remove particulate matter and improve the water quality of the water leaving the lake in order to reduce the nutrient load to the Peace River and Charlotte Harbor. Both of these projects have been completed, but the full establishment of the marsh vegetation in the treatment wetland is still underway.

The separate outlet structures at Lake Hancock and the treatment marsh are gaged to measure flow. The SWFWMD accesses flow data from these sites on a real-time basis to release water to Saddle Creek in the dry season to help meet the minimum flows for the Upper Peace River. This is a promising strategy, but it may be easier to meet the minimum low flow at the Bartow gage as opposed to the Ft. Meade gage due to water losses between these two sites.

Morphological characteristics of the Upper Peace River and its floodplain - Considerations for the location of possible future withdrawals

The morphological characteristics of the Upper Peace River and the hydrological requirements of floodplain wetlands associated with the upper river also pertain to my recommendation that with the exception of some extremely high flows, no withdrawals be obtained from the Upper Peace River above the confluence with Payne Creek. Figure 17 shows a map of wetland types along the upper river above Zolfo Springs. These wetlands were identified by U.S. Fish and Wildlife's National Wetlands Inventory, with the map adapted from the minimum flows report for the upper river (SWFWMD, 2002).

The light-green color in the map denotes deciduous wetlands that are semi-permanently flooded (P_FO6_F in the key). These wetlands are widely distributed from just above Bartow to Ft. Meade, but are much less abundant below there where the river becomes more incised. The blue color (P_FO6_C) denotes broad-leaved deciduous wetlands that are seasonally flooded, which are also widespread in this same reach but extend a little below Ft. Meade with isolated pockets located farther downstream.

Approximately two miles below Ft. Meade, broad leaved deciduous forests that are temporarily flooded (pink, P_FO1_A) become more abundant due to changes in the morphology of the river floodplain. Farther downstream about two miles below Bowling Green just below the confluence with Payne Creek, these wetlands then become less abundant. From there, uplands (gray, U) become more common, although there are pockets of seasonal and semi-permanent wetlands farther downstream, particularly between Wauchula and Zolfo Springs.

The minimum flows report by SWFWMD (2002) presented graphs and tables that showed the hydroperiods of these wetlands have been greatly reduced due to the flow declines that have occurred in the Upper Peace River. These hydroperiod reductions have been most acute and have probably had the most pronounced ecological impacts in the semi-permanent and seasonally flooded wetlands in the upper reaches of the river above Bowling Green. Further withdrawals would only worsen the hydrologic conditions in these wetlands which are a critical part of the river ecosystem, supporting the conclusion there should be no withdrawals from the upper reaches of the Peace River.

Given the distribution and hydrologic requirements of these wetlands, there should be no new withdrawals for any purpose above the confluence with Payne Creek. An exception could be the infrequent diversion of extremely high flows that inundate uplands, homes or crossings in the upper reaches of the river. No withdrawals should be allowed above Payne Creek that reduce the hydroperiods of riverine wetlands upstream of that location.

Considerations for the locations of possible withdrawal points to capture high flows farther downstream are discussed in the following section, which discusses the status of flows in the middle and lower reaches of the Peace River.

Streamflow characteristics of the middle and lower Peace River and its tributaries

The spatial patterns of land and water use in the middle and lower reaches of the Peace River watershed are very different from that of the upper river. Consequently, the human effects on streamflow are different as well. In the following section, time series and trends in streamflow and are compared between the Upper Peace River with the middle and lower reaches of the river. The differences in these streamflow characteristics are briefly discussed with regard to spatial differences in the region's physiography, hydrogeology, and patterns of land and water use as they pertain to determining preferable locations for obtaining water supplies while minimizing the potential for adverse environmental impacts.

Land use - Maps of the distribution of four major land use categories in the Peace River watershed are shown in Figure 18 for the 1940s, 1979, and 1999. The maps, which are adapted from the cumulative impact study of PBS&J and others (2007), show the distributions of improved pasture, intensive agriculture, urban development and mining. That report can be viewed for detailed discussions of the changes in land use over time in the major sub-basins in the Peace River watershed.

The major drainage sub-basins in the watershed are labeled in the map for the 1940s land use. It is apparent from Figure 18 that mining has greatly increased in the sub-basins of the Upper Peace River, including the sub-basin of Payne Creek. Apparently, since 1999 there has been some additional mining including in the Horse Creek sub-basin, but I did not check any more recent land use coverage maps or data.

Urban land uses are centered in two locations. First, in the Upper Peace River basin, particularly in the area of the headwater lakes in and near the cities of Lakeland and Winter Haven. Second, in the very lower region of the watershed along the tidal reach of the river associated with the cities of Port Charlotte and Punta Gorda. In between these two areas, other smaller urban areas are associated with the towns of Bartow, Ft. Meade, Bowling Green, Wachula, Zolfo Springs and Arcadia.

Agricultural land uses are widespread in the middle and lower regions of the watershed. Of particular note is the increase in intensive agriculture (row crops and citrus) in the sub-basins of Joshua and Shell Creeks and the Peace Arcadia and Lower Peace sub-basins. These agricultural land uses have much greater water use rates than improved pasture, which is often not irrigated or at much less rates.

Hydrogeologic characteristics - The hydrogeology of all or parts of the Peace River watershed is described in a number of documents (Lewelling and Wylie, 1993; Lewelling and others, 1998; SWFWMD, 2002; Basso, 2003; PBSJ and others, 2007; Metz and Lewelling, 2009). Briefly, there are three recognized aquifer systems in the region. As described by Basso (2003), at the surface and extending up to several tens of feet thick is the unconfined surficial aquifer. It is generally comprised of unconsolidated quartz sand, silt, and clayey sand. Underlying the surficial aquifer is the confined intermediate aquifer system which consists of a series of thin, interbedded limestone and phosphatic clays of generally low permeability**.** The third aquifer system, which underlies the intermediate aquifer system, is the confined Floridan aquifer system which is composed of a series of limestone and dolomite formations.

The Floridan aquifer if further divided into the Upper Floridan aquifer and the Lower Floridan aquifer, which are separated by a middle confining unit. Because of its poor, briny water quality, deeper depth and limited ability to yield water, the Lower Floridan aquifer is primarily used for disposal of industrial waste through deep well injection. Water supplies for municipal, industrial, and agricultural use are obtained from the higher quality and more productive Upper Floridan aquifer.

An important characteristic is that the surface of the Upper Floridan aquifer is closer to the land surface in the upper reaches of the Peace River watershed. The Upper Florida aquifer becomes gradually deeper in southerly and westerly directions and is more hydraulically isolated from the surficial aquifer and the streams channels in the lower reaches of the Peace River watershed due the presence of thicker confining units. This has important implications on how groundwater withdrawals interact with streamflow in different regions of the Peace River watershed.

Streamflow trends in the middle and southern regions of the Peace River watershed

In addition to a number of smaller streams, there are five major tributaries that flow to the Peace River south of Bowling Green, which from north to south are Payne Creek, Charlie Creek, Joshua Creek, Horse Creek, and Shell Creek (Figure 18). Flow statistics for these creeks dating from 1975 were listed in Table 3, with this time period chosen to be consistent with the period of record for the Peace River at Ft. Meade gage. It was discussed on page 9 that since 1975, the rates of area-based runoff in average cfs per square mile from these creek sub-basins are markedly greater than for the Upper Peace River sub-basins measured by the gages at Bartow and Ft. Meade.

Flow records for four of these creeks go back to before 1975, which allows for an interesting comparison of flow trends with the Peace River. The first year of complete daily records begins in 1951 for Charlie, Horse and Joshua Creeks, while the first year of complete daily records for Shell Creek is 1965 and 1980 for Payne Creek. Trends in flows at these creeks are discussed, but it is first useful to examine hydrographs for gages on the Peace River at Zolfo Springs and Arcadia for comparison.

Flows at Zolfo Springs and Arcadia - Hydrographs of yearly values for average annual flows, P5, median (P50) and P90 flows are presented for the years with complete daily records for the gages on the river at Zolfo Springs and Arcadia (Figure 19 and 20). The records are quite long, beginning in 1931 at Arcadia and 1934 at Zolfo Springs. The hydrographs for these gages appear similar to the long-term hydrographs for the Bartow gage in that generally higher values were observed in the decades prior to the 1970s. However, the declines in the flow parameters generally don't appear as pronounced as those shown for the Bartow gage (Figure 3). This is confirmed by the differences in the Tau statistics, p values, and relative slopes in the statistical trend tests that were presented in Table 4 (page 13).

There has been a dramatic drop in the low flows at Zolfo Springs as evidenced by the hydrograph of the P5 low flows (Figure 19C). The SWFWMD has adopted minimum low flow of 45 cfs at the Zolfo Springs gage, which is to be met 95% of the time each year, equivalent to the P5 flow shown in Figure 19C. In the 66 years of record prior to the year 2000, the minimum flow was met all years with the lowest P5 value of 52 cfs in the 1985 drought. However, in the 18 years since the year 2000 the minimum flow has not been 11 times, with the lowest P5 value (7 cfs) recorded in the year 2000. The years with below average rainfall that have periodically occurred since the severe drought in 1999-2001 have been a factor, but there were also some droughts in earlier decades and it appears that human factors have contributed to the decline in low flows at the Zolfo Springs gage. As discussed on page 14, there were also significant declines in the medium and high flows, but the trends were most pronounced at low flows, as this appears to be the component of the flow regime of the Peace River that has been most affected.

The time series plots of the yearly flow parameters at the Arcadia gage shows similar patterns to the Zolfo Springs, with the lowest P5 values recorded since the year 2000. The lowest values for the other parameters shown were also in the year 2000, with the exception of a nearly equal minimum value of 338 cfs for the P90 flow in 2007 when the combined rainfall deficit for that year and 2006 was 26.9 inches. The average yearly flow value in 2007 was also very close to the minimum average yearly flow in the year 2000.

It is encouraging to point out that flows at all gages in the river have increased in recent years, as there has been average or above average rainfall since 2014. Graphs of average yearly flows and other flow parameters at all gages on the river have shown increases in the last four years. An interesting variation to this is the very low P5 values in 2017, as that year started off very dry, but had above averages wet season rains (Figure 2B) which resulted in very high P90 and annual average flows. Flows have generally been generally above average during 2018 as there has been above average rainfall through the month of August.

Flows in major tributaries - Hydrographs of the same yearly flow parameters are shown for the Payne, Charlie, Joshua, Horse, and Shell Creeks in Figures 21 through 25. For Charlie and Horse Creeks (Figures 21 and 22), where flow records go back to 1951, the declines in flows from before the 1970s to later decades are not as readily apparent as for the gages on the river. These are much smaller sub-basins compared to the river and have different hydrographic characteristics, so some natural differences in long-term flow patterns can be expected. Similarly, they have different hydrogeologic characteristics, especially compared to the upper river, which could also result in differences in the streamflow response to changes in long-term rainfall.

The sub-basins of Charlie and Horse Creeks, however, also have less intensive land and water use than the sub-basin for the Upper Peace River. This has likely contributed to differences in their flows over time compared to the Peace River, especially in its upper reaches were human impacts to flows have been most pronounced. For a recent treatment of the hydrologic characteristics of Charlie Creek, readers should consult the report by Lee and others (2010), which evaluates of the effects of groundwater levels and headwater wetlands on flows in Charlie Creek. The flow regime of Charlie Creek probably represents the natural hydrology of lightly altered drainage basin in the Peace River watershed (SWFWMD, 2005A).

With flow records also going back to 1951, a very different pattern is seen for Joshua Creek (Figure 23). There is no apparent trend in average yearly flows, but the P5 low flows and median flows are increasing. Other articles and reports have concluded these increases in low and medium flows in Joshua Creek are the result of agricultural irrigation. Excess irrigation waters can directly reach the stream, plus irrigation can supplement the surfical aquifer which can increase baseflow and also result in greater runoff after storm events due to more saturated soil conditions (Flannery and Barcelo, 1998; PBS&J and others, 2007).

Compared to the upper reaches of the Peace River, the top of the Upper Floridan aquifer is deeper and more isolated from the surficial aquifer and surface water features in the Joshua Creek sub-basin. Groundwater withdrawals therefore do cause similar effects on streamflow losses, as pumpage of the deep groundwater to the land surface for irrigation can result in increased streamflow as just described. Similar increases in low flows have also been documented in the Little Manatee and Myakka Rivers, which have similar hydrogeologic characteristics, due to the effects of extensive agricultural irrigation within their watersheds (Flannery and others, 1992; SWFWMD, 2011).

Daily flow records for complete years go back to 1980 for Payne Creek, which flows into in the upper river near Bowling Green. As discussed on page 9, flows from Payne Creek are very important to improving the flow conditions and sustaining the river below Ft. Meade. The Payne Creek sub-basin is complex, as there has been extensive mining there with reclamation in various stages of succession. In a report prepared for the Florida Institute of Phosphate Research, Schreuder Inc. (2006) concluded that for Payne Creek and a series of other streams that have had extensive mining in their drainage basins, flows have not been reduced by mining activities in part due to reduced evapotranspiration from the mined/reclaimed lands. There have been concerns expressed, however, that as vegetation growth and succession proceeds on reclaimed lands evapotranspiration rates may increase.

Hydrographs for yearly flow parameters for Payne Creek are shown in Figure 24, with the horizontal axis extending back to 1950 for easier comparison to the hydrographs for the three creeks with longer flow records. All parameters show expected variations between wet and dry years since 1980. Similar to the downstream gages on the river (Zolfo Springs and Arcadia), the P5 low flows remained fairly high before the year 2000 then dropped to lower values in very dry periods since then. I have no work experience in Payne Creek and don't know if possibly there were changes in discharges from mines or other facilities may have influenced these values, but there were droughts in 1981 and 1985 and low P5 values would have been expected then.

Of special significance to the Peace River is Shell Creek, which as described on page 9, comprises the largest tributary sub-basin in the Peace River watershed and has the highest average flow (348 cfs) for comparison purposes since 1975 (Table 3). Shell Creek is located the southeastern region of the Peace River watershed, flowing into the Peace River about eight miles upstream of the river mouth at Charlotte Harbor. Shell Creek is impounded by a low-head weir about six miles upstream of its confluence with the river. During the dry season, brackish waters from the tidal reach of Shell Creek can extend up to the weir. The USGS streamflow gage Shell Creek near Punta Gorda measures freshwater flow over the top of the weir. The City of Punta Gorda has obtained municipal water supplies from the small reservoir created by the weir since the 1940s. Water use as increased slowly over the years, with yearly water use rates of 2 to 3 million gallons per day (mgd) in the 1970s increasing to a maximum average water use rate of 5.4 mgd (equal to 8.4 cfs) in 2017. For much of the year, the water use by the City of Punta Gorda comprises a small fraction of the flow at the weir, but can comprise an appreciable portion of the flow during dry periods, resulting in brief periods of near zero flow at the weir during droughts.

Hydrographs of yearly flow parameters for Shell Creek at the weir are shown in Figure 25. Withdrawals by the City of Punta Gorda were added into the flow record to represent changes in the total flow of Shell Creek over time. Although the flow records start in 1965, the horizontal axis goes back to 1950 for easier comparison to the hydrographs for Charlie, Horse, and Joshua Creeks. There are no visually apparent flow trends with Shell Creek, but the P5 low flows show a period of relatively high values in the 1990s due to climatic conditions. It is also noted the P5 flows were lowest in the 1970s, even though there were several very dry years between the years 2000 and 2013. Similar to nearby Joshua Creek, evidence indicates that increased agricultural land use and irrigation has contributed to increasing low flows in the Shell Creek sub-basin (PBS&J and others, 2007).

For a more quantitative comparison of changes of flows in the creeks compared to the Peace River, the non-parametric Mann-Kendall test was applied to the yearly flow parameters over time and a linear regression of each flow parameter as a function of year was developed. The results of these statistical tests for the four tributaries where flow records extend prior to the 1970s are presented in Table 6, along with results for the three long-term gages on the river (Bartow, Zolfo Springs, and

Table 6. Results of trend tests of yearly flow statistics (means, P5, median, and P90 flows) for three long-term gages on the Peace River and Charlie, Horse and Joshua Creeks for the period 1951 to 2017, with the period for Shell Creek beginning in 1965. Results are presented for (A) the non-parametric Mann-Kendall test and (B) linear regression of each yearly flow statisitc as a function of year. P is the probability of type 1 error or that there is no trend. P values less than 0.10 are highlighted in bold.

	A. Mann-Kendall		B. Linear Regression			
Gage, flow period, and yearly statistic tested for trend	Tau	p	Slope cfs per year	p	Slope as % of mean value	Slope as % of median value
Average Yearly Flows						
Charlie Creek (1951-2017)	-0.029	0.725	-0.84	0.4060	0.32%	-0.38%
Horse Creek (1951-2017)	-0.058	0.458	-0.58	0.4110	0.31%	-0.33%
Joshua Creek (1951-2017)	0.083	0.322	0.03	0.5025	0.02%	0.02%
Shell Creek (1965-2017)	0.154	0.1039	2.38	0.1110	0.65%	0.69%
Peace nr. Bartow (1951-2017)	-0.184	**0.0276**	-2.30	**0.0270**	1.13%	-1.46%
Peace at Zolfo Springs (1957-2017)	-0.163	**0.0508**	-4.25	**0.0440**	0.75%	-0.92%
Peace at Arcadia (1951--2017)	-0.099	0.2366	-5.91	**0.0995**	0.59%	-0.62%
Yearly P5 (Low) Flows						
Charlie Creek (1951-2017)	-0.041	0.6222	-0.03	0.4510	0.45%	-0.38%
Horse Creek (1951-2017)	-0.099	0.2360	0.03	0.4616	0.57%	1.02%
Joshua Creek (1951-2017)	0.500	**<.0001**	0.18	**0.0247**	2.30%	3.20%
Shell Creek (1965-2017)	0.190	**0.0440**	0.25	0.2579	0.92%	1.43%
Peace nr. Bartow (1951-2017)	-0.527	**<.0001**	-0.99	**<0.0001**	3.48%	-5.80%
Peace at Zolfo Springs (1957-2017)	-0.489	**<.0001**	-2.15	**<0.0001**	2.12%	-2.47%
Peace at Arcadia (1951--2017)	-0.369	**<.0001**	-2.20	**<0.0001**	1.70%	-2.12%
Yearly P50 (Median) Flows						
Charlie Creek (1951-2017)	-0.099	0.2380	-0.72	**0.0940**	0.90%	-1.25%
Horse Creek (1951-2017)	-0.084	0.3167	-0.44	0.1208	0.79%	-1.15%
Joshua Creek (1951-2017)	0.281	**0.0008**	0.33	0.1044	1.04%	0.36%
Shell Creek (1965-2017)	-0.032	0.7357	-0.32	0.6420	0.21%	0.23%
Peace nr. Bartow (1951-2017)	-0.327	**<.0001**	-2.57	**0.0003**	2.19%	-3.10%
Peace at Zolfo Springs (1957-2017)	-0.268	**0.0014**	-3.96	**0.0021**	1.19%	-1.36%
Peace at Arcadia (1951--2017)	-0.204	**0.0144**	-5.87	**0.0056**	1.16%	-1.43%
Yearly P90 (High) Flows						
Charlie Creek (1951-2017)	-0.022	0.7909	-2.160	0.4900	0.28%	-0.33%
Horse Creek (1951-2017)	-0.075	0.3719	-1.596	0.4222	0.30%	-0.36%
Joshua Creek (1951-2017)	0.007	0.4232	0.674	0.5354	0.23%	0.26%
Shell Creek (1965-2017)	0.149	0.1141	7.420	0.1253	0.74%	0.87%
Peace nr. Bartow (1951-2017)	-0.101	0.2254	-3.030	0.2638	0.59%	-0.76%
Peace at Zolfo Springs (1957-2017)	-0.082	0.3299	-5.190	0.3370	0.39%	-0.46%
Peace at Arcadia (1951--2017)	-0.052	0.5373	-10.535	0.2906	0.41%	-0.45%

Arcadia). For a consistent comparison, the trend tests for all ages begin with flows recorded in 1951 for all gages, except Shell Creek where the flow records begin 1965. Trend tests were not performed on Payne Creek due to the shorter period of record.

The results in Table 6 should be interpreted as described on pages 12 and 13 for Table 4, which listed results for the same statistical tests for the long-term gages on the river over a longer time period (1940 to 2017). Again, p values for tests had significance levels of less than 0.1 are highlighted in bold. There was a tendency for significant declining trends for the gages on the river. This was not the case for the P90 high flows, where the p values were relatively high indicating no trend. Also, there was no significant trend for average annual flows for the Peace River at Arcadia using the Mann-Kendall test, but the results for the yearly P5 and median flows for all three long-term gages on the river had significant declining trends using both the tests. Again, the trends were most pronounced at the Bartow gage, as evidenced by the larger Tau values, the greater relative slopes using the linear regression, and the greater significance levels (lower p values) for both tests compared to the gages at Zolfo Springs and Arcadia.

Very different results were found for gages on the creeks for the post-1951 time period, although they experienced what were likely very similar climatic trends. There were no significant declining trends except for median flows on Charlie Creek. There were significant increasing trends P5 low flows and median flows on Joshua Creek, supporting the patterns in the long-term hydrographs shown in Figure 23. Again, these are smaller sub-basins with different hydrographic and hydrogeologic characteristics, but I believe the human impacts to flows in the Peace River, which are most acute in the upper river, also influence the differences in these results.

The trends for Shell Creek, which was over a shorter period of record (1965-2017), showed no evidence of declining trends. There was an increasing trend for P5 low flows in Shell Creek using the Mann-Kendall tests, and some evidence of an increasing trend in P90 high flows using both tests with p values of 0.1141 and 0.1253. These results should not be over-interpreted or directly compared to the results for the river due to the different time periods analyzed. It can be concluded though, that in over fifty years of streamflow records for Shell Creek there is no evidence that the flows are declining.

Collectively, these results demonstrate how important the five major creeks from Payne Creek to Shell Creek are to sustaining hydrologic and ecological characteristics of the Peace River. In general, it does not appear that flows in the Peace River are in a steady rate of decline. Although not presented in this report, with the exception of P5 flows statistical tests found no declining trends at the long-term gages on the river after 1975, similar to the findings of other studies (Flannery and Barcelo, 1998; PBS&J and others, 2007; SWFWMD, 2010A). There was some statistical evidence of declining P5 low flows at the Bartow, Zolfo Springs and Arcadia gages since then which may be cause for concern, but the frequency of dry years with well below average rainfall between 2000 and 2013 has been a factor.

I conclude that impacts to the flows of the Upper Peace River that occurred over earlier decades have extended into the 1970s and beyond. The flow regime of the river has how largely stabilized, but generally at less flows compared to pre-impacted conditions. The extent that flows have been reduced becomes more pronounced further upstream. In that regard, the flow contributions of the tributaries that have not been so impacted are very important to maintaining the existing environmental characteristics of the Peace River and make the feasibility of achieving additional water supplies from the river much more likely at locations farther downstream.

The withdrawal of high flows - considerations for intake locations and designated water uses

It is interesting that the trend analyses beginning in 1951 did not find significant trends in the high flow parameter that was tested (yearly P90 flows), but that could probably be expected. It may be that given enough rainfall, some of the impacts to the upper river are overcome and high flow rates occur similar what occurred in earlier decades. Metz and Lewelling (2009) suggest that the filling of cavities and voids below the Upper Peace River above Ft. Meade occurs at an increasing rate at the beginning of the summer wet season, so losses to the groundwater system might be reduced later in the wet season as these cavities and voids are filled. Prolonged high flows during other times of year may function similarly. Also, storm runoff rates from some urban and agricultural lands in the Peace River watershed are probably higher than occurred from more natural, pre-development land covers.

The continuation of high flows during recent years is apparent in the daily records of the river. The report by SWFWMD (2002) made the interesting observation that after three years of severe drought, Tropical Storm Gabriel passed over the Peace River watershed in September 2001 and produced very high flows, resulting in a peak daily flow rate of 20,700 cfs at Arcadia, which with the exception of a similar peak flow of 20,900 cfs in 1960, had not been exceeded since 1949. Similarly, a peak flow rate of 21,700 cfs at Arcadia occurred in the summer of 2017, which is one of the highest daily flow rates on record. During this same event, the peak flow of 37,567 cfs from the four gages that contribute flow to the lower river (Peace-Arcadia, Horse, Joshua, and Shell Creeks) was the highest on record since 1965.

It is sometimes suggested that some of the high flows in the Peace River could be diverted and put into storage facilities for water supply. This certainly seems like a feasible scenario, but must be done with caution with regard to the quantities taken and the location of withdrawals. High flows perform important ecological functions in river systems including transporting large woody debris and organic matter, the inundation of floodplain wetlands, and the increase in habitat and food resources for fish and a variety of wildlife. Given the importance of high flows to river ecosystems, the determination of the best location and withdrawal quantities would require detailed study to simulate the effect of diverting different quantities of water at various rates of flow. It is not recommended that the diversion of low and medium flows be considered, as these components of the flow regime of the Upper Peace River have been most affected by human activities in the watershed.

Withdrawals of high flows between Bowling Green and Zolfo Springs - As described on page 27, the morphology of the Peace River changes below the confluence of Payne Creek near Ft. Meade. Above there, the river floodplain contains extensive areas of seasonally and semi-permanently flooded wetlands. As described in the minimum flows report for the Upper Peace River, declining flows in the upper river have resulted in dramatic reductions in the hydroperiods of these wetlands (SWFWMD, 2002).

To prevent additional harm to these wetlands and the instream habitats of the upper river, I suggest that no withdrawals be allowed from the Upper Peace River or its tributaries above the confluence of Payne Creek, which is approximately nine miles south of Ft. Meade and two miles southeast of Bowling Green. An exception to this might be the infrequent diversion of some very high flows from the upper reaches of the river that are inundating uplands, roads, homes or bridge crossings. Such diversions would have to be carefully assessed to not reduce the hydroperiods of riverine wetlands in the upper reaches of the river above Payne Creek.

The diversion and storage of high flows from the river below Payne Creek would be more hydrologically feasible and would have less potential ecological impacts. However, the location of any withdrawal point would have to be determined based on the physical characteristics of the river and its floodplain to avoid physical disruption of habitats as much as possible.

Withdrawals from such a location, however, should be prioritized for flow restoration of the upper river. The river is not meeting the minimum low flows adopted for the river at the Upper Peace River at the Zolfo Springs gage and evidence indicates the medium flows of the river have been impacted as well. In its proposed schedule for the adoption of minimum flows, the SWFWMD has scheduled the adoption of a full suite of minimum flows for the Upper Peace River for the year 2025. The determination of how much flow, if any, from the Upper Peace River above Zolfo Springs would be contingent on the establishment of those rules.

It is my preliminary conclusion that some diversion of high flows between Bowling Green and Zolfo Springs could be warranted it was used for the purposes of further restoration of the low and medium flows above Zolfo Springs. Such diversions could be put into various pits in the upper river basin for storage and used to directly supplement the flows of the river in the dry season. Another possibility would be to use the stored river water for aquifer replenishment in the vicinity of the upper river. The report by Basso (2003) concludes that cutbacks in overall groundwater use to restore flow to Kissengen Spring and the Upper Peace River would be economically infeasible. However, aquifer replenishment of the Upper Floridan aquifer near the river channel might act to reduce losses of water from the river to the groundwater system. I suggest, however, that direct supplementation of the flow of the river would be more efficient.

Withdrawals of high flows between Charlie Creek and Arcadia - The next logical area for an intake structure would be in the Middle Peace River between Zolfo Springs and Arcadia. To take advantage of the water contribute by Charlie Creek, the intake should be located below the confluence of Charlie Creek which is about 20 miles south of the Polk/Hardee county line. SWFMD has adopted minimum flow rules for the Middle Peace River which extends from Zolfo Springs to Arcadia (SWFWMD, 2005A). Any withdrawals from the river would have to comply with these minimum flows, which are established for three seasonal blocks which correspond to the spring dry season (Block 1 – April 20 to June 24), the summer wet season (Block 3 – June 25 to October 17), and the period which typically has medium flows from the fall to the early spring (Block 2, October 28 to April 19).

It is my recommendation that diversions be limited to high flows, using the percentages for Block 3, which allows stepped flow reductions of 13% and 8% of natural flows, which are flows in the absence of other withdrawals. The change in allowable flow reductions occurs at a flow rate of 1,362 cfs at the Arcadia gage. I suggest that withdrawals between Charlie Creek and Arcadia be limited to high flows, for I believe the evidence indicates the low and medium flows in the river above Arcadia have been impacted to some extent. Finally, since more water would be available at a location below Charlie Creek as opposed to below Payne Creek, I suggest the water withdrawn below Charlie Creek could be used for both flow restoration of the upper river and water supply for users in upstream areas.

Withdrawal point near Ft. Ogden - The optimal location to withdraw water from the Peace River to maximize water supply availability while minimizing the potential for environmental impacts is at or near the location of the intake structure of the Peace River Manasota Regional Water Supply Authority near Ft. Ogden. Located 19 miles upstream of the mouth of river, the intake is in the tidal reach of the river as there is often about a two foot daily fluctuation of water levels at the intake due to tides. This water is usually fresh, but during low flows brackish water can occur at the location of the intake. When this happens, withdrawals cease and the PRMRWSA relies on water that has been diverted into storage. This cessation of withdrawals also has the ecological benefit of preserving all the flows to the downstream estuary during low flows when the inflow of freshwater is particularly critical.

The existing PRMRWSA withdrawal point is on a small backwater slough off the west side of the lower river. Because of the large volumes of water associated with tides, withdrawals at this location have very small effects on water levels and rates of flow near the intake and no effect on the upstream non-tidal freshwater reaches of the river. Preserving flows in the upstream reaches of the river for the needs of the freshwater ecosystem makes sense, with the withdrawals taken at this downstream location where there is more water available for supply.

If sea level rise increases the time that brackish waters occur at the PRMRWSA intake, a supplemental intake for use during low flows could be implemented farther upstream, whereas the existing intake could be used at higher flows when freshwater flow physically pushes the brackish water further downstream.

As with freshwater rivers, downstream estuaries also have ecological requirements for freshwater inflows, as the ecological structure and biological productivity of these brackish water ecosystems are dependent on the quantity and quality of freshwater inflow. The SWFWMD has done extensive research on the freshwater flow needs of estuaries, including many years of study of the Lower Peace Rive and adjacent waters of Charlotte Harbor (Flannery and others, 2002; SWFWMD, 2010; Atkins Inc., 2013; CHNEP, 2016).

The results of this research were incorporated into the adoption of minimum flows for the Lower Peace River (SWFWMD, 2010A). Those minimum flows are based on the sum of daily flows at the Peace at Arcadia plus Horse and Joshua Creeks, which represents 73 percent of the area of the Peace River watershed. The minimum flows for the lower river establish a low flow cutoff for surface water withdrawals of 130 cfs, which on average the flow is below about 13 percent of the time, but can be much more frequent in dry years.

Similar to the minimum flows for the Middle Peace River, the minimum flows are established for the same three seasonal blocks as for the middle river described on page 37. The maximum allowable flow reductions allowed for the Blocks are 16% of flow in Block 1 (spring dry season); 29% of flow in Block 2 (fall to early spring); and 38% of flow in Block 3 (summer wet season). However, withdrawals in Blocks 2 and 3 must remain at the Block 1 percentage (16%) until the daily flows exceed 625 cfs, when the percentages for those blocks take effect.

It is important to note that flow reductions percentages for the lower river are higher than for the middle reach of the river, thus allowing greater withdrawals for the same rate of flow. The health of productivity of estuaries are dependent on freshwater inflow, but it has my experience that freshwater rivers are more sensitive to harm as a result of flow reductions. As will be discussed in the final section of this report, minimum flows established for freshwater rivers using the SWFWMD percent-of-flow approach are more typically more restrictive (lower percent flow reductions) than for their receiving downstream estuarine systems.

As previously discussed, the Peace River Manasota Regional Water Supply Authority is an existing legal user of flow at Ft. Ogden and they would get first priority for use. The permitted withdrawal schedule for the PRMRWSA is based on the percent-of-flow approach, at or very close to the maximum allowable withdrawal percentages allowed by the minimum flow rule for the lower river during Blocks 1 and 2 (fall to late spring). However, during these blocks there may be days when the PRMRWSA does not withdraw all the water it is allowed due to reduced customer demands or full storage. On such days, it would not be difficult to determine how much flow could be available to other users while remaining in the minimum flow limits for the Lower Peace River.

In the summer wet season (Block 3), the PRMRSA is permitted to withdraw 28% of the flow above a flow rate of 625 cfs, while the minimum flow rule allows for a flow reduction of 38%, thus there are additional high flows available for other users. The SWFWMD is currently reevaluating the minimum flows for the Lower Peace River with adoption scheduled for the year 2020. This might require that the withdrawal schedule for the PRMRWSA be revised to comply with the minimum flows if they are changed. At that time, the potential use of high flows by other water users could be assessed.

The value of a larger interconnection with Shell Creek - In addition to the different flow requirements of freshwater and estuarine systems, compared to the upper river there is simply much more water in the Lower Peace River just before it flows into the estuary. As listed in Table 1 and discussed on page 6, it is reiterated that the average flow of the lower river at the confluence with Shell Creek (1,547 cfs) is greater than the average flow at Ft. Meade (195 cfs) by nearly a factor of eight.

A major component of the increased flow in the lower river is Shell Creek, the largest tributary in the Peace River watershed. As previously discussed, the average flow for Shell Creek since 1975 (368 cfs) is equivalent to 41% of the average flow of the river at the Arcadia gage. As also previously discussed, the City of Punta Gorda makes water supply withdrawals from the reservoir behind the Shell Creek weir, with the highest average rate of water use to date being 5.4 mgd in 2017 (equal to 8.4 cfs). The water use permit for the City of Punta Gorda allows for a maximum average annual withdrawal rate of 8.1 mgd (12.5 cfs) and a peak monthly rate of 11.7 mgd (18.1 cfs). Even if the City pumps close to those quantities in future years, there will be much of the year when the City's withdrawals will comprise a relatively small percentage of flow in Shell Creek and additional water may be available for other users.

The SWFWMD did not establish minimum flows for Shell Creek when it adopted minimum flows for the Lower Peace River in 2010. However, the SWFWMD is intending that minimum flows for Shell Creek be adopted in conjunction with the reevaluation of minimum flows for the Lower Peace River, which are scheduled for adoption in 2020. The determination of those minimum flows will determine how much flow in Shell Creek can be reduced by all water users. I expect that when minimum flows are adopted, the City's withdrawals may utilize all the available water from Shell Creek at low and low-medium flows, but there may be additional water available for other users at medium and especially high flows.

It is my understanding there is a cooperative project has been funded to build a pipeline between the PRMRWSA water treatment facility on the Lower Peace River and the City's facility on Shell Creek. It is also my understanding this pipeline, which has not yet been constructed, will be for treated water to help either utility meet water supplies when flows are low in either the river or the creek.

This project is a good idea, but I suggest that if a watershed-wide plan is employed to meet regional water supply needs using the Peace River, a larger pipeline would be valuable to transmit greater quantities of untreated river water between these two facilities for storage or treatment. This would allow for the high flows in Shell Creek to be made available for use on a larger regional scale.

Construction of pipeline and water storage facilities to make water from the Lower Peace River and Shell Creek available to upstream water users

I am unfamiliar with projected water supply needs of the PRMRWSA and the City of Punta Gorda for the resource planning horizon. However, given that high flows periodically occur in the Peace River including Shell Creek, it seems possible that additional water could be made available for upstream water users. The withdrawals should be taken at or near the location of the PRMRWAS facility as it is in the optimal location for maximizing water supply availability while minimizing the potential for environmental impacts.

The flow reduction limits established by the minimum flow rule for the Lower Peace River would apply to the total percentages of water that can be withdrawn by all users. If necessary at this time, I suggest the existing minimum flow rule with some possible withdrawal scenarios assigned for Shell Creek could be used for feasibility assessments. The final total withdrawal amounts, however, would have to be resolved when the minimum flows for the Lower Peace River and Shell Creek are reevaluated in 2020.

Associated parties would have to work out how much of the water would be available for the different users and their customers at different rates of flow. As stated before, the withdrawals by the PRMRWSA should be first priority as they are an existing legal user. The withdrawal schedule for the PRMRWA comprises all or nearly all of the allowable minimum flow percentages at low and medium flows, but as previously discussed there might be days when they do not take all their permitted quantities, periodically making water available for other users. As is the case the PRMRWSA's current withdrawal schedule, during high flows there could be additional available for other users on a routine basis.

Implementation of such a watershed-wide supply plan would require the construction of a pipe to transport water upstream. In addition, water storage facilities would need to be located somewhere in the Peace River corridor to store water during high flows for later use. For reference, it is about 37 linear miles from the PRMRWA water treatment plant to the Polk/Hardee county line. Construction of such a pipeline and water storage facilities would require considerable funds, but I suggest that if the water supply simulations indicated that the water supplies were feasible and needed for upstream water users, the project would be valuable to the region.

The Upper Peace River has been seriously impacted by industrial and agricultural activity and population growth in the upper river sub-basin, much of which occurred before adequate regulatory and resource planning tools were in effect. To varying degrees based on river location, these hydrologic and ecological impacts have extended some distance downstream. If new water supplies are from the Peace River are truly needed, the expenditure of public funds to transport water from more resilient downstream locations to upstream water users would be well justified to make such water supplies available without causing further environmental harm to the Peace River.

Finally, as long as the Upper Peace River is not meeting its low minimum flows, if water is transported from downstream locations to upstream water users, consideration should be given to reserving a portion of that water for flow restoration of the Upper Peace River just below the Bartow gage. Flow supplementation of the upper river during very dry periods would help fill the cavities and voids in the aquifers beneath the river that have been caused by groundwater drawdowns and help the flow recover more quickly when surface runoff resumes.

The section on the Alafia River begins on the following page

Alafia River

Overview

A discussion of considerations for the implementation of any new surface water withdrawal sites for water supply from the Alafia River is presented below. This discussion is shorter than that presented for the Peace River, but makes the same conclusion that any new withdrawals from the river or its tributaries should be located as far downstream as possible to maximize water supply availability while minimizing the potential for adverse environmental impacts.

The physical and hydrologic characteristics of the Alafia River and its watershed are briefly summarized in a general manner. Much more detailed information about the Alafia River and its watershed is contained in SWFWMD minimum flows reports for the freshwater and lower estuarine reaches of the river (SWFWMD, 2005B; SWFWMD, 2008).

Hydrographic and watershed characteristics

The Alafia River has headwater reaches in western Polk County, but it flows primarily through Hillsborough County to Tampa Bay. The total watershed area of the river is 422 square miles. The total length of the Alafia is 50 miles, including the channel of its longest headwater tributary.

A map of the Alafia River including its major tributaries, springs, and flow measurement gages is shown in Figure 26. The north and south prongs of the river flow together near Alderman's Ford near State Road 39 to form the Alafia River which flows 25 miles to the mouth of the river at Tampa Bay. Tampa Bay Water has an intake site on the south bank of the river just upstream of Bell Shoals Road, approximately 12 miles above the mouth of the river (Figure 26). The river becomes tidally affected a short distance below Bell Shoals Road and brackish waters can extend approximately 10 to 11 miles upstream of the river mouth during low flows.

Flows in the Alafia River have been measured since 1932 by the USGS at the Alafia River at Lithia gage, located 16 miles upstream of the mouth of the river. Long-term USGS flow gages are also in operation on the north and south prongs of the river, with the records extending back to 1950 for the north prong and 1962 for the south prong. The Alafia River also receives flow from two spring complexes. Lithia Springs flows to the river approximately 14 miles upstream of the river while Buckhorn Springs flows into the estuarine reach of the river via a spring run that enters the river about eight miles upstream of the river mouth. Flows records from these gages on the river and the springs are discussed in a later section of this report.

Hydrogeologic characteristics - Similar to the Peace River, there three principal aquifer systems in the Alafia River watershed; the unconfined surficial aquifer, the confined intermediate aquifer system, and the confined Floridan aquifer (UFA) system which is divided into upper and lower zones by a middle confining unit comprised of low-permeability zones.

The report by SFWMD (2005B) states that “due to the relatively thin and discontinuous nature of the sediments, groundwater flow in the surficial aquifer is more local in nature rather than regional. Flow direction is variable and is controlled primarily by the surface topography. Water levels from nearby wells and Alafia River stage indicate that the water table gradient slopes toward the river during both the dry and wet periods of the year (May and September), providing baseflow to the river all-year round. Conversely, water levels between the UFA and river stage suggest a seasonal pattern of flow, with potential recharge to the UFA (from the river) during the drier months and potential discharge from the UFA (to the river) during the summer months.”

The report further states that “for the most part, water levels in the surficial aquifer are consistently higher than levels in the intermediate aquifer system and UFA, indicating a downward flow gradient. Along the coast, this downward gradient is typically reversed with water from the UFA being discharged upward into the overlying aquifers. However, for much of southern coastal Hillsborough County, water levels in the UFA have declined due to groundwater withdrawals. This has resulted in a seasonal reversal of the vertical gradient between the aquifers. During the drier periods of the year (typically the spring months), water levels decrease with depth along the coast and water moves downward from the surficial aquifer. During the remainder of the year, water levels in the UFA are higher and the vertical movement of water resumes in an upward direction.”

The report also described the region known as the Brandon Kart Terrain, an area of approximately 40 square miles located to the north of the Alafia River and west of Lithia Springs. The limestone is this area is dominated by karst topography including a high density of ancient and modern sinkholes, internal drainage, springs, and significantly increased transmissivities in the limestone. The report also includes a section that summarized previous studies on the relationships of groundwater levels with springflow from Lithia and Buckhorn Springs and new results prepared for that study. They found there was strong correlation between groundwater levels in wells in and near the Brandon Karst Terrain and springflow, but the relationship was somewhat stronger for Lithia Springs than for Buckhorn Springs.

Land Use - The land use characteristics of the Alafia River basin are discussed in detail in the minimum flows report for the freshwater reach of the river (SWFWMD, 2005B). Table 10, which is reprinted from that report, list the percentages of major land use/cover types in the Alafia River watershed for the years 1972, 1990, and 1999. Maps of four of these land use types (urban, citrus, other agriculture and mines) are shown in Figure 27 which is also reprinted from SWFWMD (2005B). Also shown are coverages for rangeland, upland forests, wetland forests, non-forested wetlands, and water.

Table 7. Percentages of major land use and land cover types in the Alafia River watershed for 1972, 1990, and 1999. Adapted from SWFWMD (2005B).

Land Use / Cover	1972	1990	1999
Urban	10.9%	13.9%	17.6%
Citrus	9.1%	4.9%	4.7%
Other Agriculture	26.9%	21.8%	18.4%
Uplands	30.7%	12.8%	10.1%
Wetlands	9.3%	12.1%	10.7%
Mines	10.9%	32.8%	35.9%
Water	2.3%	1.8%	2.5%

Along with the Peace River, the Alafia River is the notable for the extensive amount of phosphate mining that has occurred in its watershed. The first evaluation of the possible effects of mining on the water quality and biology was presented in the 1955 report of the Florida State Board of Health about the Peace and Alafia Rivers, which was conducted in response to citizen concerns expressed about these rivers in the late 1940s (Florida State Board of Health , 1955A). As shown listed in Table 7 and shown in Figure 27, most of the increase in mined area occurred after 1972, with much of the increase occurring in the sub-basin of the south prong of the river. As of 1999, over one-third (35.9%) of the Alafia River watershed was affected by mining activities.

Since the early 1970s there has been marked decreases in the area of citrus, other agriculture and uplands, largely in response to increases in mining and urban development as urban land use increased from 10.9% to 17.6% of watershed area from 1972 to 1999. Urbanized areas include parts of the cities of Lakeland, Plant City, Mulberry and the unincorporated community of Brandon which lies in the western portion of the watershed.

Streamflow statistics and trends

Summary statistics, hydrographs, and trend analyses for the flow data at the long-term gages on the Alafia River and the north and south prongs are summarized below using data collected through 2017. Using previously published findings that were not updated with recent data, flows from Lithia and Buckhorn Springs are also characterized.

Table 8 lists average values for flow and area based runoff for the USGS gages on the main stem of the river and the north and south prongs. To use a consistent record for comparison, averages were taken for the 55 years of record since 1963, which is the first year of complete flow records for the south prong of the river. With an average flow of 142 cfs, the North Prong provides nearly half of the flow measured at the Alafia River at Lithia gage (298 cfs). With a smaller sub-basin area and average flow, the mean flow of the south prong (99 cfs) comprises one-third of the flow at the gage on the river. The remaining increase in flow at long-term river gage comes from drainage between these gage locations.

Average values for area based runoff are similar for the three gages, ranging from 0.89 cfs/mi^2 to 1.05 cfs/mi^2. These rates are as high or higher than the average runoff rates for the less impacted sub-basins in the Peace River watershed (Table 3), indicating there is not an apparent problem with human caused flow reductions in these sub-basins.

Table 8. Years with complete flow records, drainage areas, gage locations, and average values for flow and area-based runoff for long-term streamflow gages on the Alafia River including the North and SouthProngs for the period 1963 - 2017*

		Drainage area and location of gage		Average Flow and Runoff 1963 - 2017	
USGS gage	**Years with complete records**	**Drainage area (mi^2)**	**Distance from the river mouth (miles)**	**Mean Flow (cfs)**	**Area Based Runoff (cfs/mi2)**
Alafia River at Lithia	1933 - 2017	335	16	298	0.89
North Prong Alafia River at Keysville*	1951 - 2017	135	29	142	1.05
South Prong Alafia River nr. Lithia	1963 - 2017	107	34	99	0.92

*** No flow data for North Prong for Oct. 1, 1992 to June 30, 1995**

Percentile values for daily flows at these gages are listed in Table 9. As with average flows, there is an increase in all the percentile values at the gage on the river that is more than the sum of the values at the two gages on the north and south prongs. These results demonstrate there is potentially more water available for supply from the main stem of the river, rather than from two separate withdrawal points on the north and south prongs.

Hydrographs of yearly flow parameters at these three gages are shown in Figures 28, 29 and 30. The years on the horizontal axis for all the graphs begin in 1930 for easier comparison to the gage on the main stem of the river, where the period of record is the longest with the first year of complete daily records beginning in 1933.

Table 9. Percentile values for daily flows for long-term gages on the Alafia River including the North and South Prongs for the period 1963 - 2017.*

	Flow Percentiles (cfs)								
USGS gage	Minimum	P5	P10	P25	P50	P75	P90	P95	Maximum
Alafia River at Lithia	4	35	54	96	172	346	642	932	9,820
North Prong Alafia River at Keysville*	2	19	26	46	83	152	289	455	9,550
South Prong Alafia River nr. Lithia	0	6	12	27	55	117	230	334	2,430

* No flow data for North Prong for Oct 1, 1992 to June 30, 1995

The plot of average yearly flows for the Alafia River at Lithia (Figure 28A) shows some similarly to the long-term gage for the Peace River at Arcadia (Figure 20) in that there were a higher frequency of high yearly mean flows (e.g., above 500 cfs) in the decades prior to the 1970s. Since that 1970s, however, there has been no apparent trend. As was described for the Peace River, long-term patterns in regional rainfall including the effects of the Atlantic Multidecadal Oscillation have affected these long-term flow patterns. The minimum flows report for the freshwater reach of the Alafia River discusses this point and suggests that changes in flow in the Alafia River have been more of a step function due to changes in rainfall rather than a monotonic trend (SWFMWD, 2005B).

A notable pattern in the graphs for the river and also the north and south prongs is a rise in the yearly median and low (P5) values from the late 1950s to the late 1970s or the early 1980s (graphs B and C in Figures 28, 29 and 30). The minimum flow reports for the freshwater and estuarine reaches of the Alafia River attribute this to runoff and discharges from the phosphate mining industry during that time (SWFWMD, 2005B, 2008). As in the Peace River watershed, the phosphate mining industry has become much more efficient in their groundwater use and retention of water onsite so that such discharges to the river are now much less. This is corroborated by the significant reduction in the concentrations of a number of chemical constituents (e.g., phosphorus, fluoride, sulfate, specific conductance) that had been previously elevated due to mining activities (SWFWMD, 2005B)

All three gages show the lowest values for P5 low flows since the year 2000. As described on page 11, the high frequency of very dry years which has occurred since the year 2000 has certainly been a major factor in this pattern. However, in the preparation of this report I did not do an inventory of past or current point sources discharges to either the north of south prongs of the river. It may be that changes in point source discharges could affect the long-term patterns in low flows, but that is a topic I did not consider.

In addition to the presentation of hydrographs, trend tests on yearly flow parameters were run on the three gages for two time periods. The first was for the entire period of years with complete daily records for the Alafia River at Lithia (1933-2017) and the North Prong of the

Alafia River nears Keysville (1951-2017). In order to compare results within a consistent time period, trends at these gages are later examined with the South Prong of the Alafia River for the years 1963 to 2017, which is the period of complete daily records for the south prong.

The long-term, period of record trends for the Alafia River and the north prong are listed in Table 10. These results should not be compared since they are over different time periods, with flow records for the river gage starting 18 years before the north prong. Also, values for 1992 to 1995 were not included for the north prong as there was no data for October, 1992 through June, 1995. Given these constraints, there were significant declining trends for average yearly flow at both gages, with changes in long-term rainfall likely playing a major factor. Declining trends in median flows and P5 low flows were also found for the north prong, which was influenced by the period of increased flows from phosphate mining activity which was occurring near the beginning of that flow record (Figures 29 B&C). Since this period of increased flows occurred toward the middle of the flow record for the Alafia River gage (Figure 28 B&C), it did not result in a statistically significant declining trend. There were significant declining trends in P90 high flows for the gage in the river, due in part to the frequency of high flows in the year up to 1960 (Figure 28D). Significant trends in high flows were not found for the north prong, as what were probably high flows in the 1940s were not measured at this site where the flow records began in 1951.

Table 10. Results of trend tests of yearly flow statistics (means, P5, median, and P90 flows) for the Alafia River at Lithia for 1933 to 2017 and for the North Prong of the Alafia River at Keysville for 1951 to 2017. Results are presented for (A) the non-parametric Mann-Kendall test and (B) linear regression of each yearly flow statisitc as a function of year. P is the probability of type 1 error or that there is no trend. P values less than 0.10 are highlighted in bold.

	A. Mann-Kendall		B. Linear Regression			
Gage and yearly statistic tested for trend	**Tau**	**p**	**Slope cfs per year**	**p**	**Slope as % of mean value**	**Slope as % of median value**
Average Yearly Flows						
Alafia River at Lithia (1933-2017)	-0.180	**0.0148**	-1.58	**0.0165**	-0.48%	-0.52%
North Prong at Keysville * (1951-2017)	-0.146	**0.0910**	-0.83	**0.0668**	-0.56%	-0.64%
Yearly P5 (Low) Flows						
Alafia River at Lithia (1933-2017)	-0.055	0.4569	-0.09	0.5859	-0.16%	-0.18%
North Prong at Keysville * (1951-2017)	-0.361	**<.0001**	-0.57	**<.0001**	-1.62%	-2.04%
Yearly P50 (Median) Flows						
Alafia River at Lithia (1933-2017)	-0.045	.5436	-0.22	0.5481	-0.12%	-0.14%
North Prong at Keysville * (1951-2017)	-0.355	**<.0001**	-1.00	**<.0001**	-1.15%	-1.20%
Yearly P90 (High) Flows						
Alafia River at Lithia (1933-2017)	-0.182	**0.0138**	-3.96	**0.0104**	-0.55%	-0.60%
North Prong at Keysville * (1951-2017)	-0.028	0.7442	-0.49	0.6516	-0.16%	-0.19%

*** Values for 1992 to 1995 not inlcuded due to incomplete daily data within those years**

Results for trends tests at all three gages for the period 1963 – 2017 are listed in Table 11. There were no significant trends for average yearly flows, although p values for the Mann-Kendall test for the river gage was near 0.10. Significant declining trends were observed for median and P5 flows for the river and the north prong, again due to the period of increased flows due to mining activity which were in effect in the 1960s and 1970s. Significant declining trends were observed for the P5 low flows in the south prong, but not for median flows where there has been a number of high yearly median flow values since the mid-1990s (Figure 30B).

The hydrographs show there was an increase in average yearly flows and P90 high flows at all three gages since 2014, due to years with average or above average rainfall since that time. There was also no evidence of trend for P90 high flows at all three gages since 1963. Although this is just one flow parameter, this does indicate that the high flows of the Alafia River and its tributaries have continued to fluctuate in ecologically healthy range for the last 50-plus years. Accordingly, it seems feasible that some high flows could be withdrawn from the Alafia River for water supply without causing adverse impacts to the river ecosystem.

Table 11. Results of trend tests of yearly flow statistics (means, P5, median, and P90 flows) for the Alafia River at Lithia, the North Prong of the Alafia River near Keysville and the South Prong of the Alafia River near Lithia for 1963 to 2017*. Results are presented for (A) the non-parametric Mann-Kendall test and (B) linear regression of each yearly flow statisitc as a function of year. P is the probability of type 1 error or that there is no trend. P values less than 0.10 are highlighted in bold.

	A. Mann-Kendall		B. Linear Regression			
Gage and yearly statistic tested for trend	**Tau**	**p**	**Slope cfs per year**	**p**	**Slope as % of mean value**	**Slope as % of median value**
Average Yearly Flows						
Alafia River at Lithia (1963-2017)	-0.150	0.1055	-1.12	0.2622	-0.38%	-0.41%
North Prong at Keysville* (1963-2017)	-0.139	0.1505	-0.59	0.2381	-0.42%	-0.46%
South Prong near Lithia (1963-2017)	-0.137	0.1406	-0.52	0.1960	-0.53%	-0.57%
Yearly P5 (Low) Flows						
Alafia River at Lithia (1963-2017)	-0.494	**<.0001**	-1.51	**<.0001**	-2.42%	-2.52%
North Prong at Keysville* (1963-2017)	-0.547	**<.0001**	-0.96	**<.0001**	-2.81%	-3.45%
South Prong near Lithia (1963-2017)	-0.290	**0.0018**	-0.29	**0.0028**	-1.89%	-2.26%
Yearly P50 (Median) Flows						
Alafia River at Lithia (1963-2017)	-0.286	**.0020**	-1.77	**0.0040**	-1.00%	-1.06%
North Prong at Keysville* (1963-2017)	-0.447	**<.0001**	-1.43	**<.0001**	-1.71%	-1.79%
South Prong near Lithia (1963-2017)	-0.139	0.1347	-0.33	0.2160	-0.55%	-0.64%
Yearly P90 (High) Flows						
Alafia River at Lithia (1963-2017)	-0.062	0.5042	-0.41	0.8580	-0.06%	-0.07%
North Prong at Keysville* (1963-2017)	0.009	0.9224	0.97	0.4350	0.33%	0.37%
South Prong near Lithia (1963-2017)	-0.070	0.4502	-0.88	0.3732	-0.39%	-0.33%

*** Values not inlcuded for 1992 to 1995 due to incomplete daily data within those years**

Flows and withdrawals below the Alafia River at Lithia gage

Lithia and Buckhorn Springs - With regard to maximizing water supplies while minimizing the potential for environment impacts, it is important point out the Alafia River gains considerable flow below the Alafia River at Lithia gage. Lithia and Buckhorn Springs flow into the river below this gage, so they are not reflected in the long-term flow records reported there.

I did not acquire recent flow data for Lithia and Buckhorn Springs, but present data for the springs taken from the minimum flows report for the Lower Alafia River which reported data through the year 2003 (SWFMD, 2008). Average flow data for these two spring complexes taken from that report are listed in Table 12. Flows from Lithia Springs have been measured periodically since the 1930s by the USGS and since 1984 by Tampa Bay Water (previously the West Coast Regional Water Supply Authority). Years with at least four flow measurements within each year begin in 1956.

Lithia Springs if used for industrial process water by Mosaic Fertilizer, with withdrawal records dating back to 1978. The average net flow from Litha Springs to the Alafia River uncorrected for withdrawals was 33.5 cfs for the period 1956-2003 and 29.8 cfs for the period 1978-2003. Correcting this more recent record for withdrawals by Mosaic, which averaged 6.7 cfs, the total flow of Lithia Springs was 36.5 cfs between 1978 and 2003. I did not access more recent withdrawal data by Mosaic and do not know if their withdrawals have gone up or down, but seem to recall that their withdrawals may have gone down in recent years.

Flows from Buckhorn Springs have been periodically measured by Tampa Bay Water since 1987. Buckhorn Springs is also used for industrial process water by Mosaic, but only very infrequently on an emergency basis if there are reasons why Lithia Springs cannot be used. The average flow of Buckhorn Springs to the river was 12.0 cfs for the period 1987-2003, while the total flow corrected for withdrawals by Mosaic was 12.7 cfs.

Table 12. Average rates of flow for Lithia and Buckhorn Springs for time periods through 2003, showing net flows to the river and total springflow corrected for withdrawals by Mosiaic Fertilizer, Inc. Values taken from SWFWMD (2008).

	1956 - 2003 (cfs)	1978 - 2003 (cfs)	1987 - 2003 (cfs)
Lithia Springs flow to the river	33.5	29.8	
Lithia Springs total flow corrected for withdrawals		36.5	
Buckhorn Springs flow to the river			12.0
Buckhorn Springs total flow corrected for withdrawals			12.7

Total flow to the Lower Alafia River including ungaged flow - In addition to flow from Lithia and Buckhorn Springs, the Alafia River gains considerable ungaged flow below the Alafia River at Lithia gage, which measures flow from 79% of the river watershed. Below this gage the river receives unmeasured flow from Fishhawk Creek, Bell Creek, and storm runoff from other ungaged areas. As part of the determination of minimum flows for the Lower Alafia River, the SWFWMD contracted the University of South Florida to develop and HSPF (Hydrologic Simulation Program – Fortran) runoff model for the ungaged areas that drain to the lower river (Tara and others, 2001). Model output was produced for 1989-2001, with the average ungaged flow equal to 37% of the average flow at the Alafia River at Lithia gage during that period.

Table 13 lists the estimated average total flow at the mouth of the Alafia River for the period 1989-2001, which is the sum of the following flows which are also listed; the flow at the Alafia River at Lithia gage, modeled ungaged flows, and recorded flows from Lithia and Buckhorn Springs uncorrected for withdrawals by Mosaic Fertilizer. The average total flow was 396 cfs, with the flow at the long-term gage representing 65% of the estimated total flow. By comparison, the combined gaged flow for the north and south prongs of the river during this period was 204 cfs, equivalent to 52% of the total flow at the mouth of the river.

Table 13. Average flows in the Alafia River for 1989-2001 expressed at cubic feer per second (cfs) and as pecent of the average total flow at the mouth of the river. Gaged flows are for the Alafia River at Lithia, the North Prong at Keysville, and the South Prong near Lithia.

	Total Flow at mouth	River Gage	Ungaged	Lithia Springs	Buckhorn Springs	North Prong	South Prong
cfs	396	259	96	30.1	10.5	119.5	84.5
Percent	100%	65%	24%	8%	3%	30%	21%

As with the Peace River, these data demonstrate there is potentially more water available for supply the father the downstream that withdrawals are taken. Also, the physical and ecological characteristics of the river change downstream, which in turn affect its sensitivity to potential environmental impacts that could result from withdrawals.

Adopted minimum flows for the freshwater and lower segments of the Alafia River

Minimum flows for the Lower Alafia River were adopted in 2009, based on the minimum flows report published the previous year (SWFWMD, 2008). The adopted minimum flows for the Lower River allow a 19 percent reduction in daily flows above a low flow cutoff of 120 cfs, at which surface water withdrawals must cease. Flows to the Lower Alafia River are defined in the rule as the sum of the flow at Bell Shoals Road plus Buckhorn Springs, with the flow at Bell

Shoals Road calculated as the flow at the Alafia River at Lithia gage multiplied by a factor of 1.117, plus the flow from Lithia Springs corrected by withdrawals from Mosaic Fertilizer. Ungaged flow below Bell Shoals Road is not regulated under the rule, but the effects of the ungaged flow were included in the District's analyses that determined the minimum flows.

The SFWMD has also adopted minimum flows for the freshwater reach of the Alafia River, which are based on the flow at the Alafia River at Lithia gage. The first component of the minimum flow rule is a low flow threshold which prohibits any surface water withdrawals below a flow of 59 cfs at that gage. When flows are above 59 cfs the minimum flow rule allows different withdrawal percentages of daily flows within the same three seasonal blocks as established for the Peace River, which correspond to the spring dry season (Block 1 – April 20 to June 24), the summer wet season (Block 3 – June 25 to October 27), and the period which typically has medium flows from the fall to the early spring (Block 2, October 28 to April 19).

The maximum allowable percentage flow reductions are also based on the Alafia River at Lithia gage and are 10% of daily flow in Block 1, 15% of daily flow in Block 2, and 13% or 8% of the daily flow in Block 3, switching to the lower percentage when flows at the gage are above 374 cfs, which is 25% exceedance flow of the river at that site.

As with the Peace River, these allowable percentage flow reductions for the freshwater reach of the Alafia are more restrictive than the minimum flows rule for the Lower Alafia River, which allows for a 19% reduction in daily flow year-round. As with the Peace River, the withdrawal percentages needed to protect the tidal part of the Alafia River are not as restrictive as allowable flow percentages for the upstream freshwater segment of the river.

The minimum flow for the lower river does have a more restrictive low flow cutoff (120 cfs), but this is calculated as the flow at Bell Shoals Road plus the flow of Buckhorn springs. Because of its location downstream, the low flow threshold for the lower river supercedes the low flow threshold of the freshwater reach, and would apply to any new water users whether they are on the main stem of the river or the north or south prongs.

Suitable location for additional withdrawals from the Alafia River

The effect of the differences in the minimum flow rules for the freshwater and lower reaches of the Alafia River, combined with the hydrologic statistics of the river presented in Tables 8, 9, and 13, demonstrate that there is much more water available for supply farther downstream.

Impracticality of withdrawals from the north and south prongs - Withdrawals from the north of south prongs of the Alafia River would yield much less water and deprive much longer lengths of the river and its tributaries of freshwater flow. A photograph of the North Prong of the Alafia River about a mile upstream of the confluence with the south prong is shown in

Figure 31. The north and south prongs are not rivers but instead are creeks, with a high degree of ecological sensitivity and very limited water supply yield. With regard to environmental protection and regional water supply concerns, there should be no practical reason to allow new withdrawals from either the north or south prongs of the Alafia River. Similarly, withdrawals s from the Alafia River should be located are far downstream as possible.

Withdrawals near Bell Shoals Road The location of the Tampa Bay Water Intake just upstream of Bell Shoals Road is in an optimal location to maximize water supply availability as it is just above the tidal estuarine reach of the river (Figure 26). Diversions at this site are piped either to a water treatment plant located to the north near the Tampa Bypass Canal or to the C.W. "Bill" Young reservoir, which is an offstream reservoir located approximately six miles southeast of the intake on the river.

Withdrawals at this location have only a minor effect on affect water levels and velocities near and downstream of the intake and no effect on the freshwater segment of the river upstream. The withdrawals, however, do affect flows to the Lower Alafia River, which becomes tidally affected a short distance below Bell Shoals Road. The ecological flow requirements of the downstream tidal estuary are critical, but those have been accounted for in the determination of minimum flows for the Lower Alafia River (SWFWMD, 2008).

The withdrawals schedule currently permitted to Tampa Bay Water is in compliance with the 19% flow limit contained in the minimum flow rule for the Lower Alafia River, as TBW is allowed to take 10 percent of the preceding daily flow at Bell Shoals, which is calculated as flow at the Alafia River near Lithia gage * 1.1117, plus the net flow of Lithia Springs uncorrected for withdrawals by Mosaic Fertilizer. In addition, withdrawals by Tampa Bay Water cannot reduce the flow at Bell Shoals Road below a daily flow rate of 124 cfs.

As a result, there is more water available for supply at the Bell Shoals Road than is currently permitted to Tampa Bay Water. I have no idea of the regulatory or policy matters might concern the transfer of water between counties or hydrologic basins and leave that for others to consider. Plus, Tampa Bay Water is an existing legal user of the Alafia River and I don't know how the Alafia factors into their needs for water supplies in the future. If considered to be feasible, any withdrawals at this location for other users would require analyses of water conveyance and storage facilities which are beyond the scope of this report.

Possible reevaluation of minimum flows for the Lower Alafia River - I suggest that the minimum flows for the Lower Alafia River could be reevaluated at a future date, as the District periodically reevaluates the minimum flow rules it has adopted. I was the principal scientist who wrote the minimum flows report for the Lower Alafia River (SWFWMD, 2008) and believe the 120 cfs low flow threshold and the 19% withdrawal limit are effective limits for making water available for supply while protecting the lower river from significant harm at low and medium flows. However, there may be the possibility of withdrawing somewhat higher percentages of water at high flows.

If it is concluded that additional water supplies are needed from the Alafia River and the diversion of higher withdrawal percentages could help achieve those needs, the SWFWMD could schedule the reevaluation of the minimum flows of the Lower Alafia River. As with the existing minimum flow rule, the SFWMD would have to perform technical analyses to demonstrate that the revised minimum flows would not cause significant harm to the ecology of the Lower Alafia River.   However, the existing 19% of flow rule already allows for substantial quantities of water to be diverted at high flows, so a reevaluation may not be necessary if the existing minimum flow rule allows the Alafia to effectively meet regional water supply needs within the resource planning horizon.

General application of findings from the Peace and Alafia Rivers to other rivers in the region

As should be painfully obvious to readers by now, the principal concept presented in this report is that a watershed based approach should be used to identify locations on rivers where water supply availability can be maximized while at the same time minimizing the potential for adverse environmental impacts.   To a large extent, the considerations described for the Peace and Alafia Rivers in this report can be applied to other rivers in west-central Florida as well.

One important factor that applies throughout the region is that the rivers are small.   With a total length of 106 miles, the Peace River is the second longest river in Southwest Florida Water Management District, second only to the Withlacoochee River which has a total length of 157 miles.   Estevez and others (1991) identified seven other primary rivers in the region in which flows are dominated by surface drainage; which are the Myakka, Manatee, Little Manatee, Alafia, Hillsborough, Anclote, and Pithlachascotee Rivers.   The total lengths of these rivers range from 34 to 54 miles with an average total length of 44 miles.   As these rivers all occur along the Gulf coast, brackish waters can extend upstream considerable lengths in the dry season, with the maximum upstream penetration of waters with mineral concentrations over potable water supply standards averaging about 13 miles upstream of the river mouths.   As a result, the lengths of these rivers that can be used for potable water supply are even shorter.

Given the short length of these rivers, it makes sense to consider withdrawal points that can maximize water supply yields and minimize environmental impacts, even if the withdrawal point is located some distance downstream from the actual point of water use or storage. As was shown for the Peace and Alafia, the greatest quantities of freshwater flow available for supply will be just above where the river enters its tidal reach.

Secondly, the ecological health of freshwater and estuarine ecosystems are both dependent on freshwater flow, but the relationships of the physical, chemical, and biological characteristics of these ecosystems with freshwater flow are very different. For this reason, the SWFWMD evaluates minimum flows separately for the freshwater and the tidal estuarine reaches of rivers.

In freshwater rivers the withdrawal of water has immediate effects on water levels and current velocities and resulting direct effects on the river's biology over time. In estuaries the effects of withdrawals on water levels and velocities are diminished by the volume of water exchanged by tides. However, freshwater inflows have critical functions in maintaining healthy estuaries, including beneficial effects on salinity distributions, circulation, primary production, the delivery of nutrients and organic matter and the distribution and productivity of many estuarine dependent animals of sport and commercial importance.

For the management of withdrawals from unimpounded rivers, the SWFWMD has utilized a percent-of-flow approach that limits withdrawals to a percentage of flow at the time of the withdrawal which can vary between seasons and flow ranges (Flannery and others, 2000). This approach has been favorably reviewed as a progressive and effective water management method in the technical peer reviews that are conducted for each SWFWMD minimum flows report and in the general scientific literature (Alber, 2002; Postel and Richter, 2003; National Research Council, 2005; Instream Flow Council, 2008).

Because of the different flow requirements of freshwater and estuarine ecosystems, the maximum percentage flow reductions allowed by the minimum flow rules adopted by the SWFWMD have differed between the freshwater and tidal reaches on each river. In the Anclote River the minimum flow percentages were fairly similar between the freshwater and estuarine reaches, but freshwater minimum flows requires a reduction in seasonal percentage withdrawals to 8% when flows in the river are above 138 cfs, whereas the estuarine minimum flows do not (SWFWMD, 2010B). As a result, the SWFWMD adopted the freshwater minimum flow rates for the entire Anclote River. In the Peace, Alafia and the Pithachascotee Rivers, which are the other comparable examples, the minimum flows adopted for the estuarine reaches allowed for higher percentage withdrawals than the freshwater reaches and separate minimum flows were adopted.

Considering that there is more water is available for supply in the lower reaches of each river, combined with the change in freshwater flow requirements between freshwater and estuarine ecosystems, it makes sense to implement withdrawals are far downstream as practically possible. As described in this report, this approach was taken by the regional water supply utilities the use the Peace and Alafia Rivers, as their intakes are optimally located to maximize water supply availability while minimizing the potential for adverse environmental impacts.

Another case of large scale withdrawals that are regulated using the percent-of-flow approach are diversions from the Little Manatee River to a 4,000 acre offstream cooling pond for the Manatee power plant operated by Florida Power and Light Company. The intake for this facility, which was constructed in the 1970s, is located approximately 18 miles upstream of the mouth of the river and seven miles upstream of the maximum penetration of brackish water in the dry season. Although it would be preferable if this intake were located several miles downstream, this location is good in that the withdrawals affect only a fairly short portion of the freshwater reach of the Little Manatee River with no impacts extending upstream.

With the approach that has been implemented on these three rivers, flows are not affected in river above the intake where the maintenance of water levels and current velocities is particularly critical. Flows are withdrawn at a downstream location just above the estuarine reach, where the requirements for freshwater flows are different due to the changes in the rivers physical, water quality, and ecological characteristics.

Sea level rise associated with global warming should be considered when assessing the new surface water withdrawal sites, as sea level rise will act to push brackish waters farther upstream. This however, can be accounted for in developing a withdrawal schedule that ceases surface water withdrawals during low flows when brackish waters occur at the intake and then resume withdrawals when higher freshwater flows push brackish waters downstream. As described on page 37, this is currently the operational plan at the intake of the PRMRWAS facility on the Lower Peace River. If necessary, another alternative could be to develop a secondary intake father upstream to be used during times of low flow and maximum upstream brackish water penetration.

Minimum flows adopted for rivers by the SWFWMD typically have a low flow threshold for the cessation of surface water withdrawals, which can be implemented based on water quality or environmental protection. In tidal river estuaries, low flow thresholds have the benefit of preserving all the freshwater inflow during times of low flow when it is ecologically most critical, and are frequently in effect in the spring dry season when there is extensive use of tidal river ecosystems by estuarine dependent species (Flannery and others, 2002).

By locating the intake site as far downstream as possible, flows are preserved in the upstream reaches of the rivers which are most sensitive to impacts. Many of Florida’s freshwater rivers have already been affected by non-point source pollution, nutrient enrichment, habitat alteration and the invasion of non-native plant, invertebrate and fish species. Over much of their flow regime the last thing these freshwater rivers need is to have their flows reduced.

Given the small size and short length of the region’s rivers and their susceptibility to impacts, water supply plans that include the region’s rivers should evaluate intake sites located as far downstream as possible. The funds necessary to construct water transmission lines to transport water to upstream users or water storage facilities would be money well spent.

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Figure 1. Map of Peace River watershed showing the main stem of river, major tributaries, and the locations of long-term USGS streamflow gages. Adapted from SWFWMD (2002).

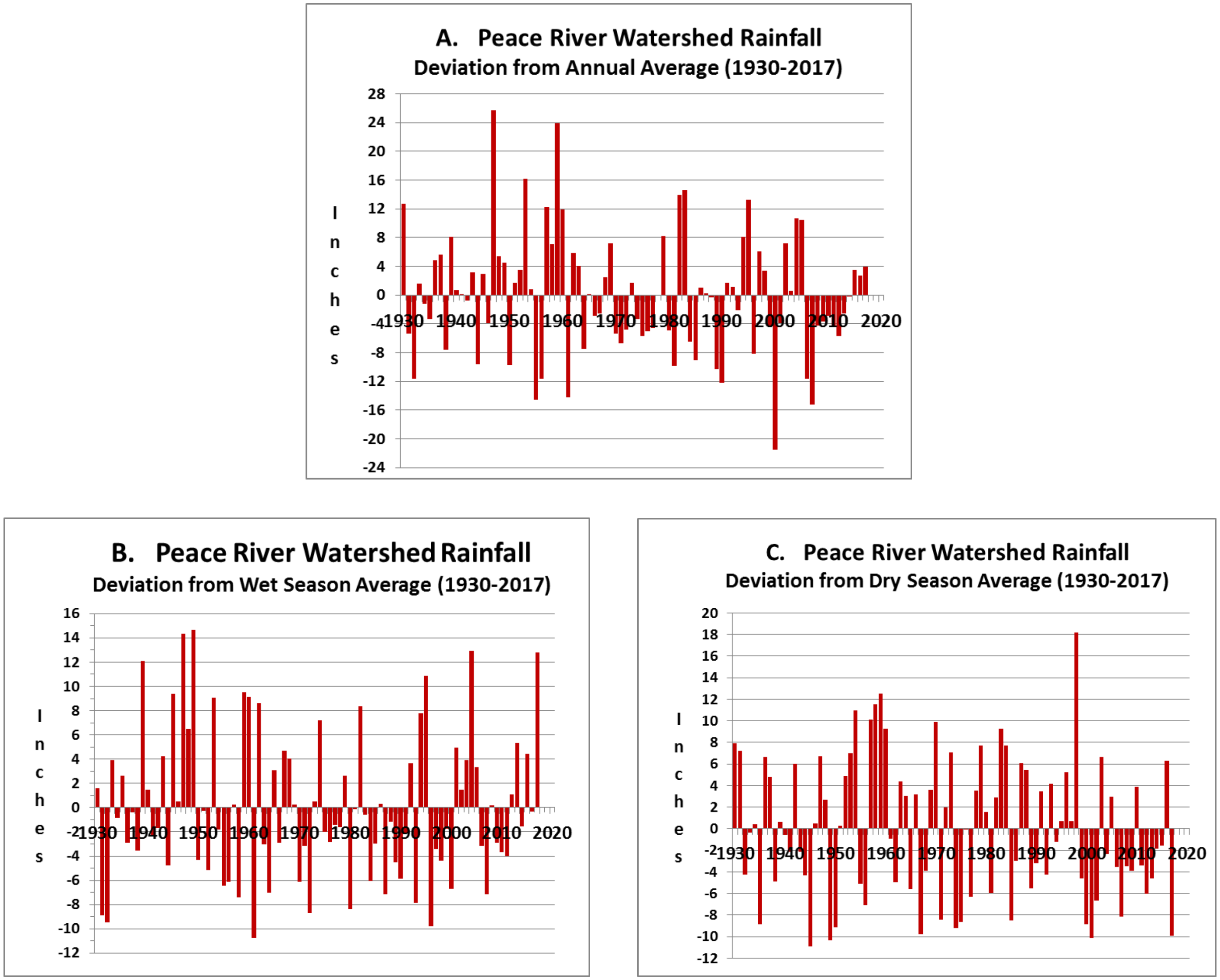


Figure 2. Yearly deviations from: (A) annual average; (B) wet season (June – September); and (C) dry season (October – May) average rainfall totals for the Peace River watershed taken from the regional rainfall summaries available from the Southwest Florida Water Management District website. Average rainfall totals for the 1930 to 2017 are annual - 52.2 inches, wet season - 31.5 inches, and dry season - 20.7 inches.

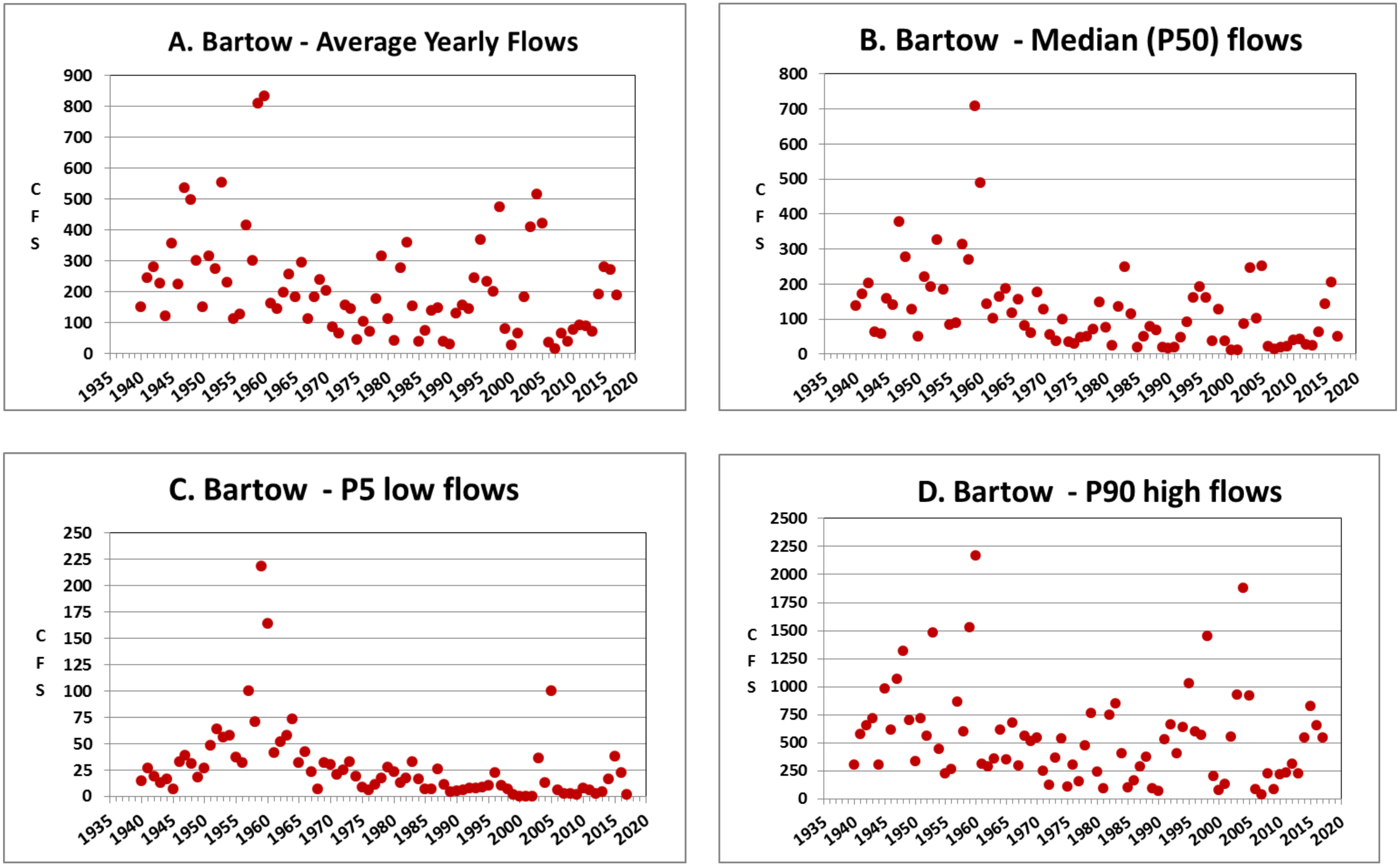
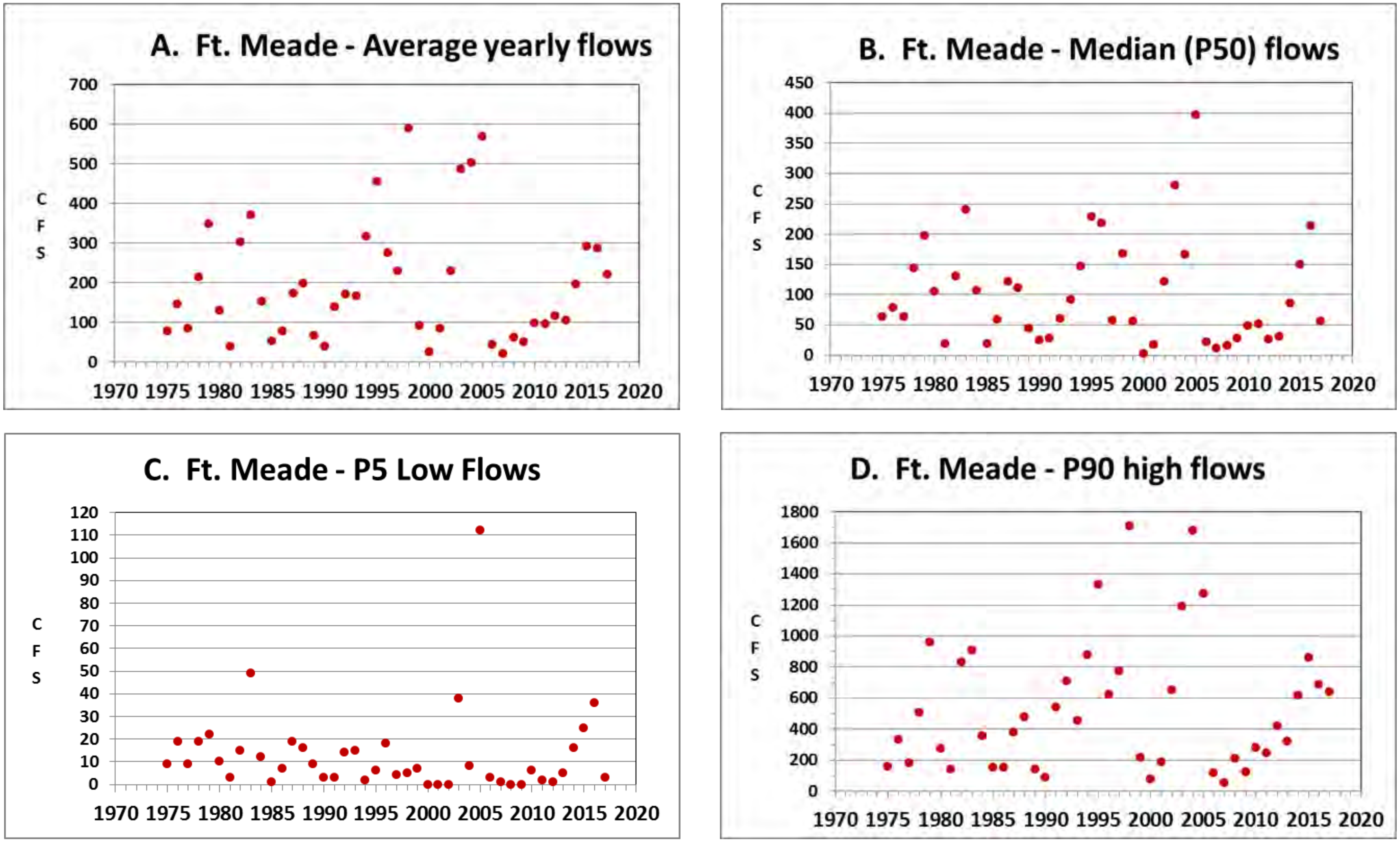


Figure 3. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for the Peace River at Bartow gage for 1940 to 2017.



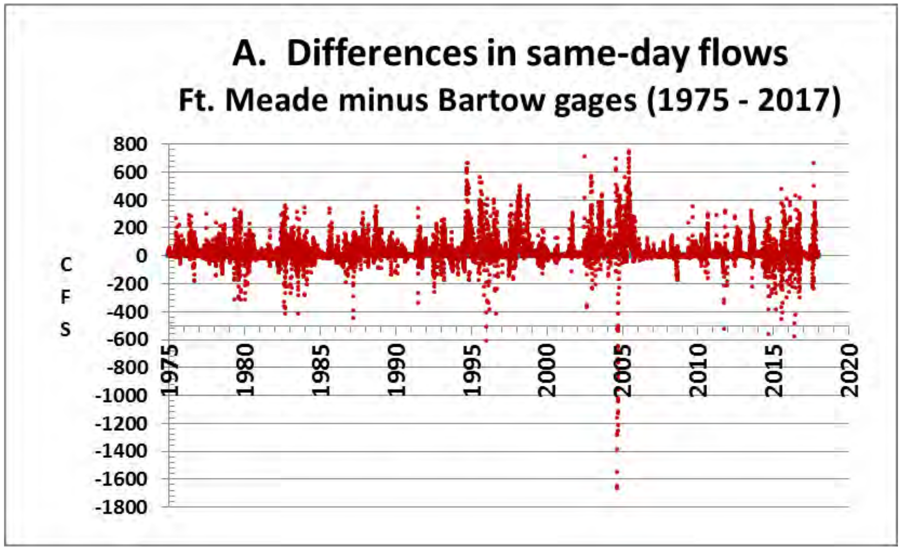
A. Ft. Meade - Average yearly flows

B. Ft. Meade - Median (P50) flows

C. Ft. Meade - P5 Low Flows

D. Ft. Meade - P90 high flows

Figure 4. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for the Peace River at Ft. Meade gage for 1975 to 2017.



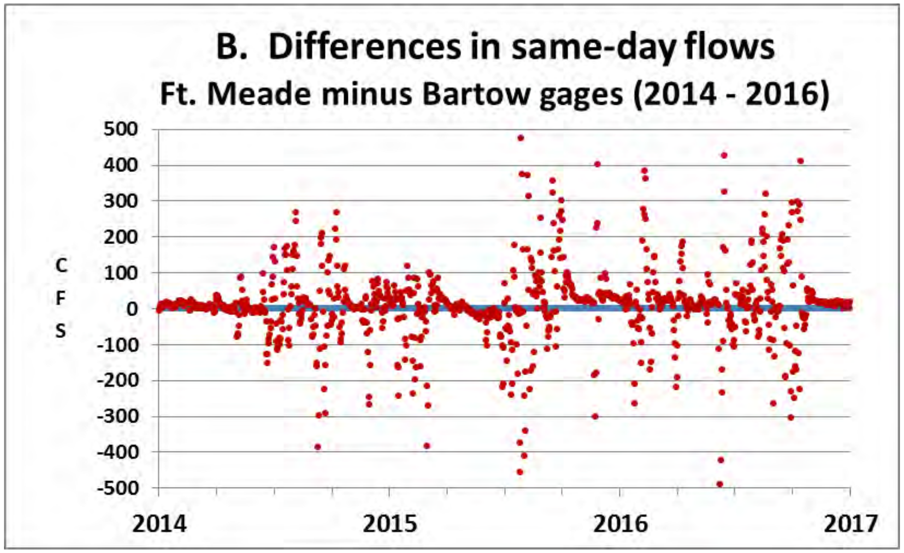


Figure 5. Hydrographs of differences in same-day flows reported by the USGS for the Peace River at Bartow and Peace River at Ft. Meade gages (Ft. Meade minus Bartow) for 1975 – 2017 and 2014 – 2016.

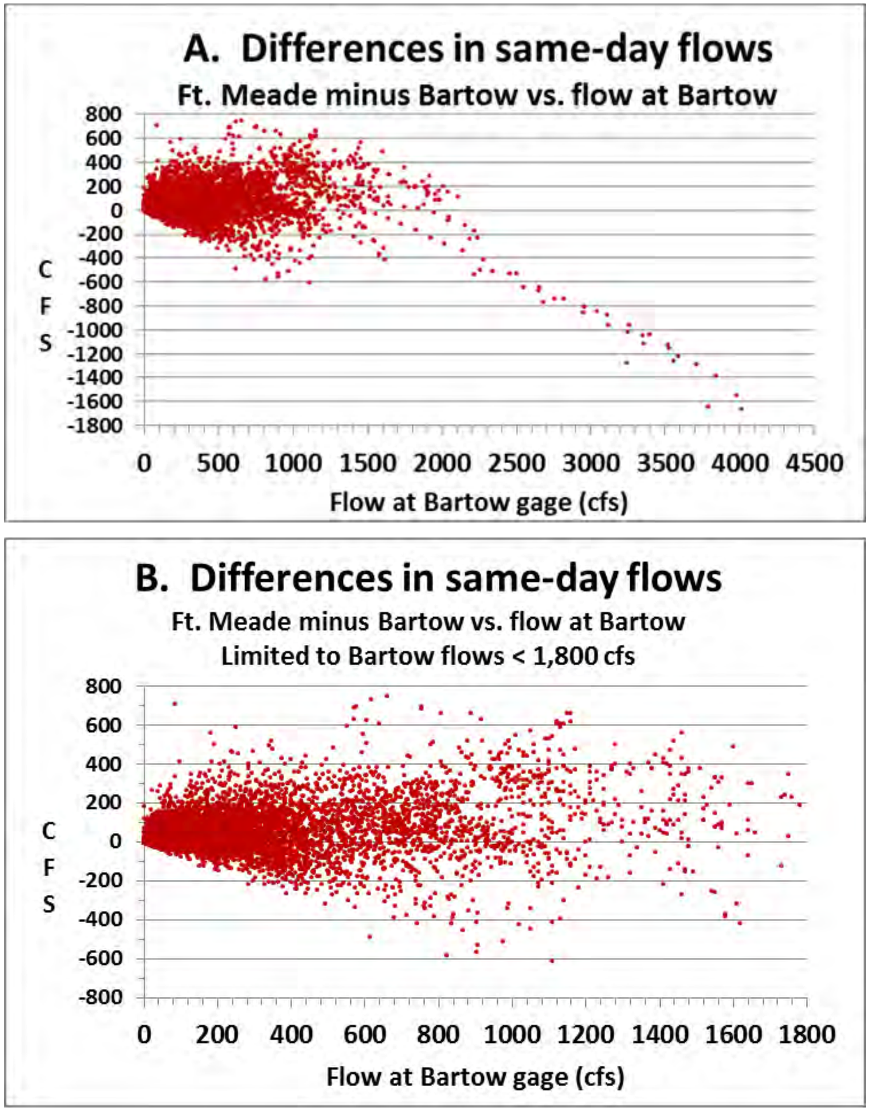


Figure 6. Hydrographs of differences in same-day flows reported by the USGS for the Peace River at Bartow and Peace River at Ft. Meade gages (Ft. Meade flow minus Bartow) versus the flow at Bartow. Hydrograph B is limited to flows at Bartow less than 1,800 cfs for better resolution. As described in the text, caution should be used in interpreting these graphs at very high flows when the river is well outside its banks.

Figure 7. Photographs of locations on the channel of the Upper Peace River between Bartow and Ft. Meade during droughts showing areas with no or very little water.

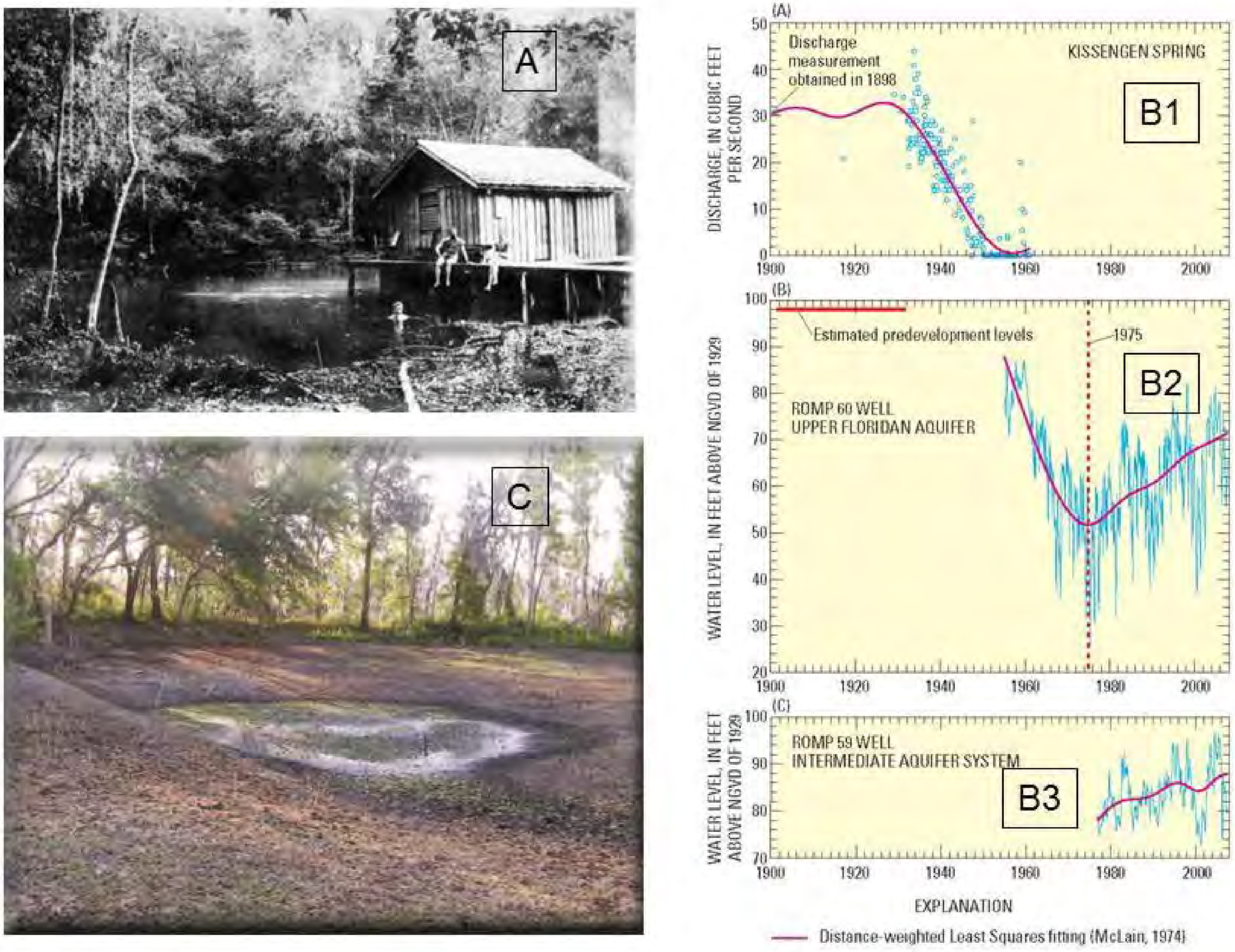


Figure 8. A - Photograph of Kissengen Spring in 1894. B1 - Discharge from Kissengen Spring, B2- Water levels in the Upper Floridan aquifer at the Romp 60 well, and B3 - Water levels in the Intermediate aquifer at the Romp 59 well. C- Photograph of the site of inactive Kissgengen Spring during 2006.

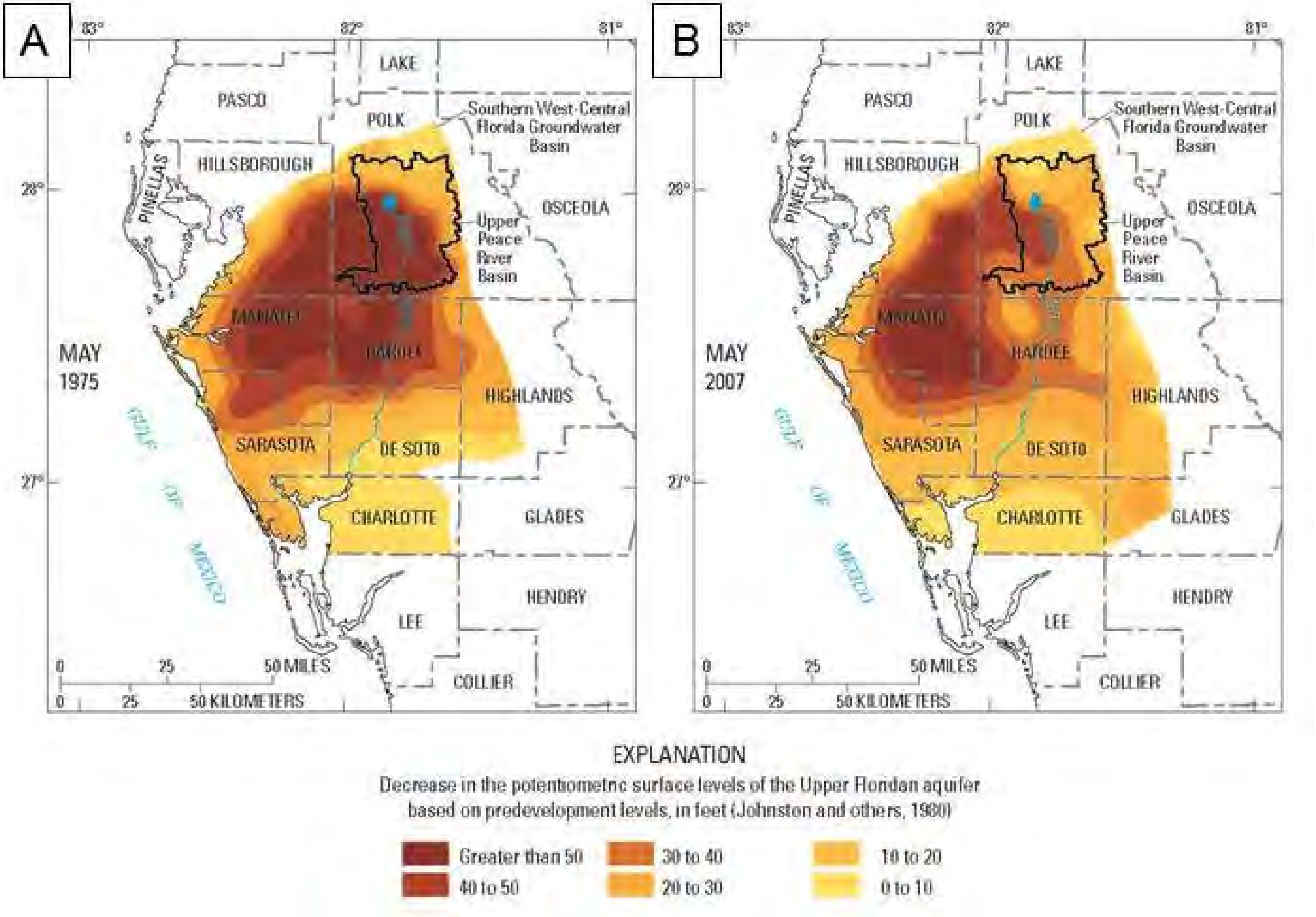


Figure 9. Changes in the potentiometric surface of the Upper Floridan aquifer in the Southern Groundwater Basin from estimated predevelopment conditions to 1975 (A) and 2007 (B). Adapted from Metz and Lewelling (2009).

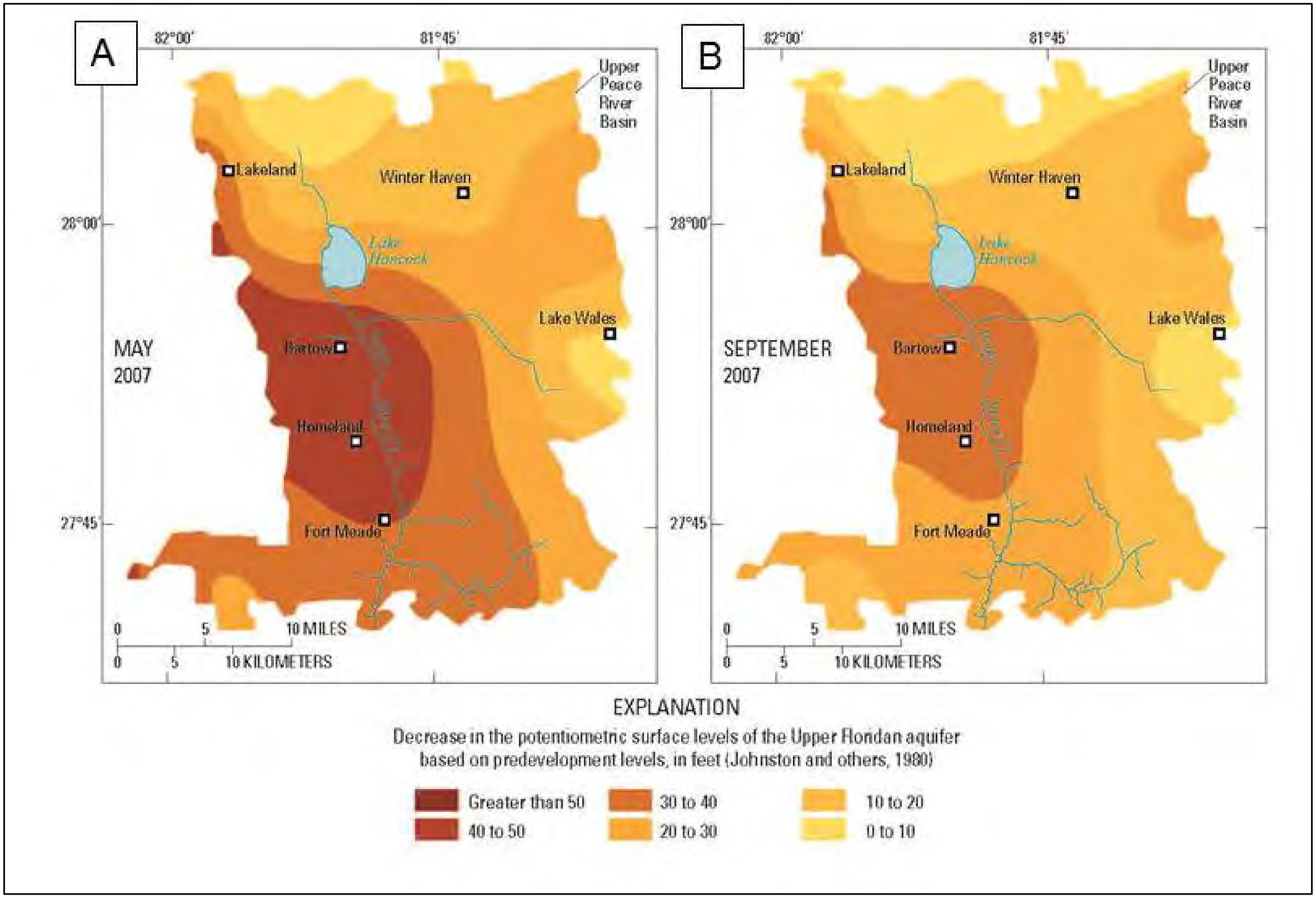


Figure 10. Changes in the potentiometric surface of the Upper Floridan aquifer in the Upper Peace River basin from estimated predevelopment conditions to May 2007 (A) and September 2007 (B) levels. Adapted from Metz and Lewelling (2009).

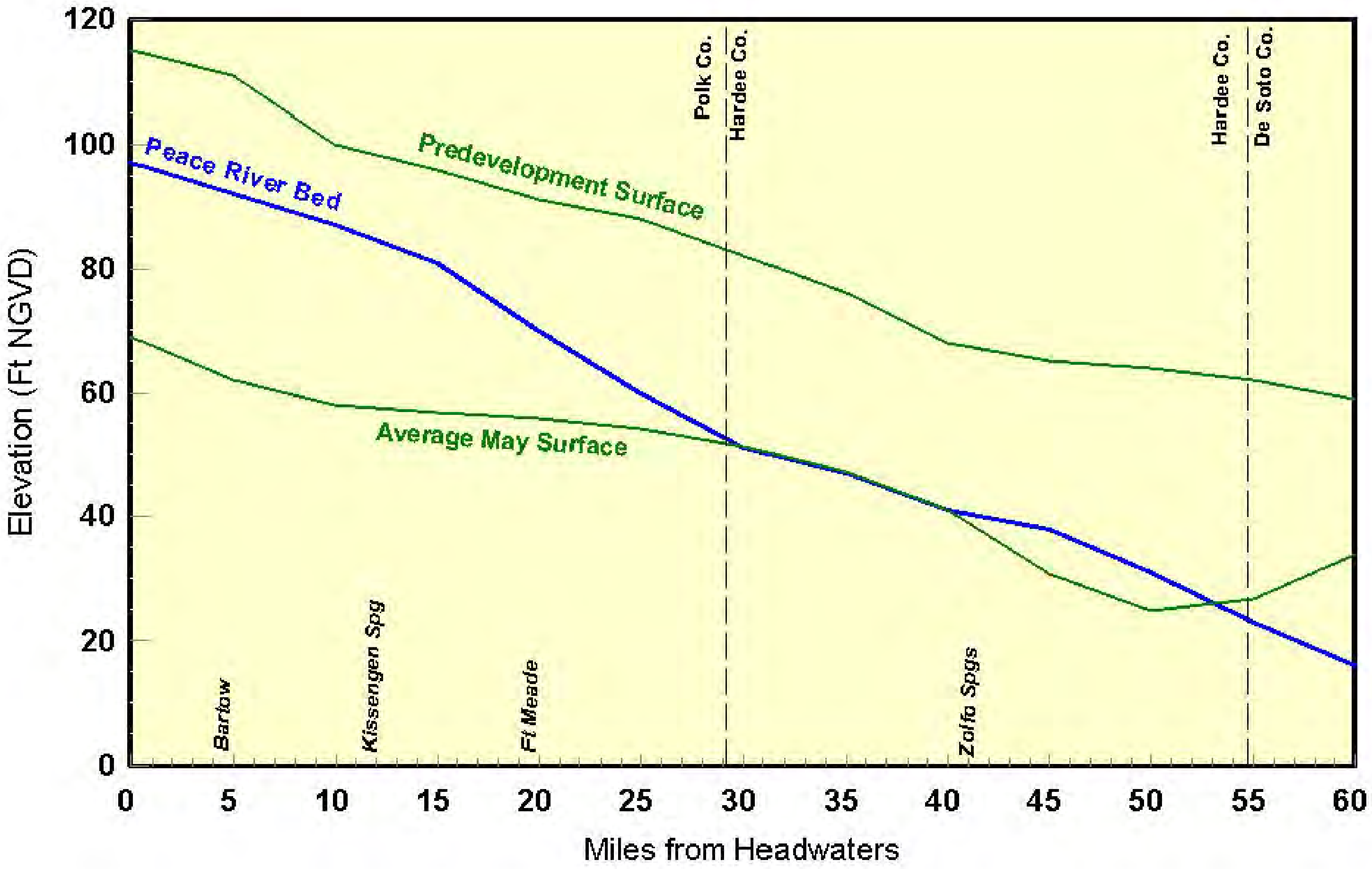


Figure 11. Generalized potentiometric surface of the Upper Floridan aquifer relative to the bed of the channel of Peace River for pre-development conditions and average May conditions for 1989-2002. Reprinted from Basso (2003).

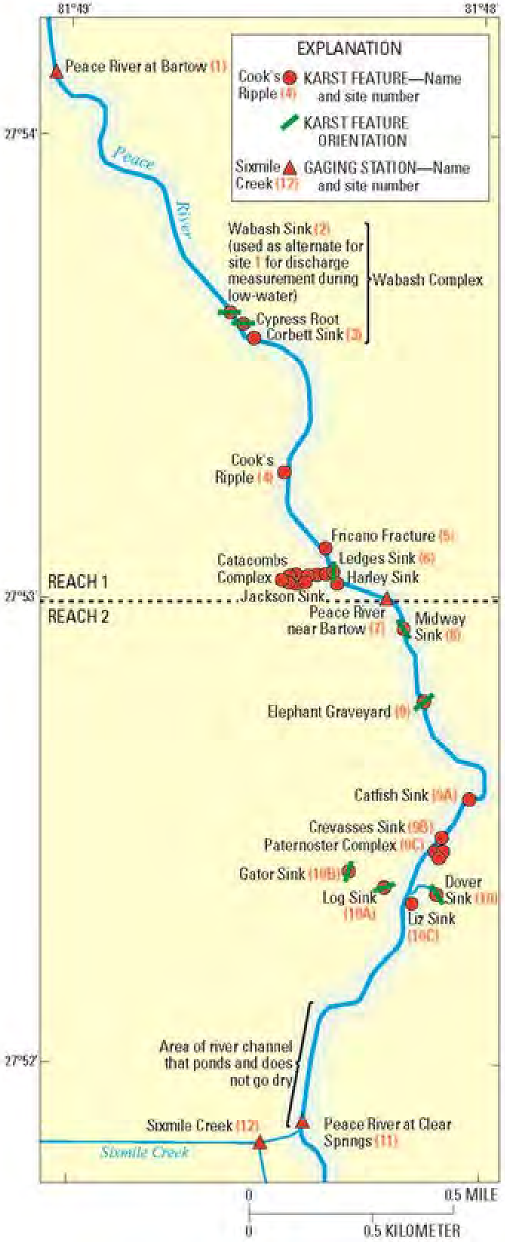


Figure 12. Location of karst features in reaches 1 and 2 of the Upper Peace River. Reprinted from Metz and Lewelling (2009).

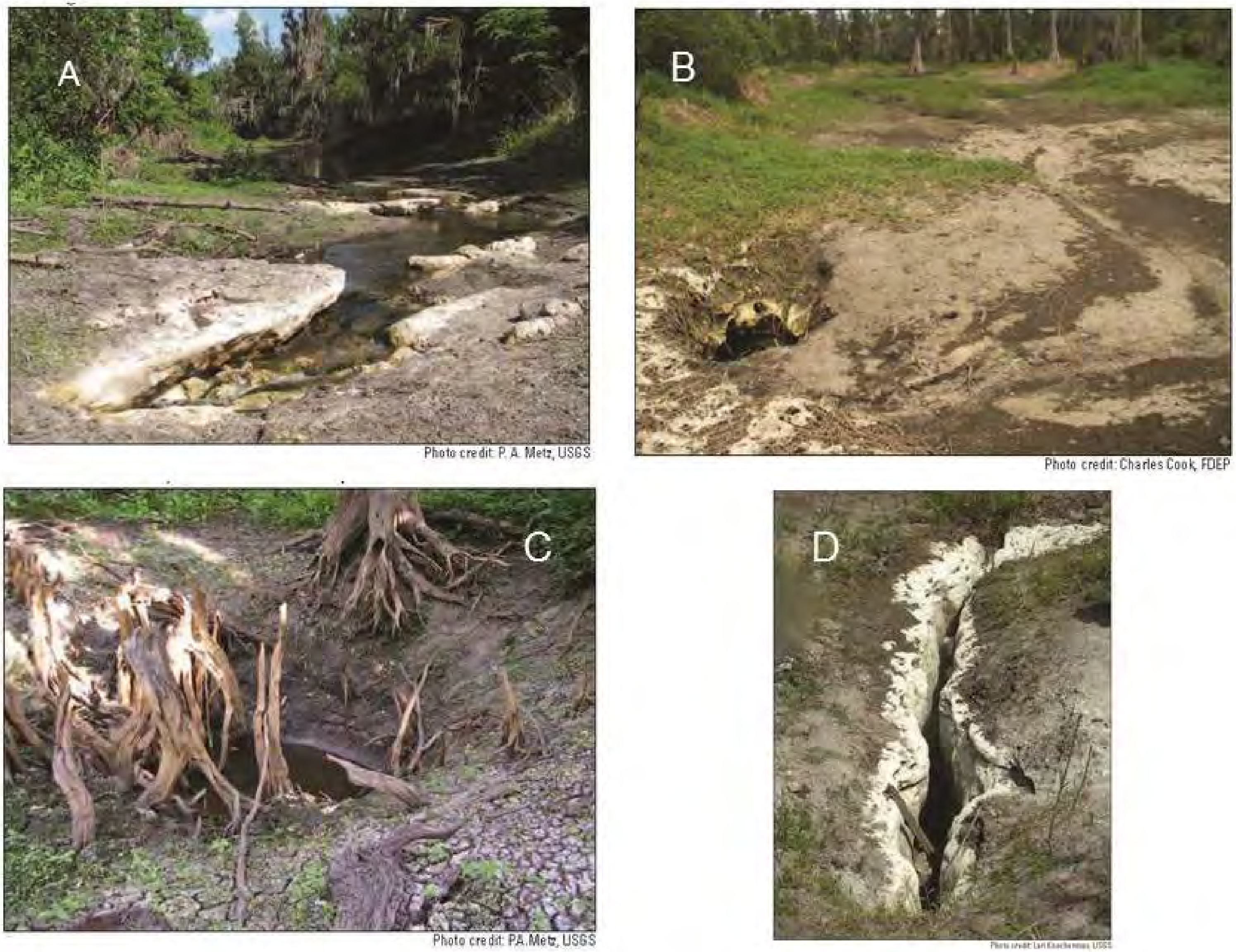


Photo credit: P. A. Metz, USGS

Photo credit: Charles Cook, FDEP

Photo credit: P.A. Metz, USGS

Photo credit: Lari Knochenmus, USGS

Figure 13. Photographs of sinks in the channel of the Peace River between Bartow and Ft. Meade: (A) Ledges sink; (B) Midway Sink; (C) Cavity near Wabash complex; (D) Crevasses Sink. Adapted from Metz and Lewelling (2009)

Photo credit: Charles Cook, FDEP

Photo credit: P. A. Metz, USGS

Figure 14. Photographs of sinks in the floodplain of the Peace River between Bartow and Ft. Meade: (A) Sink in eastern floodplain; (B) Gator Sink; (C) Dover Sink during dry conditions; (D) Dover Sink with ponded water during high river water levels.

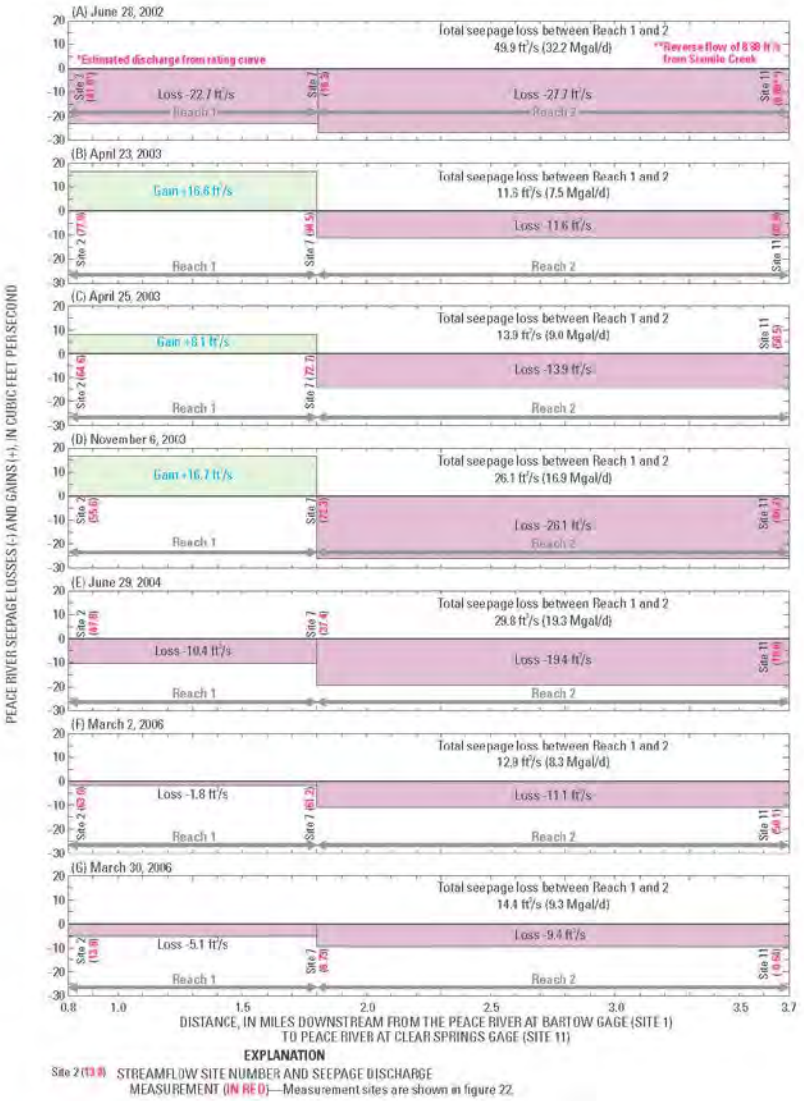
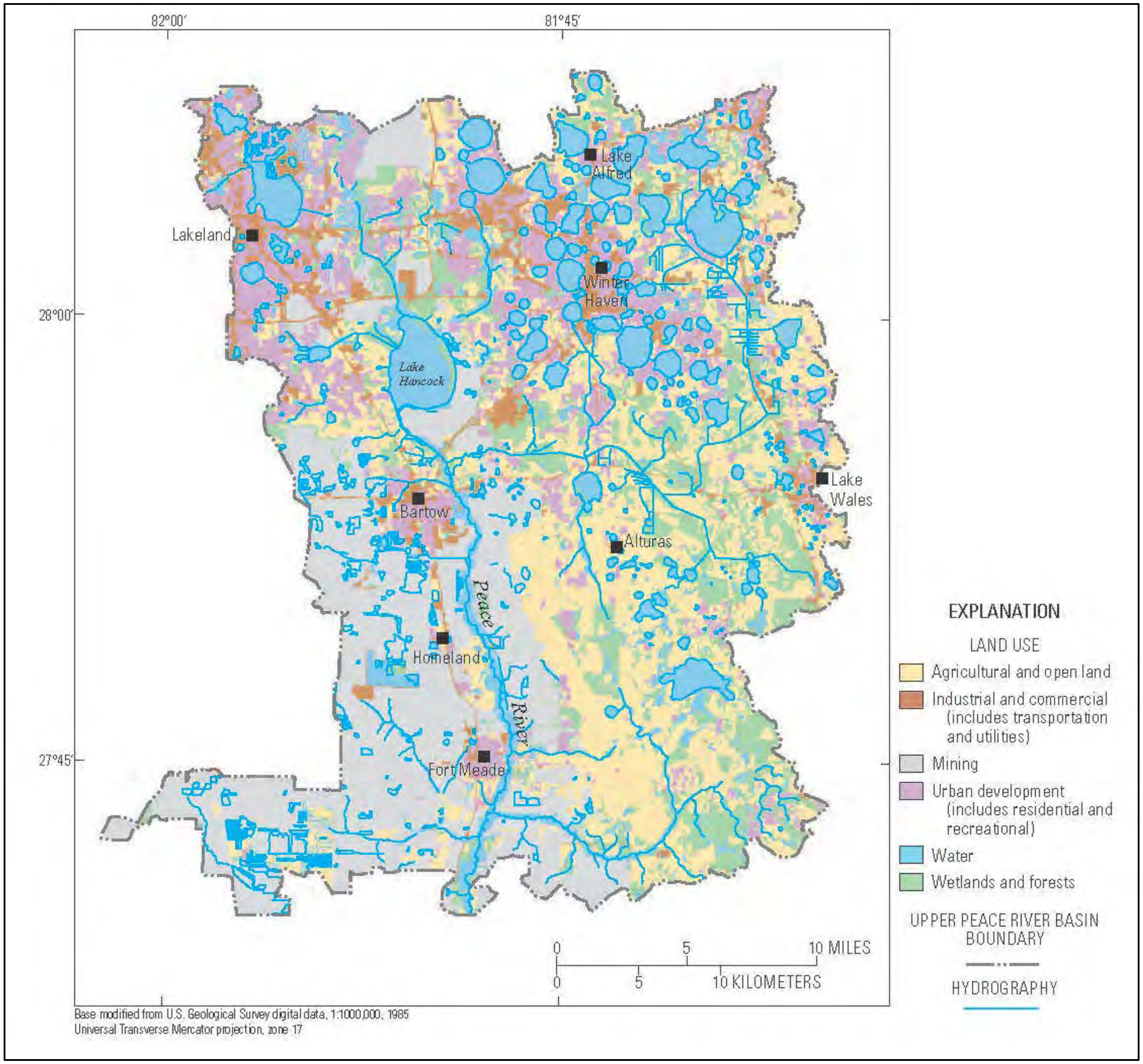


Figure 15. Streamflow gains and losses along reaches 1 and 2 from the Peace River at Wasbash (site 2) to the Peace River at Clear Springs gaging stations (site 11). Reprinted from Metz and Lewelling (2009).



Base modified from U.S. Geological Survey digital data, 1:1000,000, 1985
Universal Transverse Mercator projection, zone 17

Figure 16. Major Land use categories in the Upper Peace River Basin for 2005. Reprinted from Metz and Lewelling (2009)

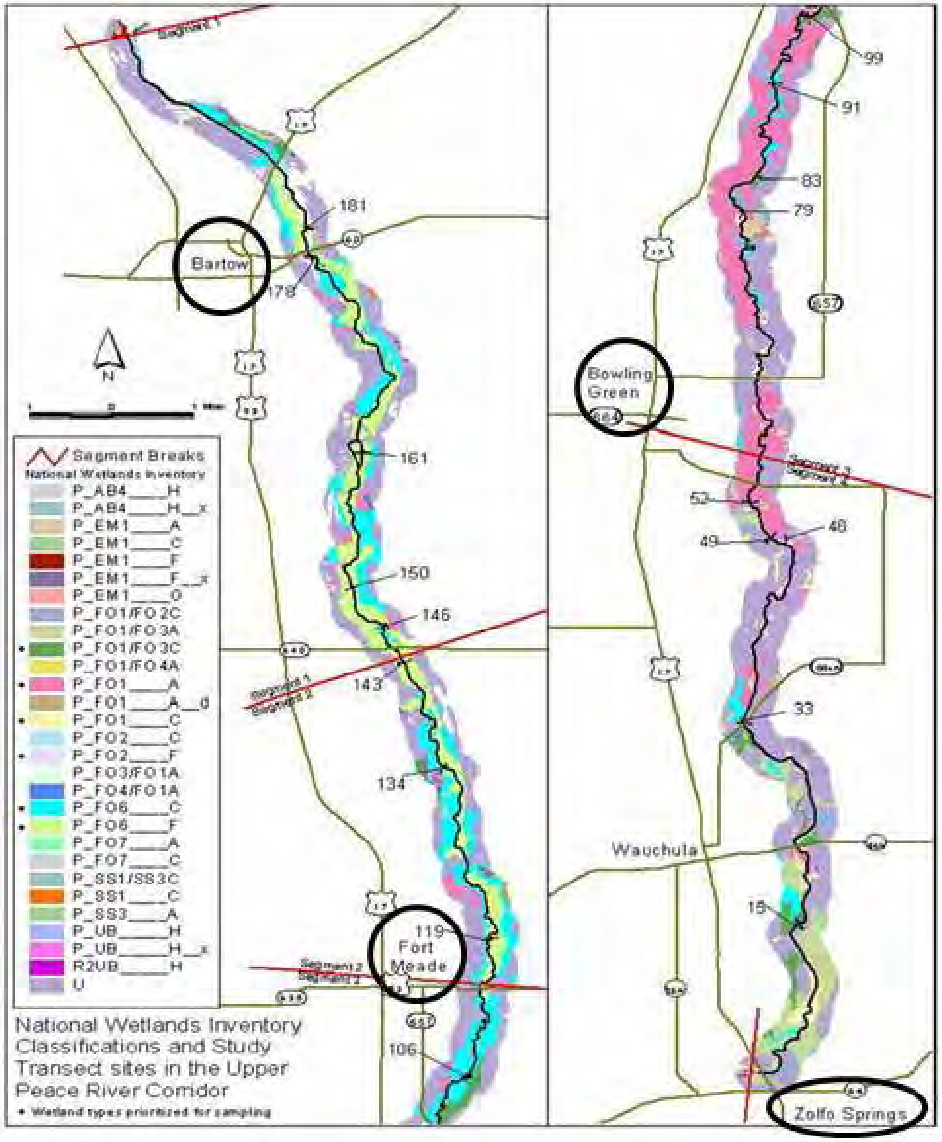


Figure 17. Distribution wetland types classified by the National Wetlands Inventory along the Upper Peace River from the origin of the Peace River above Bartow to Zolfo Springs. Towns are circled for geographic reference. Adapted from SWFWMD (2002).

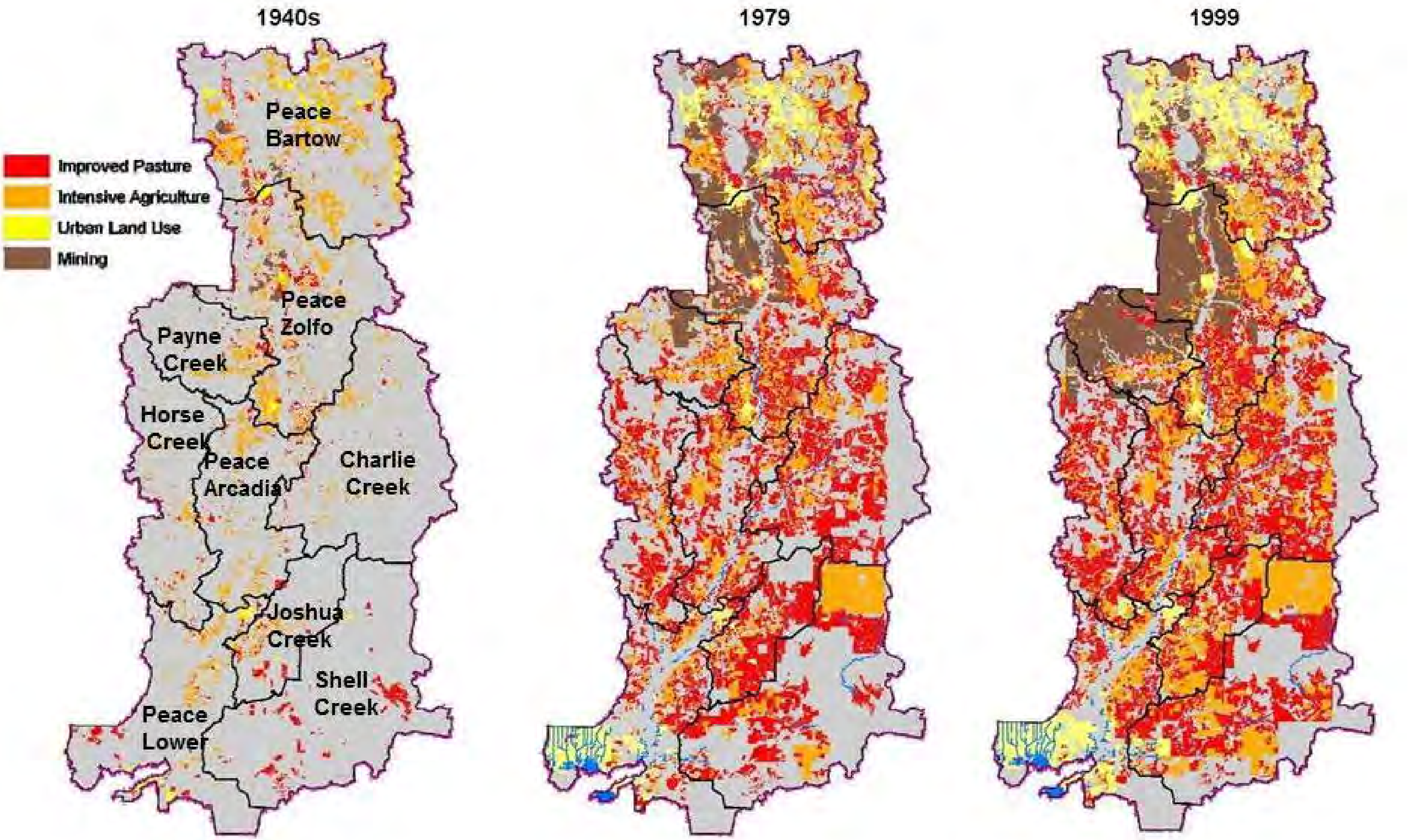


Figure 18. Distribution of major developed land uses in the Peace River watershed for the 1940s, 1979, and 1999. Major sub-basins labeled in the 1940s map for reference. Adapted from PBS&J and others (2007).

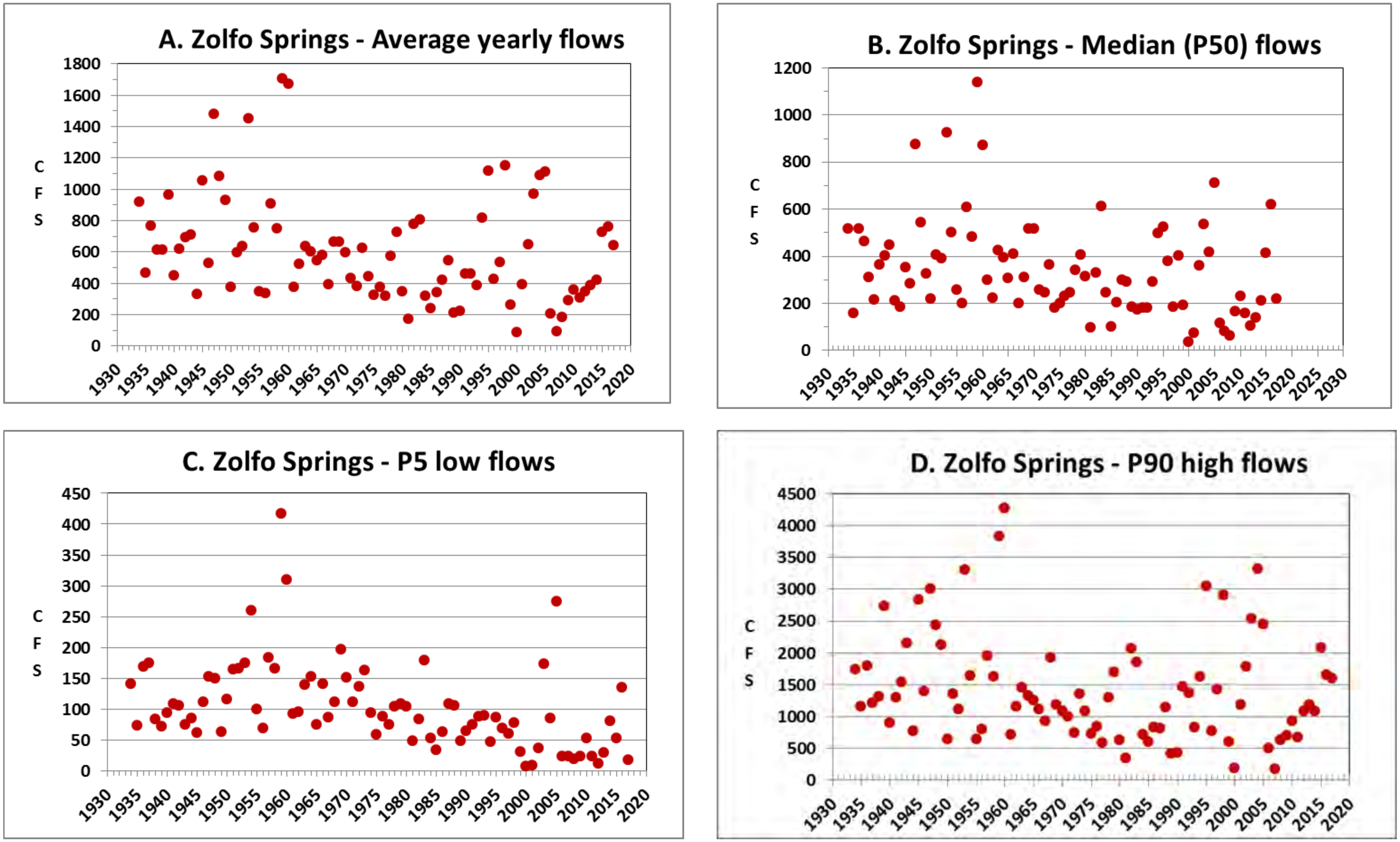


Figure 19. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for the Peace River at Zolfo Springs gage for 1934 to 2017.

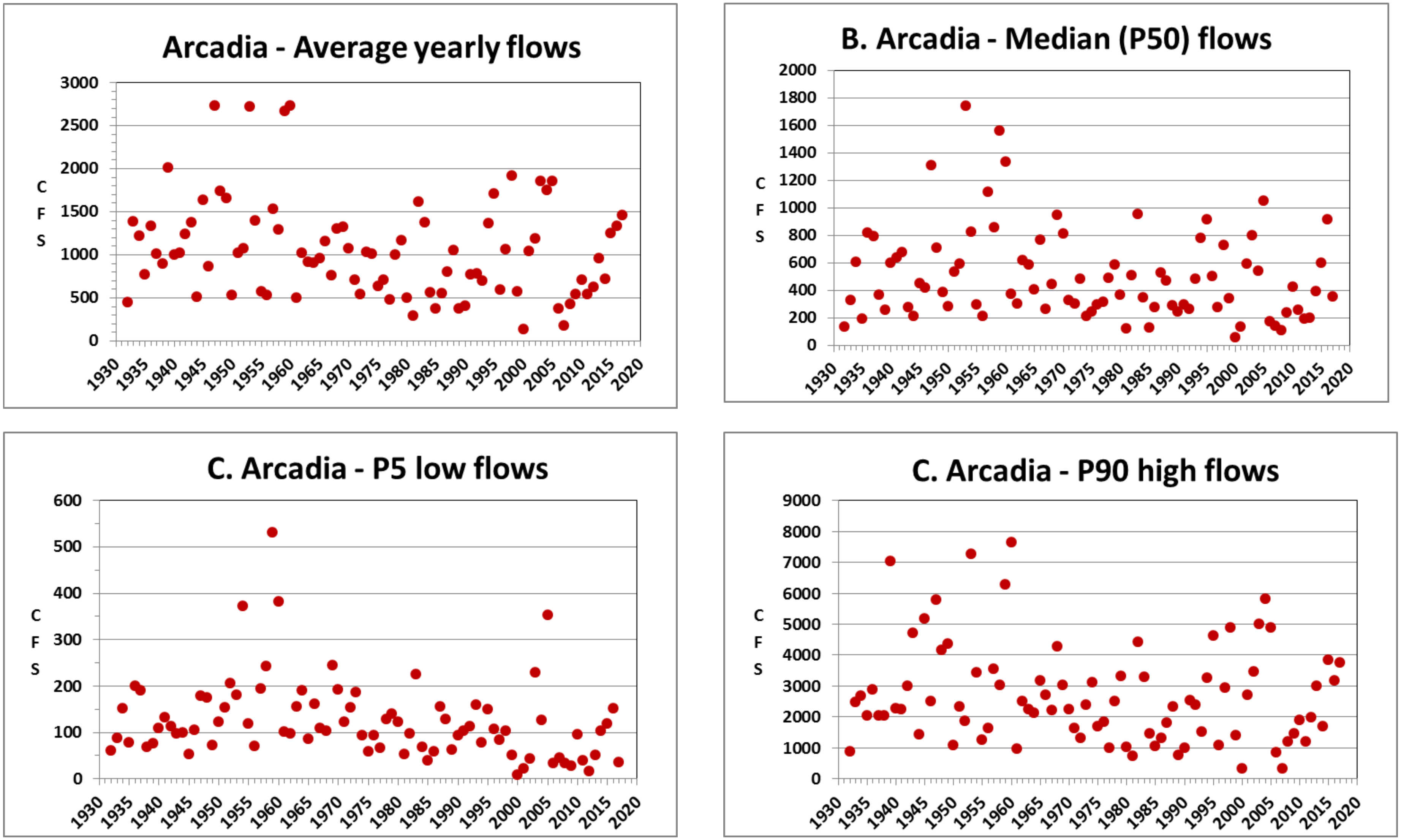


Figure 20. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for the Peace River at Arcadia gage for 1931 to 2017.

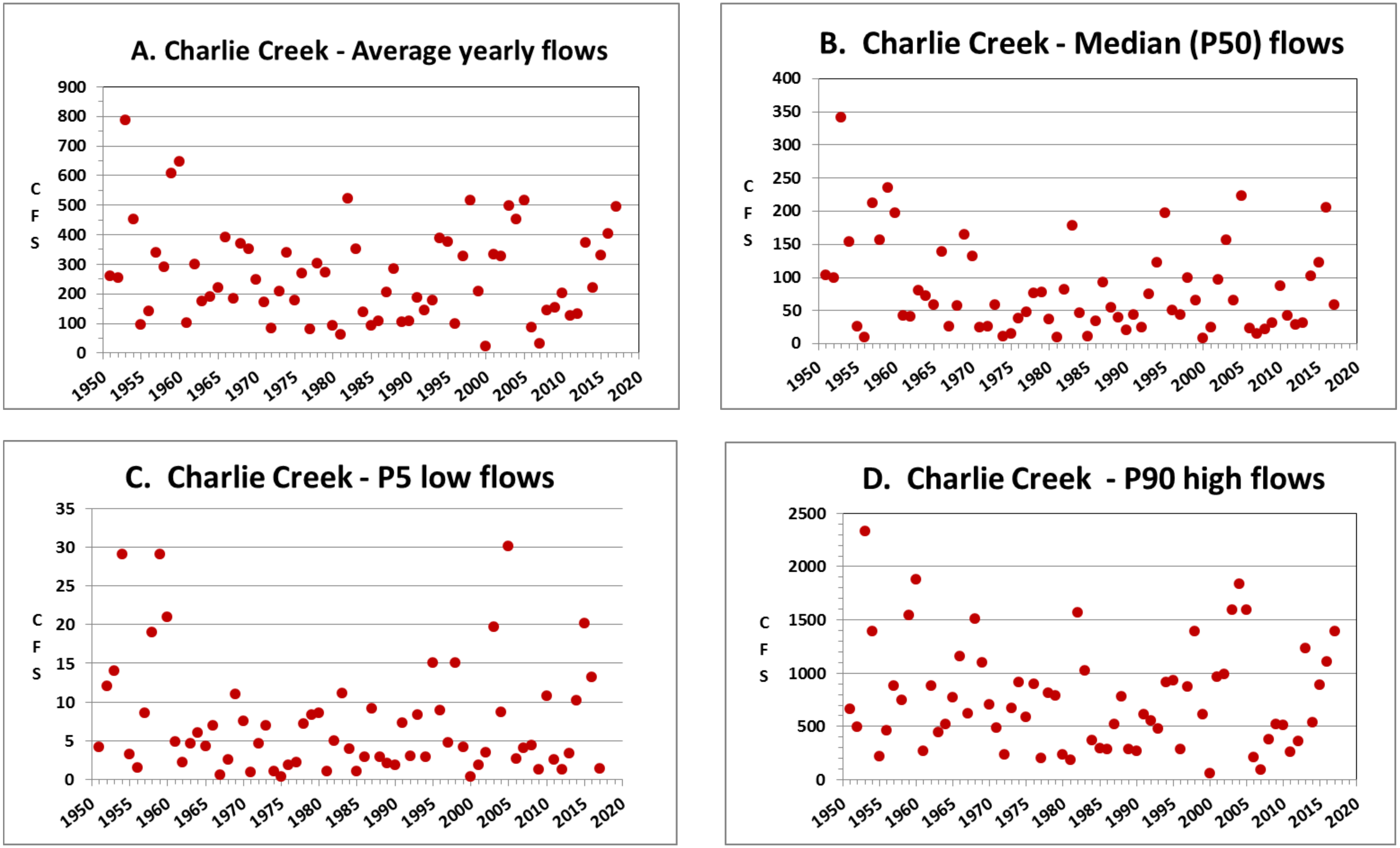


Figure 21. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for Charlie Creek near Gardner for 1951 to 2017.

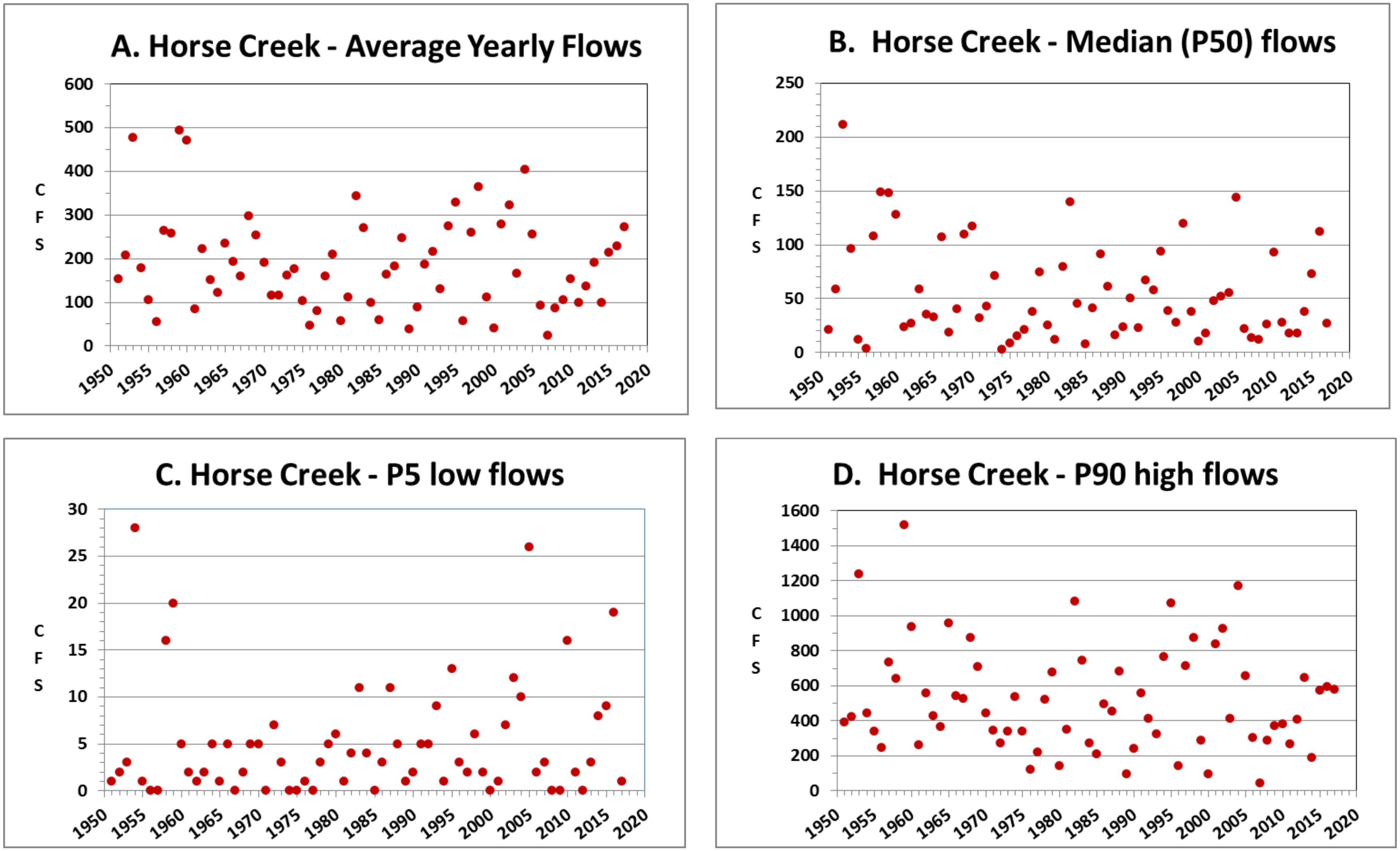
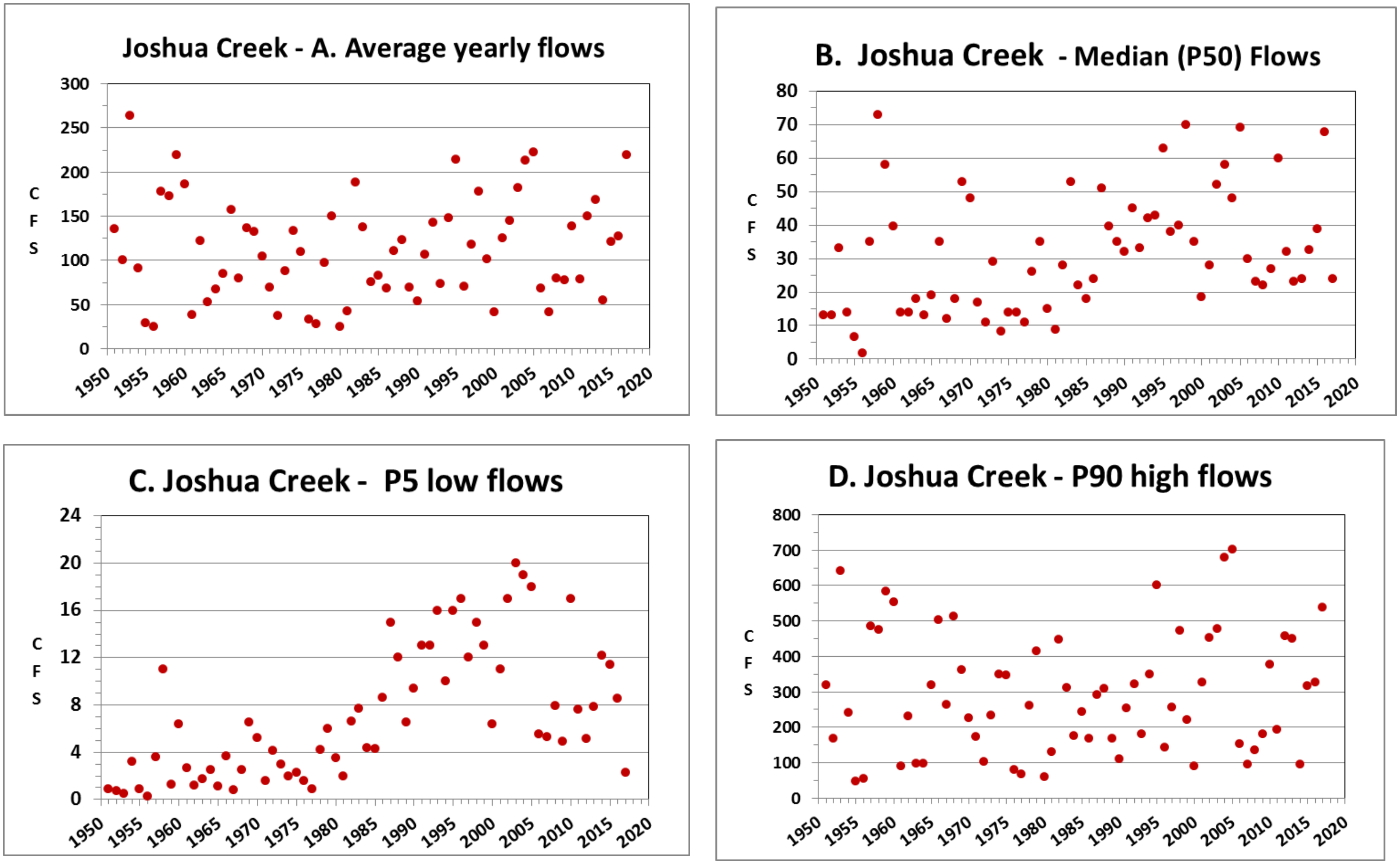


Figure 22. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for Horse Creek near Arcadia for 1951 to 2017.


Joshua Creek - A. Average yearly flows

B. Joshua Creek - Median (P50) Flows

C. Joshua Creek - P5 low flows

D. Joshua Creek - P90 high flows

Figure 23. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for Joshua Creek at Nocatee for 1951 to 2017.

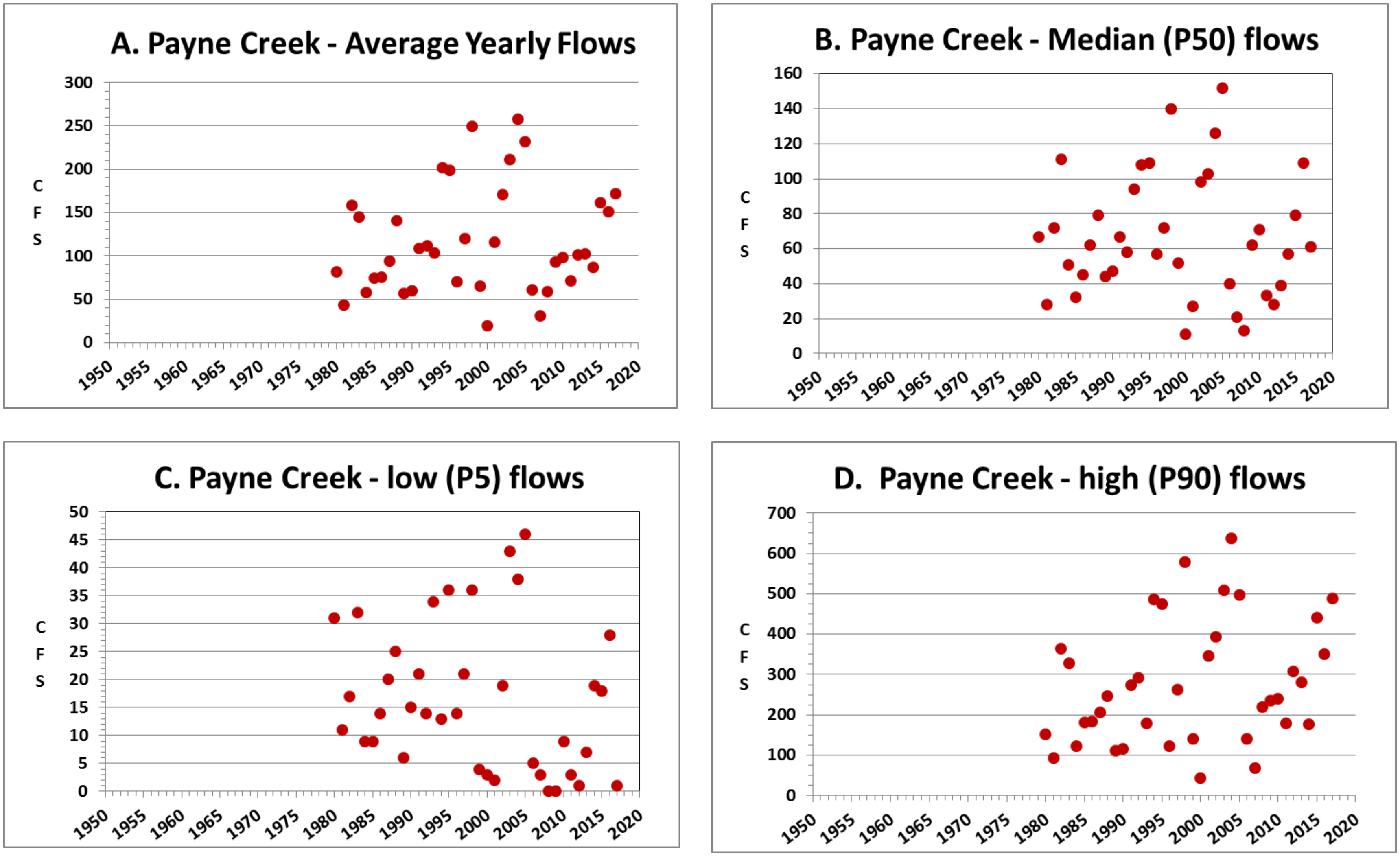


Figure 24. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for Payne Creek near Bowling Green for 1980 to 2017.

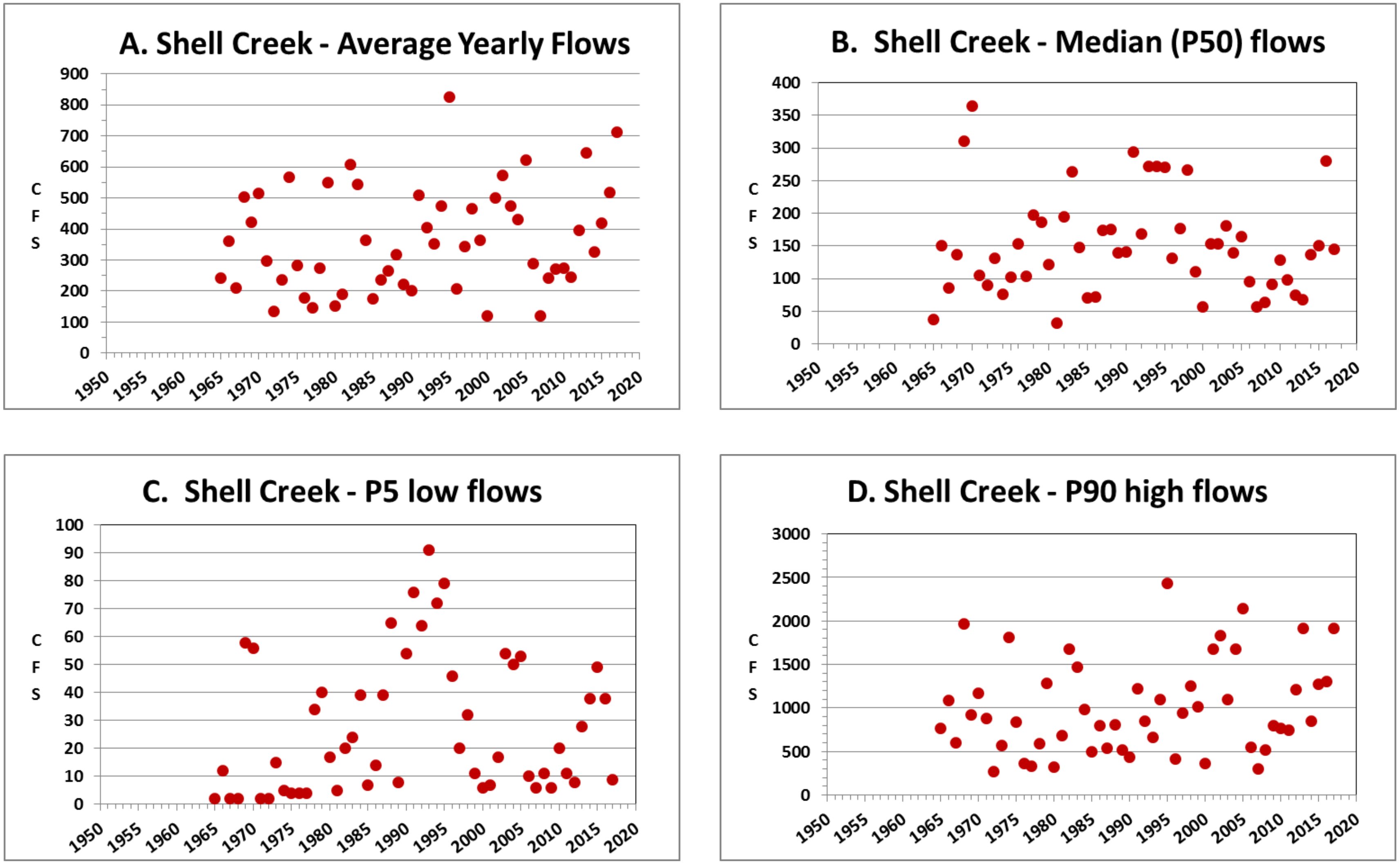


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Figure 25. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for Shell Creek near Punta Gorda for 1965 to 2017.

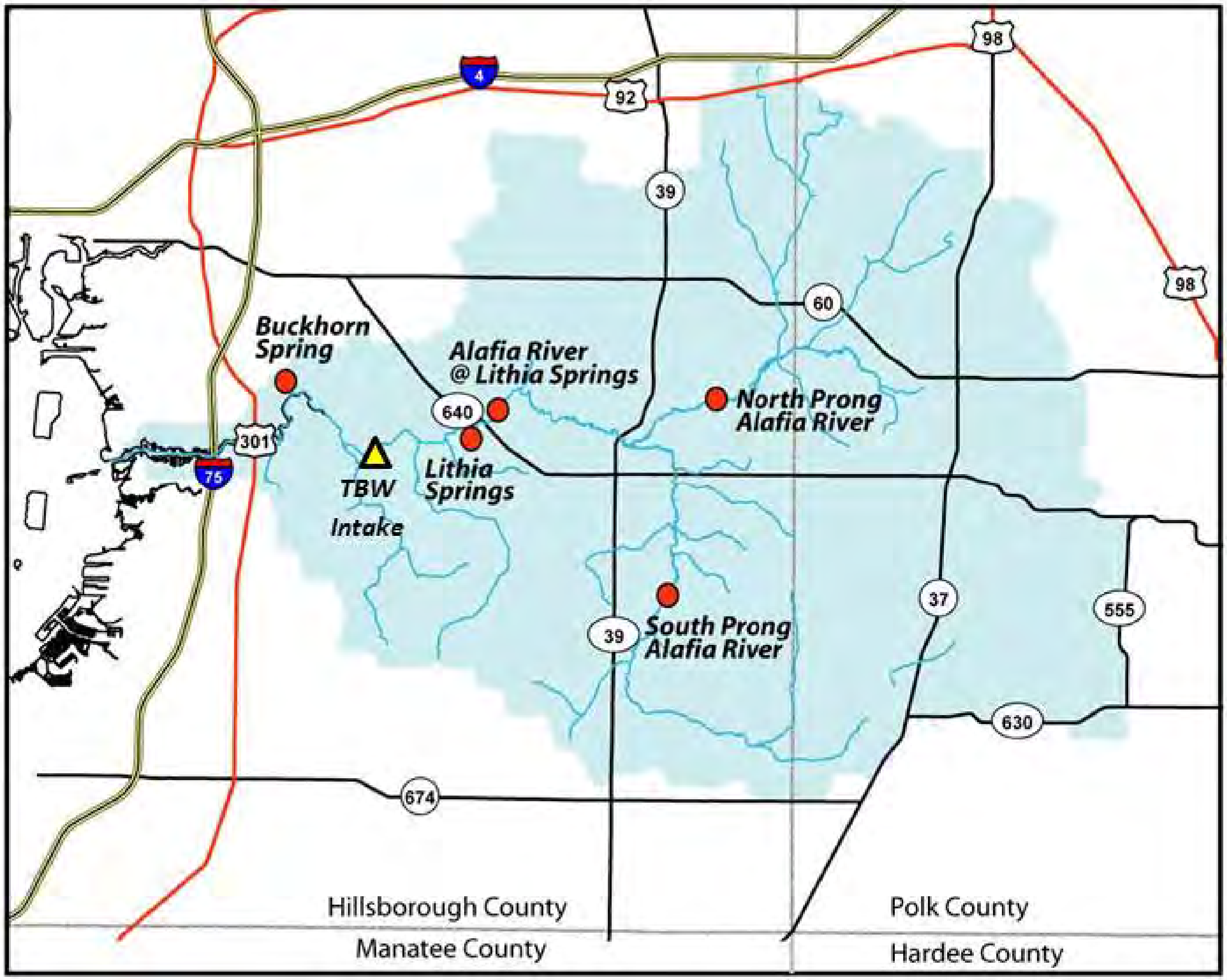


Figure 26. The Alafia River watershed showing the channels of the river and north and south prongs with the location of USGS gages on the Alafia River at Lithia, the North Prong at Keysville, and the South Prong near Lithia. Also shown is the location of Lithia and Buckhorn Springs and the intake site for Tampa Bay Water (yellow triangle). Adapted from SWFWMD (2005B).

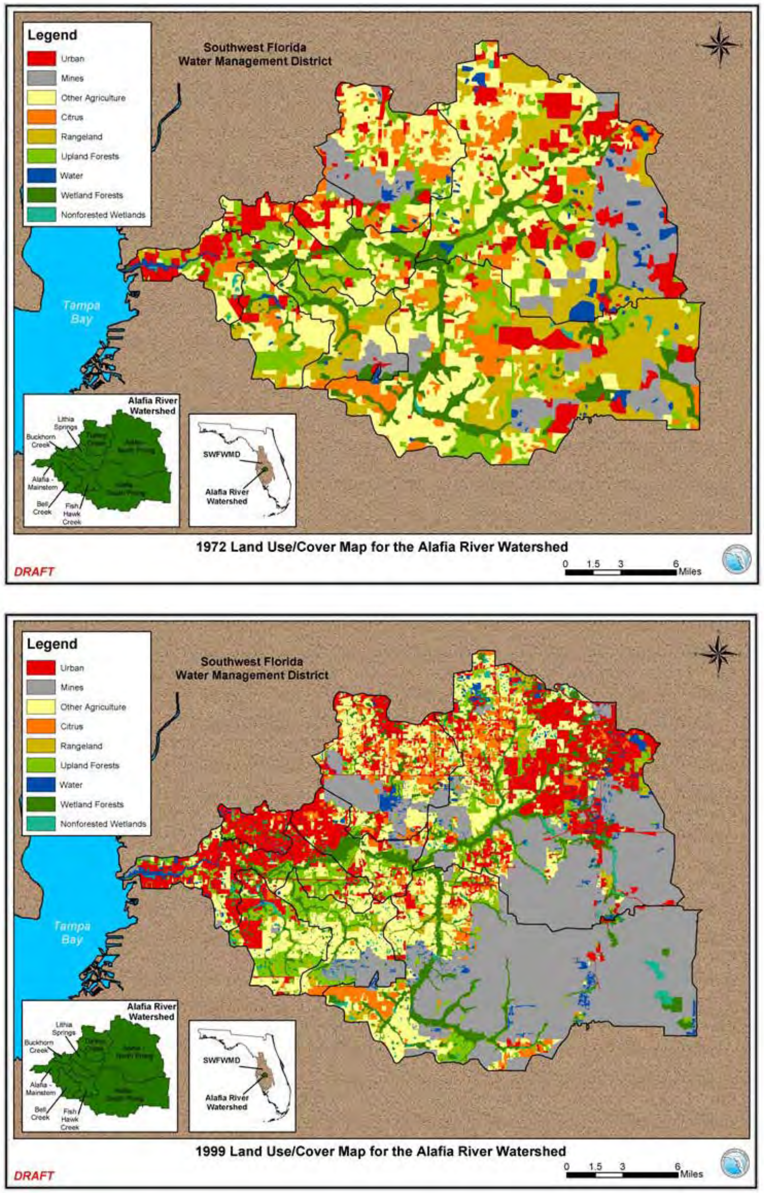


Figure 27. Major land use categories in the Alafia River watershed for 1972 (top) and 1999 (bottom). Reprinted from SWFWMD (2005B).

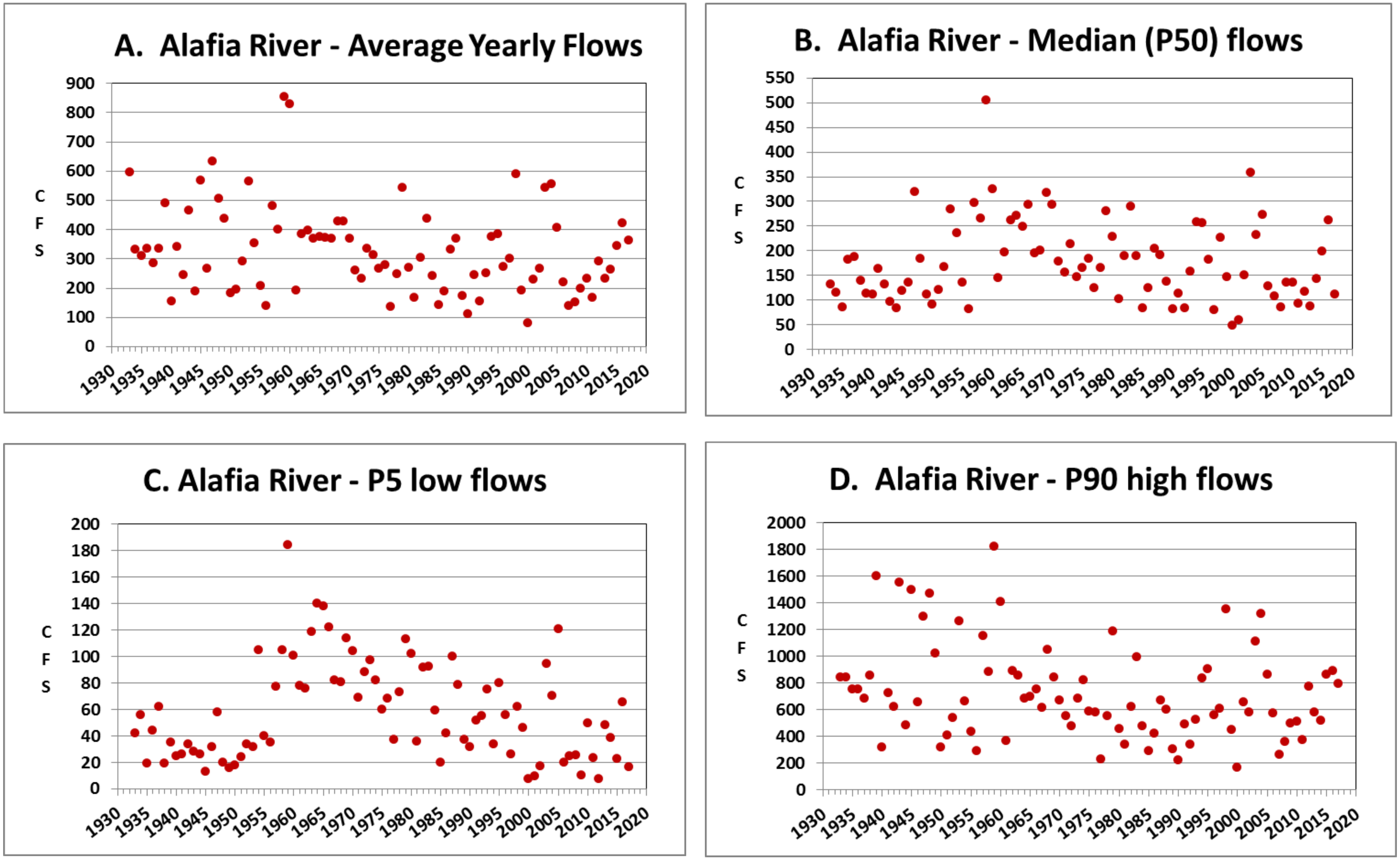
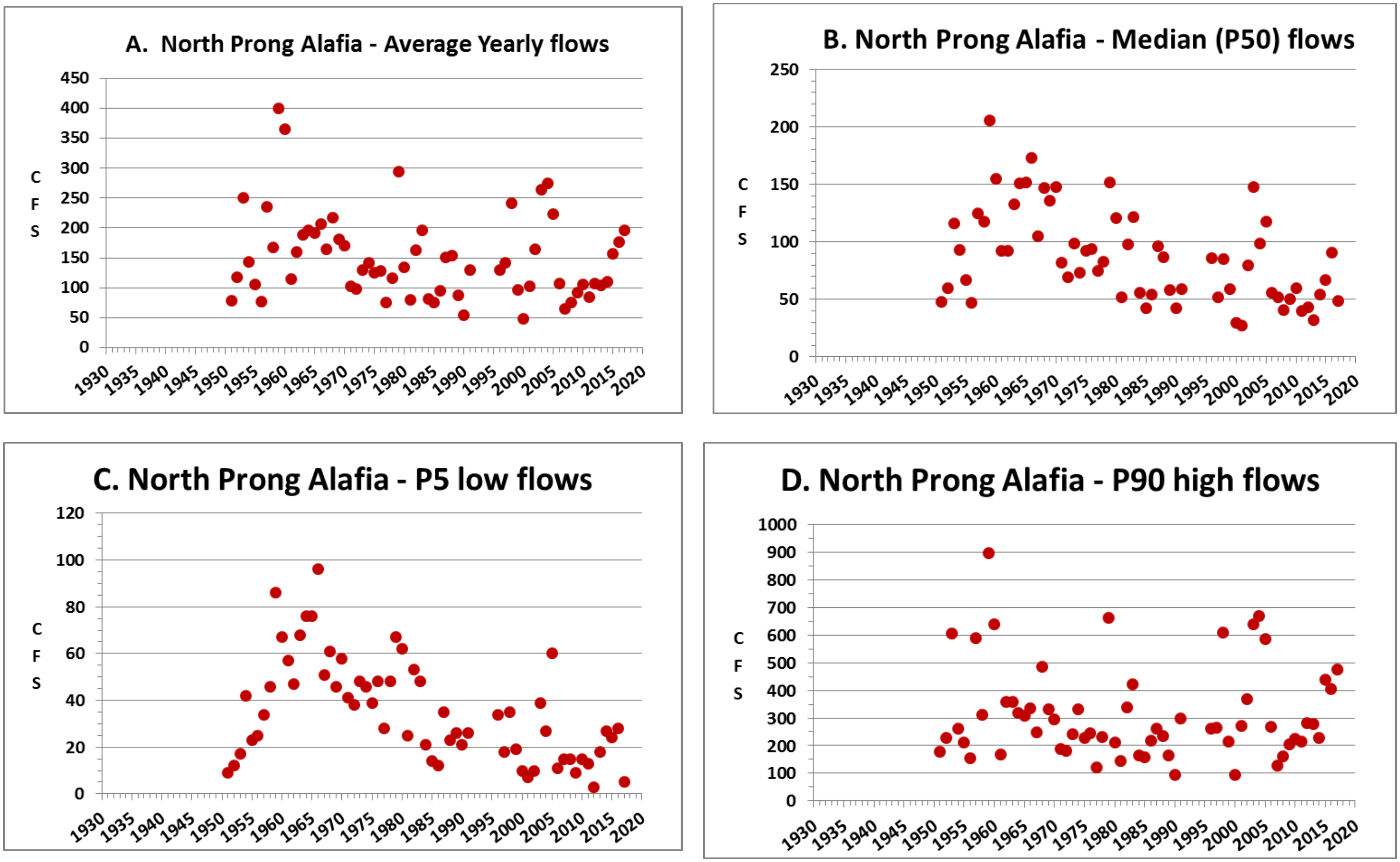


Figure 28. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for the Alafia River at Lithia for 1933 to 2017.



A. North Prong Alafia - Average Yearly flows

B. North Prong Alafia - Median (P50) flows

C. North Prong Alafia - P5 low flows

D. North Prong Alafia - P90 high flows

Figure 29. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for the North Prong of the Alafia River at Keysville for 1951 to 2017. No values shown for 1992 - 1995 due to lack of complete daily records within those years.

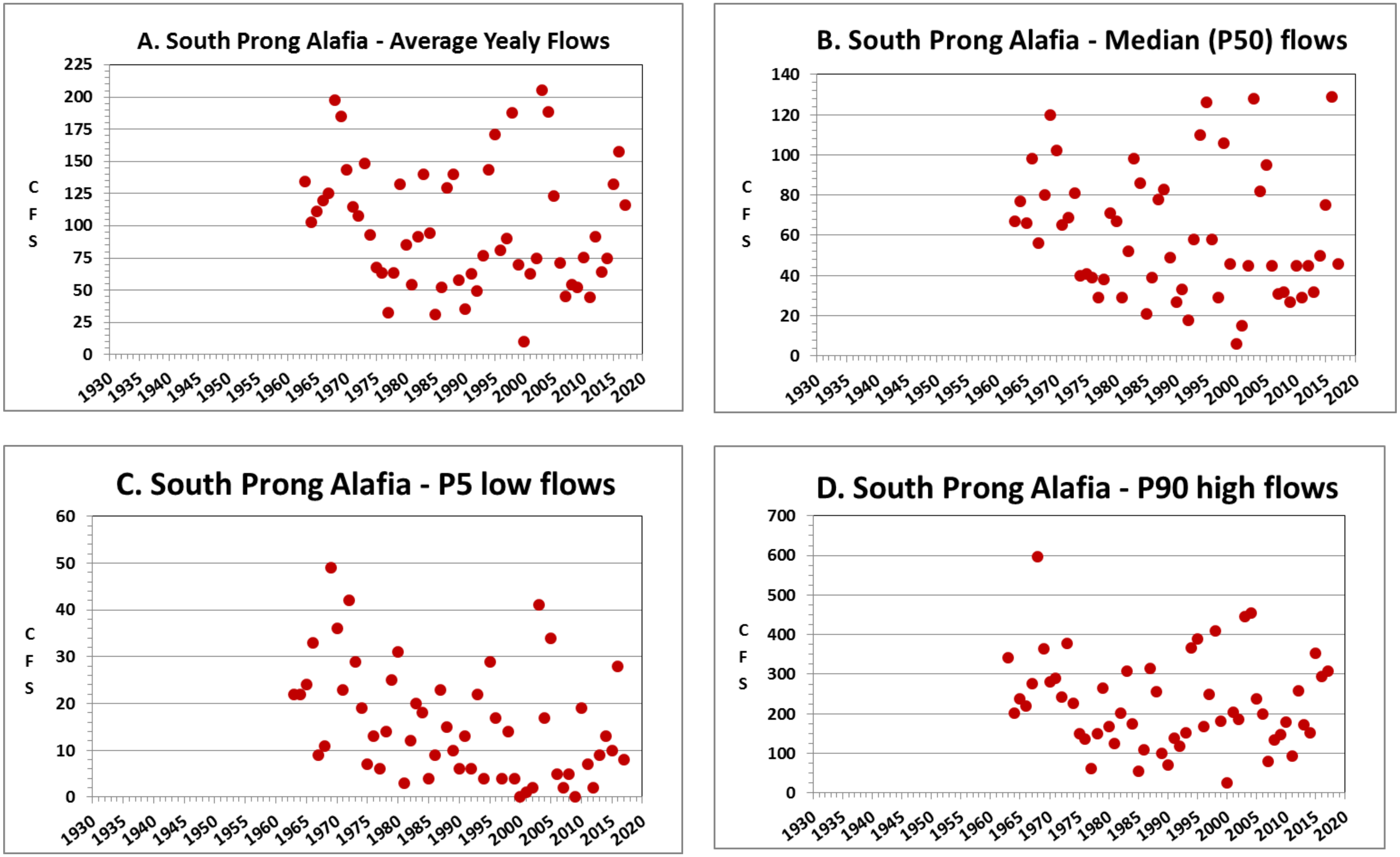


Figure 30. Hydrographs of yearly values for average, median (P50), fifth percentile (P5) and ninetieth percentile (P90) flows for the South Prong of the Alafia River near Lithia for 1951 to 2017.

Figure 31. The North Prong of the Alafia River approximately one mile above the confluence with the South Prong.

Appendix A

Summary informatipon for additional flow gages on the Peace River or tribuaries to the river not listed in Table 1.
Only the most downstream gage on each tributary is listed.

	Gage Number	Drainage Area (mi2)	Beginning month and year of flow data
Polk County			
Peace Creek Drainage Canal nr. Wahneta	2293987	162	April - 1991
Peace Creek nr. Bartow	2294161	205	January - 2006
Saddle Creek at St. Hwy 542 nr. Lakeland*	2294217	53	August - 1996
Saddle Creek at St. Hwy 570 nr, Eaton	2294290	61	February - 2009
Peace River nr. Bartow	2294655	395	May - 2002
Sixmile Creek at Bartow	2294747	not listed	December- 2002
Phosphate Mine Outfall CS-8 nr. Bartow	2294759	not listed	February - 2003
Barber Branch nr. Homeland	2294760		October - 2006
Peace River at Clear Springs nr. Bartow	2294775	396	June - 2002
Peace River nr. Homelad	2294781	411	October - 2001
Bowlegs Creek nr. Ft. Meade	2295013	47.2	February - 1991
Whidden Creek nr. Ft. Meade***	2295163	43	November - 2000
Hadee County			
Peace River at Bowling Green	2295184	613	December - 2010
Payne Creek nr. Bowling Green	2295420	121	October - 1986
Little Charlie Creek nr. Mouth nr. Wachula*	2295580	not listed	October - 2012
Charlie Creek nr. Gardner	2296500	330	October - 1991
DeSoto County			
Horse Creek nr. Arcadia	2297310	218	April - 1950
Joshua Creek at Nocatee	2297100	132	April - 1950
Charlotte County			
Shell Creek nr. Punta Gorda	2298202	371	January - 1950

Appendix B

Minimum Flow Rule for the Upper Peace River

CHAPTER 40D-8
WATER LEVELS AND RATES OF FLOW

(7) Minimum Flows for upper Peace River.

(a) Over the last several decades there has been a significant decline in flow in the upper Peace River, especially during the dry season. One of the major contributing factors is the elimination of baseflow as a result of ground water withdrawals that have lowered the potentiometric surface of the upper Floridan aquifer. In addition, surface-water drainage alterations, reduction in surface storage, long-term cyclical declines in rainfall and karst openings in the riverbed have played significant roles in reducing flow in the upper Peace River.

(b) The minimum flows are to ensure that the minimum hydrologic requirements of fish and natural systems associated with the river are met and not jeopardized by withdrawals. At this time only Minimum Low Flows are being established. It is anticipated that mid- and high-minimum flows will be established once the controlling factors that affect those flows are better understood.

(c) The Minimum Low Flows for the upper Peace River are set forth in Table 8-8 below. The Minimum Low Flows are established based on the lowest acceptable flow under the lowest anticipated flow conditions. This is determined by providing for the hydrologic requirements of biological communities associated with the upper Peace River system, as well as considering non-consumptive uses including fishing, wildlife observation, general recreation, aesthetic enjoyment, canoeing and boating. This determination uses professional experience and judgment to identify key habitats and hydrologic requirements for specific biotic assemblages. This approach results in establishing Minimum Low Flows for the upper Peace River based on maintaining the higher of the water elevations needed for fish passage (0.6 feet or 7.2 inches) or the lowest wetted perimeter inflection point (as much stream bed coverage as possible for the least amount of flow) as set forth below. A ninety-five percent annual exceedance occurs when the flow is greater than the Minimum Low Flow at least ninety-five percent of the days, or 350 days, of a calendar year.

Table 8-8 Minimum Flows for the upper Peace River

Location/Gage	Minimum Flow (cubic feet per second)
Bartow / USGS Bartow River Gage No. 02294650	Annual 95% exceedance flow of 17 cfs
Ft. Meade / USGS Ft. Meade River Gage No. 02294898	Annual 95% exceedance flow of 27 cfs
Zolfo Springs / USGS Zolfo Springs River Gage No. 02295637	Annual 95% exceedance flow of 45 cfs

(d) Compliance – The Minimum Low Flow is achieved when the measured flow rate is at or above the Minimum Low Flow for three consecutive years. Once the Minimum Low Flow has been achieved for three consecutive years, the Minimum Low Flow is not met when the measured flow rate is below the Minimum Low Flow for two out of ten years commencing the year after achievement. If the two years below the minimum flow occur anytime before the ten year period is complete, the upper Peace River is deemed below its Minimum Low Flow and the three consecutive years above the Minimum Low Flow is again required for compliance. Once the ten-year period is complete, the period will roll forward one year each year.

SF 4 – Analysis of the frequency and magnitude that the proposed minimum flows for the Upper Peace River are being met at the Ft. Meade gage

Submitted by Sid Flannery, January 29, 2026

This document presents graphical and statistical analyses of the frequency and magnitude that proposed minimum flows are being met the USGS gage Peace River at Ft. Meade, which is one of the three index stations used for applying the minimum flows for the Upper Peace River. I think the Ft. Meade gage is key for assessing this question, for as described in the draft District report, the Peace River can be a losing stream on many days between the Bartow and Ft. Meade gages.

The Ft. Meade gage can also be a limiting factor for any withdrawals upstream, including those based on the Bartow gage, as they would have to also comply with the minimum flows for the downstream gages including Ft. Meade. This memo does not discuss the frequency that the minimum flows are being met at the Zolfo Springs gage, for the flows in the river are in much better shape at Zolfo Springs, and based on the material presented in the draft District report it appears the river is meeting the minimum flows requirements at that site.

As will be shown in graphics on the following pages, there is a very clear pattern with the gaged flows at Ft. Meade being below the baseline flows by the greatest percentage amounts at low and medium flows, with flow deficits being much less at high flows. For that reason, it is important to examine the flow duration characteristics of the time periods over which evaluations of the adequacy of the minimum flows are made.

The deficits in the gaged flows relative to baseline flows at Ft. Meade are described for three time periods in this memo, all of which are discussed in the draft District report. The first is the entire period for which baseline flows were calculated, which is the period from 1975 to 2022. The second period is the years from 2003 to 2018 over which the Peace Rive Integrated Model (PRIM2) was calibrated. The third is the period from 2016 to 2022, during which time the Lake Hancock project became operable which improved the low flow characteristics of the river.

Tables with the means and selected percentile values for both the gaged and baseline flows are presented for these three time periods, with the percent reduction in daily baseline flows represented by the gaged flows listed for each of these parameters.

The table of values for the 1975 to 2022 period is shown on the following page.

Table 1. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 1975 - 2022 (48 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	230	14	23	45	102	255	615	945
Gaged flow	209	3	7	26	78	230	591	923
Percent reduction	9%	79%	70%	42%	24%	10%	4%	2%

Because it is based on many more years of record (48 years) compared to the other two time periods, it is important to consider the percentile values in Table 1 when viewing the flow percentiles for shorter time periods, which might be biased to drier or wetter multi-year periods. Although the estimated baseline flows have sources of uncertainty and possible error, they are very valuable for they estimate the flows in the river in the absence of groundwater withdrawals. As described in the draft District report, there have been reductions in groundwater use in the Upper Peace River basin over this nearly 50 year period. As such, the effects of groundwater withdrawals on flows in the river have varied as well. Given that, the baseline flow record probably best represents the natural flow characteristics of the river at the Ft. Meade gage.

Note that the median flow for Ft. Meade is 102 cfs, with an interquartile range (25th to 75th percentiles) of 45 to 255 cfs. Although this period covers a long period of record over which impacts to the flows of the river have likely changed, the percent reductions in the baseline flows are very large. For example, the median gaged flow (78 cfs) represents a 24% reduction in the median baseline value. The reductions in low flow percentiles (P5 and P10) are much greater, at 79 and 70 percent, respectively. This is not surprising, as the formation of karst features in the river channel and floodplain and groundwater drawdowns have caused large reductions in the low flows of the river.

Table 2 shows the same statistics for the years for 2003 to 2018 for which the PRIM2 model was calibrated. Given that adjustments that were applied to earlier years based on water use estimates, the years from 2003 to 2018 probably represent the most accurate period for the baseline predictions. This 16-year period had some high flow years (2004 and 2005), but included a several dry years (see Figure 2-3 in District report) and values for the median and lower flow percentiles (P5 to P25) are somewhat lower than for the long-term period shown in Table 1. However, as with the longer period, there are still substantial reductions from baseline conditions for the median and lower percentile flows.

Table 2. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 2003 - 2016 (16 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	237	11	18	39	87	267	696	1008
Gaged flow	220	3	6	21	70	246	675	986
Percent reduction	7%	73%	67%	46%	20%	8%	3%	2%

Much higher mean and percentile values exist for seven-year period from 2016 to 2022, as it included a number of years with near average or above average rainfall. For baseline flows, the mean value for this recent period listed in Table 3 below is 320 cfs, compared to mean values of 230 and 237 cfs for the other periods in Tables 1 and 2. Also, the median flow for the recent period (145 cfs) is well above the long-term median of 102 cfs (Table 1) and the median value of 87 cfs for the 2003 to 2018 period (Table 2).

Table 3. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 2016 - 2022 (7 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	320	40	44	61	145	417	860	1273
Gaged flow	305	31	34	49	127	400	835	1250
Percent reduction	5%	22%	23%	20%	12%	4%	3%	2%

It is notable that the P5 and P10 values for the gaged values during this recent seven-year period were much greater than for the other two periods. This is partly due the implementation of the Lake Hancock project, which came online in 2016 and stores water in the wet season and releases it to the river in the dry season.

However, the P5 and P10 values for baseline flows were also much greater in this recent period compared to the other two periods. At the time of this writing, I did not know if the baseline scenario produced by the PRIM2 model for these later years included Lake Hancock discharges (I would think not), but regardless, there appears to be a major climatic factor for the high P5 and P10 values in Table 3 as this was a fairly wet seven-year period. There is serial effect to flows in that wet years and high flows tend to bring up aquifer levels, which may slow the rate of groundwater loss from the river to the underlying aquifer during dry periods.

In that regard, I offer a cautionary note to the District and readers of the minimum flows report, in that the encouraging results from the last several years seem to have been influenced by a strong climatic effect in addition to the release of water from Lake Hancock. Similarly, in viewing the graphics presented on the following pages, keep the long-term flow statistics of the river (Table 1) in mind when considering how well the river is meeting it minimum flows over the typical flow range of the river.

Text continued on the following page

Plots are presented on the following pages for daily percent reduction values the gaged flows represent relative to baseline flows vs. the same-day rate of gaged flow at the Ft. Meade gage. Red reference lines are shown in the graphs for the maximum percentage withdrawal rates for the four flow blocks allowed by the proposed minimum flow rule, which are listed in Table 4. Note that 21 cfs serves as a low-flow threshold below which no withdrawals are allowed.

Table 4. Flow ranges and maximum allowable percentage withdrawl rates for the four flow blocks at the Ft. Meade gage.

Block 1	≤ 21 cfs	0%
Block 2	>21 cfs and ≤120 cfs	12%*
Block 3A	> 121 cfs and ≤ 529 cs	10%
Block 3B	> 529 cfs	7%

*** A full 12% of flow cannot be taken until flows reach a rate of 24 cfs**

Daily percentages that gaged flows are reduced from baseline flows are plotted vs. the same-day flow rate for the gaged flow in Figure 1 for the 48-year period from 1975 to 2025. There is a strong nonlinear relationship in the greatest flow reductions occur at low flows and substantial reductions occur over range of medium flows. Keep in mind the median gaged flow for this period is 102 cfs.

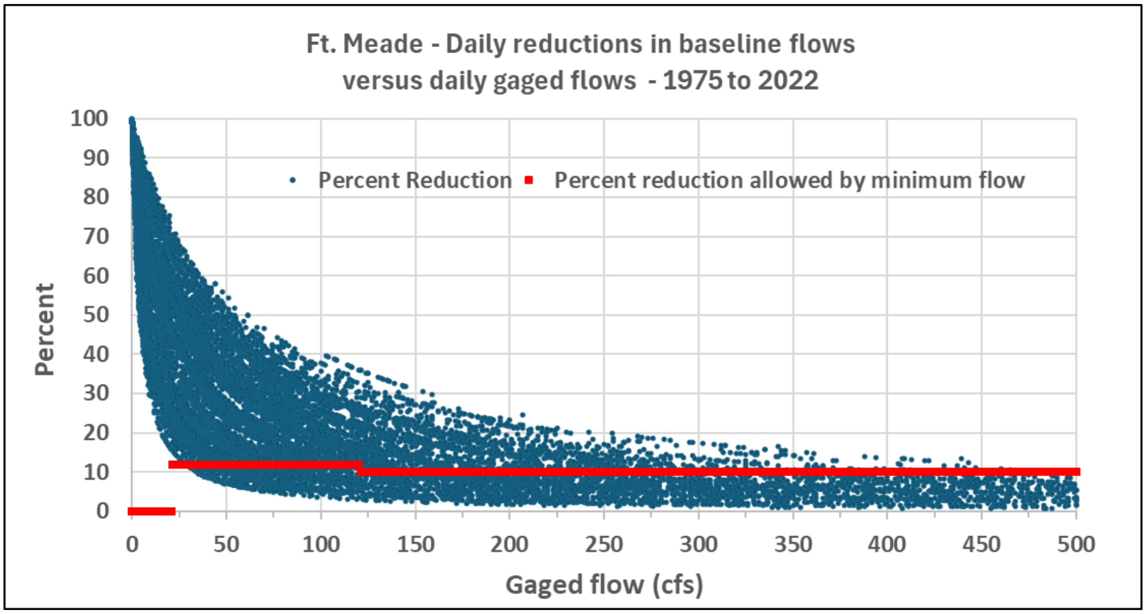


Figure 1. Daily values for percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 1975 – 2022.

It is clear there is a strong nonlinear pattern for the percent reductions in baseline flows as the most severe reductions are at low flows, as it has been well documented in several studies that the low flows in the river have been highly impacted near the Ft. Meade gage. Analysis for this period found that 91 percent of the days below the median flow of 102 cfs were not meeting the minimum flows and 82 percent of they days below the 75th percentile flow of 255 cfs were not meeting the minimum flows.

However, this could be viewed as a worst-case scenario, as the impacts to the river at Ft. Meade might have been most pronounced a number of years ago. So, to assess more recent conditions, graphs were also created for two later periods previously described. A similar graph for the sixteen-year period 2003 to 2018 is presented in Figure 2.

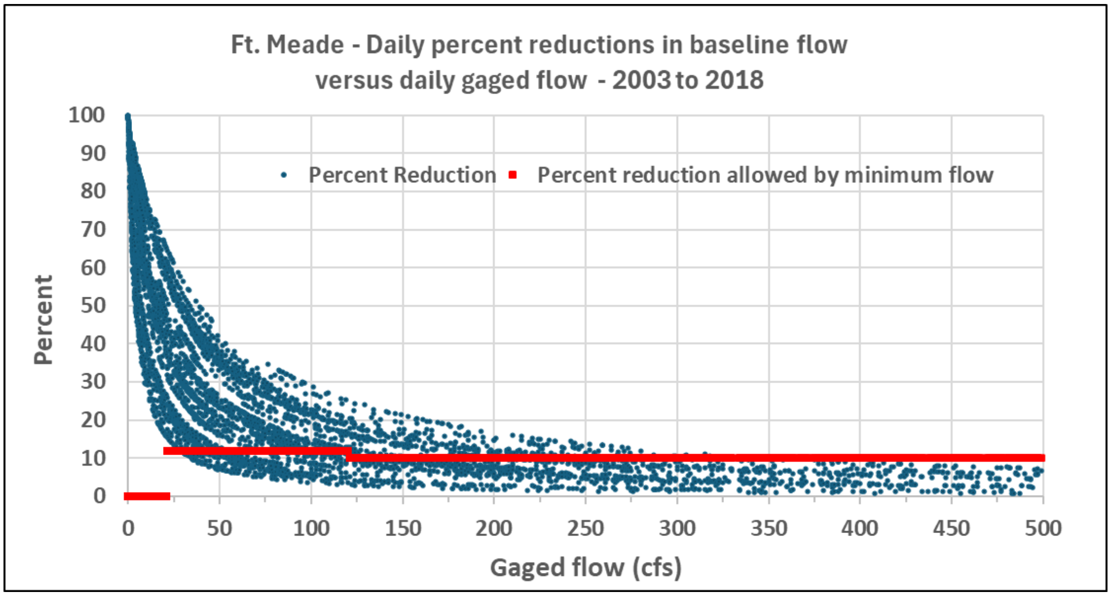


Figure 2. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 2003 – 2018.

The same pattern emerges as there are dramatic reductions in baseline flows at low flows, with substantial reductions in extending to medium flows. For this period, 90 percent of the days below the median long-term median flow of 102 cfs were not achieving their minimum flows, while 79 percent of the days below the long-term 75th percentile value were not meeting the minimum flows.

However, in both Figures 1 and 2 there is clear pattern of the percent reductions being within the minimum flow percentages at higher flow rates. Flows above 500 cfs occurred during both study periods, but are not shown here in order to give better resolution on the X axis. As will be discussed, even though the allowable withdrawals go down to seven percent at flow rates above 529 cfs, the river continued to comply with the minimum flow limits above that flow. Graphics were also generated plotting the daily percent reductions vs. the same-day baseline flows, but the patterns and interpretation are very similar to the plots presented here.

A similar graph for the seven-year period from 2016 to 2022 is shown in Figure 3. It is obvious from this graph that this period included much less that data than the other two evaluation periods. Also, as previously discussed, the gaged flows (and corresponding baseline flows) were generally higher during this period, so there is not as much data at low and low-medium flows.

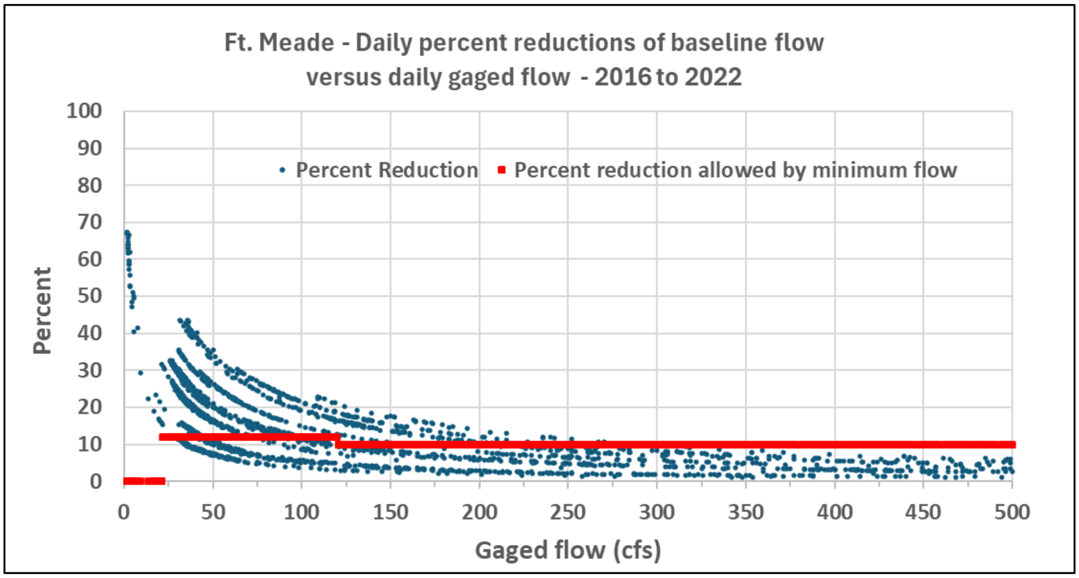


Figure 3. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 2016 to 2022.

Still, the same patterns emerge as percentage reductions in baseline flows are greatest at low flow and extend to medium flows. Seventy-two percent of the days below the long-term median flow of 102 cfs did not meet the minimum flows, while 63% of the days below the long-term 75th percentile flow of 255 cfs did not meet the minimum flows during this period.

As previously described, this was generally a wet period and this may have helped keep groundwater levels somewhat higher near the river which benefited dry season flows. The Lake Hancock project also seemed to benefit the low flows in the river, as the reductions in gaged flows in Block 1 (< 21 cfs) maxed out at percentages between 60 and 70 percent, whereas the other two time periods had many days with flow reductions between 70 and 100 percent at very low flows. Also, it should be noted that when the baseline flow is very small (less than 10 or so cfs), so relatively small reduction in flow can result in large percentage changes.

The District report states there was a very dry spring in 2017, which is when most of the flows in Block 1 occurred within this seven-year period. During that dry spring, flows ceased completely for a brief period of time at the Clear Springs gage, which is located about a quarter of the way downstream from Bartow toward the Ft. Meade gage. The evidence indicates the Lake Hancock project is benefitting the low flows of the upper river, but the effectiveness of the project should be revisited in drier years or a series of years that have more prolonged dry conditions than what occurred in the 2016 to 2022 period.

Another way to evaluate the effectiveness of the minimum flows is to examine the number of days within each of the flow blocks that met the percentage flow reductions allowed by the proposed minimum flows listed in Table 4. This was approach was done only for the two more recent periods, as the values going back to 1975 would capture some groundwater conditions that no longer apply, as there has been some recovery of groundwater conditions in the region.

The values for the period from 2003 to 2018 are listed in Table 5, calculated for days when the gaged flows were within the various flow blocks. It is notable that during this period, which included some low flow years, the gaged flows in river at Ft. Meade were in the low flow Block 1 twenty-five percent of the time, which is quite a lot.

Block 2 is very important for the ecology of the river, as it based on habitats and communities that are in the river channel, which are closely related to the water levels and current velocities of the river. During this 16-year period, only 20% of the flows at Ft. Meade would have met the minimum flows in Block 2.

A total of 37% of the days in this period were in Blocks 3A and 3B, which correspond to flows that inundate the floodplain of the river. The percentages that the minimum flows were met were much higher for these blocks, at 70% for Block 3A and 100% for Block 3B. This is keeping with the data shown in Figures 1, 2, and 3 that the percent reductions in baseline flows are much less at high flows in the river. Finally, for all the blocks combined, basically all days in the period, the minimum flows were only achieved 40 percent of the time during this sixteen-year period.

Table 5. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of days within that block that the minimum flows were met at the Ft. Meade gage for the years 2003 to 2018. Values at the bottom are for all blocks combined.

	Flow range for each Block	Total number of days in block	Percent of total days within the block	Percent of days minimum flow met in the block
Block 1	< 21 cfs	1,457	25%	0%
Block 2	> 21 cfs and ≤ 120 cfs	2,179	37%	20%
Block 3A	> 120 cfs and ≤ 529 cfs	1,436	24%	75%
Block 3B	> 529cfs	772	13%	100%
All Blocks combined		5,884		40%

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As it was during a generally wetter period, the results for the period from 2016 to 2022 are much different (Table 6). The first very striking point is the smaller percentage of days in Block 1, which was partly due to climate, and possibly due operation of the Lake Hancock structure. However, the baseline flows only had 33 days in Block 1. As previously discussed, generally weather helps groundwater levels in the region, and most of the days in Block 1 in this period occurred in the spring of 2017, which was the driest stretch of time during this seven-year period.

Nearly half for the total number of days in this period occurred in Block 2, again demonstrating the importance of this flow block to the ecology of the river. The minimum flows were met only 30% of the time in Block 2, which clearly means the minimum flows oriented to the health of the river channel were not adequately met. As with the 2003 to 2018 period, the percentages of days that met the minimum flows were much higher for Blocks 3A and 3B, with 100 percent compliance in Block 3B. The minimum flows were met for 59% of all the days in this recent seven-year period, which is a surprisingly low number, given that it was a relatively wet period.

Table 6. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of days within that block that the minimum flows were met at the Ft. Meade gage for the years 2016 to 2022. Values at the bottom are for all blocks combined.

	Flow range for each Block	Number of days in the Block	Percent of total days within the Block	Percent of days minimum flow met withinin the Block
Block 1	< 21 cfs	37	1%	0%
Block 2	> 21 cfs and ≤ 120 cfs	1,197	47%	30%
Block 3A	> 120 cfs and ≤ 529 cfs	840	33%	81%
Block 3B	> 529cfs	483	19%	100%
All Blocks combined		2,557		59%

Collectively, the findings presented in this memo strongly suggest that it would be incorrect for the District to conclude in the minimum flows report that the minimum flows for the Ft. Meade gages are being met. As previously discussed, this also has application to the river near the Bartow gage, as withdrawals from that reach of the river would have to also comply with the minimum flow limits at Ft. Meade. I will likely add more perspective on this topic when I submit my final review comments on the draft report to the District, which I hope to do before the peer review meeting scheduled for February 6th.

SF-5 Verbal comments presented to the January 30, 2026 meeting of the Upper Peace River minimum flows scientific review panel by Sid Flannery

This morning the District uploaded to the minimum flows WebBoard five documents I hope you will review. Two of these documents were previously uploaded to the WebBoard, but they were uploaded again today to make them easy to find along with the three new documents.

Four of these documents focus on the Ft. Meade gage, as it is the key index station for establishing minimum flows for the northern reaches of the Upper Peace River, as any new withdrawals near Bartow would also have to comply with the minimum flow limits at Ft. Meade.

Document 1 discusses two hydrographs presented in the draft District report that I think indicate the minimum flows are not being met at Ft. Meade for significant amounts of time. It also disagrees with the statement on page 233 in the minimum flows report, that states that Table 5-6 in the report indicates that the minimum flows for the Upper River are being met. Document 1 also questions the assumption that there is linear rate of increase in the relationship between groundwater levels and streamflow in the PRIM modeling approach.

Document 2 is a transcript of the verbal comments I had hoped to give at last week's peer review meeting that got canceled.

Document 4 is particularly important, for on Monday I requested from the District, records for the baseline and gaged flows for three USGS gages that they analyzed for the minimum flow report. Using those data, Document 4 contains graphical and statistical analyses of the amount of time the gaged flows at Ft. Meade have been within the flow reduction limits specified in the proposed minimum flows. As that document demonstrates, the minimum flows are not being met for significant periods of time at the Ft. Meade gage, and I think it is incorrect for the District to claim the minimum flows are being met in that reach of the Upper Peace River. I do think the minimum flows are being met at the Zolfo Springs gage. I hope you read all of these documents, but document 4 is particularly critical.

Document 5 is simply the written transcript of what I am saying to you today, in case you want to consult it as a guide to these documents.

Finally, Document 3 is a report that I wrote and submitted to the District in 2018, which examines flow quantities and trends in the Peace River and discusses human impacts to flows in the Upper Peace River. That report presents a technically sound approach for the establishment of minimum flows in the Peace River, for although flows in the northern reaches of the Upper Peace River have been highly impacted, the flow regime of the river greatly improves as you proceed downstream from Ft. Meade, and new withdrawals in compliance with minimum flows could be obtained near Zolfo Springs.

Again, I don't think the minimum flows are being met in the reach of the river near Ft. Meade and Bartow, and a credible position needs to be taken on this matter in order to properly manage the natural resources of the Upper Peace River and apply the percent-of-flow method, which the District has worked on very conscientiously for a long time to develop and implement.

From: Angel Martin
To: Kristina Deak
Subject: Upper Peace River MFLs Review Panel
Date: Friday, January 30, 2026 4:45:12 PM

Below are comments concerning the proposed minimum flows for the Upper Peace River on January 30, 2026, peer review panel meeting.

1. More discussion is needed in the report concerning the historical flows and what is meant by the robustness of the flows.
2. Additional discussion is needed concerning groundwater/surface-water interaction. Specify conditions where the Peace River is either a gaining or losing river flow. Conditions will change with increasing rainfall and/or recovering groundwater levels. Specify the conditions concerning the linearity or nonlinearity of baseline flow conditions. Specify where the major karst features are located, specifically on a map.
3. Add some references and discussion concerning changes in water color, pH, and dissolved-oxygen concentrations. Discuss the possible reasons for the results of these water-quality parameters.
4. Concerning the differences if flow at various USGS streamgages after the 2004 hurricanes, conditions at the streamgages can appreciably change at a gaging station due to changes in river conditions and dynamics. The USGS usually discusses these changes as part of their records. Maybe a brief discussion on this subject with the USGS is warranted.

Thank you for the opportunity to comment on the subject panel meeting. Please contact me if you need any additional information and/or clarification.

____

Angel Martin
813-767-6944

From:	Bauzo-Deleon, Vanessa <Vanessa.Bauzo@fdacs.gov>
Sent:	Wednesday, February 4, 2026 1:06 PM
To:	Lei Yang
Cc:	Hart, Madeline; Escribano, Yesenia; Kristina Deak; Chris Zajac
Subject:	Re: Upper Peace River Draft MFL Comment FDACS OAWP

Amazing, thank you so much for the prompt response and clarification.

This response via email is perfect for me, however if you would like this also reflected on the webboard I'm all for it.

Vanessa Bauzo
Environmental Consultant
Office of Agricultural Water Policy (OAWP)
Florida Department of Agriculture and Consumer Services

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vanessa.bauzo@FDACS.gov

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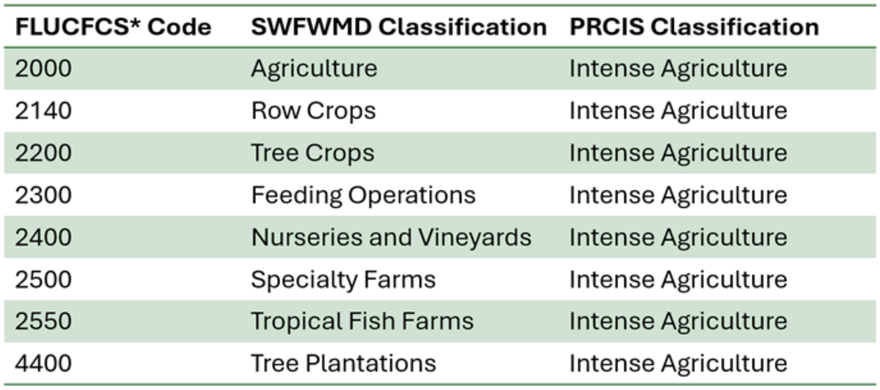
From: Lei Yang <Lei.Yang@swfwmd.state.fl.us>
Sent: Tuesday, February 3, 2026 4:16:01 PM
To: Bauzo-Deleon, Vanessa <Vanessa.Bauzo@fdacs.gov>
Cc: Hart, Madeline <Madeline.Hart@fdacs.gov>; Escribano, Yesenia <Yesenia.Escribano@fdacs.gov>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>
Subject: RE: Upper Peace River Draft MFL Comment FDACS OAWP

Hi Vanessa,

Thank you for your comment during the January 16, 2026 peer review meeting, which has been included in the kickoff meeting minutes currently posted on the WebBoard. I've reviewed the matter, and here is a brief explanation:

We adopted the definition established in the *Peace River Cumulative Impact Study* (PRCIS) by PBSJ (2007) – Appendix C. I this study, the Florida Land Use, Cover and Forms Classification System (FLUCFCS) categories listed in the table below were classified as “Intense Agriculture.”



FLUCFCS* Code	SWFWMD Classification	PRCIS Classification
2000	Agriculture	Intense Agriculture
2140	Row Crops	Intense Agriculture
2200	Tree Crops	Intense Agriculture
2300	Feeding Operations	Intense Agriculture
2400	Nurseries and Vineyards	Intense Agriculture
2500	Specialty Farms	Intense Agriculture
2550	Tropical Fish Farms	Intense Agriculture
4400	Tree Plantations	Intense Agriculture

* Commonly recognized and used for FLUCCS

To ensure consistency, clarity, and shared understanding for all readers and stakeholders, we plan to include additional descriptions of these definitions in the report update following the Peer Review Panel’s initial review report, which is scheduled around Feb 13.

If you prefer, I can also post this communication on the WebBoard so others can view both your message and my response. Please let me know your preference.

Best regards,

Lei Yang, PhD, PE
Chief Professional Engineer
Environmental Flows and Levels Section
Natural Systems and Restoration Bureau
Southwest Florida Water Management District
2379 Broad Street • Brooksville • FL 34604-6899
☎ 352-269-5947 • ✉ Lei.Yang@swfwmd.state.fl.us

From: Bauzo-Deleon, Vanessa <Vanessa.Bauzo@fdacs.gov>
Sent: Tuesday, February 3, 2026 3:39 PM
To: Lei Yang <Lei.Yang@swfwmd.state.fl.us>
Cc: Hart, Madeline <Madeline.Hart@fdacs.gov>; Escribano, Yesenia <Yesenia.Escribano@fdacs.gov>
Subject: Upper Peace River Draft MFL Comment FDACS OAWP

[EXTERNAL SENDER] Use caution before opening.

Good Afternoon Dr. Yang,

I am writing to document a comment raised during the January 16th peer review meeting on the proposed minimum flows for the Upper Peace River.

FDACS requests that the report include a clear definition of “intensive agriculture”, including a list of the land use categories classified as intensive agriculture and a description of the process used to categorize intensive agriculture from other agriculture to ensure consistency, clarity, and shared understanding for all readers and stakeholders.

Thank you for the opportunity to review and comment on the report and we look forward to this Fridays Peer Review Meeting.

All the best,

Vanessa Bauzo
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Florida Department of Agriculture and Consumer Services

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Whereas the Ancient Islands Group of Sierra Club Florida believes it is important to maintain adequate flows in the Upper Peace River to provide for a properly functioning riverine ecosystem and to provide adequate flow to allow the use of the river's Blueway corridor for outdoor recreation

The Ancient Islands Group's Executive Committee resolves to urge the Southwest Florida Water Management District staff to review the data in its draft minimum flows and levels report that claims the river is meeting minimum flow standards and will meet them for the next 20 years for errors in light of independent analyses that have concluded those standards are not being met.

Approved Feb 4, 2026.

Tom Palmer, Chair.

SF-6 A. Flow duration analysis at the Zolfo Springs gage

B. Analysis of the frequency and magnitude that the proposed minimum flows for the Upper Peace River are being met at the Zolfo Springs gage

Submitted by Sid Flannery, February 5, 2026

This document presents graphical and statistical analyses of the frequency and magnitude that proposed minimum flows are being met the USGS Peace River at Zolfo Springs gage, which is one of the three index gages used for applying the minimum flows for the Upper Peace River. As will be described on pages 7 to 10 the minimum flows are clearly being met at the Zolfo Springs gage.

However, in order to better interpret those findings, it is helpful to first describe and compare the flow characteristics for the Ft. Meade and Zolfo Springs gages. Data were presented for the Ft. Meade gage in Document SF-4, and similar statistics for the Zolfo gage are presented in this document.

As with document SF-4, flow data are analyzed for three time periods, all of which are discussed in the draft District report. The first is the entire period for which baseline flows were calculated, which is the period from 1975 to 2022. The second period is the years from 2003 to 2018 over which the Peace Rive Integrated Model (PRIM2) was calibrated. The third is the period from 2016 to 2022, during which time the Lake Hancock project became operable which improved the low flow characteristics of the river.

First, as a follow-up to the scientific peer review meeting that was held on January 30, 2026, data are first presented for the most recent 2006 to 2022 period. At that meeting, one of the panel members suggested that the improvement in low flows at the Bartow and Ft. Meade gages may have been party due in part to climatic factors, in addition to operation of the Lake Hancock structure. Based on analysis of the flows during this final period, my document SF-4 similarly stated that some of the improvement in flow flows at Ft. Meade was due to a series of years with average or above average during the 2016 to 2022 period.

To examine this further, seven-year moving average flows were calculated for gaged and baseline flows for both the Ft. Meade and Zolfo Springs gages. The seven-year period was chosen because it was the length of time that the Lake Hancock was operable during the period for which baseline flows were calculated, which ended in 2022.

Seven-year average flows for both gaged and baseline flows at the Ft.. Meade gage are listed in Tables 1 and 2. Seven-year average flows can be calculated for 43 years in the 48-year period from 1975 to 2022 for which both gaged and baseline flows were available. During this period, the seven-year mean gaged flow for 2022 (305 cfs) was tied with period ending in 2020 for the second from highest value, with these same two years tied for third highest value (320 cfs) for baseline flows. It is not surprising that these two years had similar values as they had five over-lapping years.

Table 1

Ft. Meade - Gaged Flows Moving Seven-Year Means Ranked by value

Year	Seven-Year Mean (cfs)
2012	70
2013	79
2014	104
1991	107
1990	108
1992	124
2011	135
1993	136
2015	137
1981	148
1989	156
1994	157
1986	161
1987	167
2016	170
1982	181
2017	188
1988	189
2010	193
1995	193
1985	199
1983	213
2002	218
1984	222
1996	223
2018	226
2003	248
2009	248
2001	250
1997	250
2019	264
2008	274
2007	277
2006	278
2000	283
2005	284
2004	287
2021	297
1999	303
2022	305
2020	305
1998	315

Table 2

Ft. Meade - Baseline Flows Moving Seven-Year Means Ranked by value

Rnked	Seven-Year Mean (cfs)
2012	89
2013	97
2014	121
1991	133
1990	135
1992	149
2011	153
2015	154
1993	162
1981	177
1989	181
1994	182
1986	185
2016	187
1987	191
2017	204
1982	208
2010	211
1988	214
1995	217
1985	224
1983	238
2002	240
2018	243
1996	246
1984	247
2009	266
2003	270
1997	272
2001	272
2019	280
2008	292
2007	296
2006	298
2000	305
2005	305
2004	308
2021	312
2022	320
2020	320
1999	324
1998	336

Similar results are presented for the Zolfo Springs gage in Tables 3 and 4. At that location the seven-year mean flows both the gaged and baseline records were the highest among the 43 years that were available for analysis.

These results show the period for which the Lake Hancock project was available was generally very wet. As described in my Document SF-4, there is a serial effect with streamflow that carries over between seasons, especially for rivers where streamflow is closely linked to groundwater levels in the Floridan aquifer such as the Upper Peace River. Prolonged wet periods tend to bring aquifer levels up which can benefit flows in the dry season. It appears this was likely occurring during the period of operation of the Lake Hancock project. As I discussed in document SF-4, the effectiveness of the Lake Hancock project for raising low flows in the upper river should be revisited in drier years or series of dry years that have more frequent and prolonged dry conditions than what occurred in in the 2016 to 2022 period.

The sixteen-year period from 2003 to 2018, for which the PRIM2 model was calibrated was a very different situation, as it captured one of the most prolonged dry periods in the last few decades, that being a series of seven consecutive years with below average rainfall from 2006 to 2012. Figure 2-37 in the draft District report shows that rainfall deficits were particularly large in 2006 and 2007, with the 5-year moving average rainfall in 2010 being the lowest in the 104 years of record shown in that Figure. Similarly, Figure 2-31 in the District report shows that the five-year average flows at all three index gages reached their lowest values on record in 2010, with some rebound in recent years.

These effects of these dry and below average rainfall years are reflected in the flow statistics that were shown for 2003 to 2018 at the Ft. Meade gage in document SF-4. Although the period contained some wet years including 2004, 2025, and four consecutive years with above average rainfall from 2015 to 2018, the flow statistics for this sixteen-year period were lower at Ft. Meade for the 1975-2022 period and considerably lower than the more recent 2026 to 2022 period.

Flow statistics similar to those presented for Ft. Meade in document SF-4 are presented for the Zolfo Springs gages on the following pages. The findings for Zolfo Springs show similar trends as Ft. Meade for the three periods, with the 2003 to 2018 period having the lowest values for the P5 to P50 percentiles and the 2016 to 2022 period having the highest values for all the statistical metrics.

However, all of values are much higher for the Zolfo Springs gage compared to Ft. Meade, as the flows increase greatly between Ft. Meade and Zolfo Springs due to a number of factors. Also, in the following tables it is important to note that the all the statistical values for gaged flows at Zolfo Springs are greater than or nearly equal to the values for baseline flows. This is very different than at the Ft. Meade gage, where the gaged values were consistently lower than the baseline values, often by considerable amounts, reflecting that the flows of the upper river near the Ft. Meade gage are highly impacted.

Table 3

Zolfo Springs - Gaged Flows
Moving Seven-Year Means
Ranked by value

Year	Seven-Year Mean (cfs)
2012	255
2013	280
2014	327
1990	329
1991	349
2011	364
1992	381
1993	387
2015	404
1981	405
1989	413
1986	429
1987	439
1994	444
1982	470
2016	472
2010	475
1985	484
1988	493
2002	499
2017	513
1995	525
1984	532
1983	532
1996	556
2009	563
2001	567
2003	577
2018	589
1997	600
2008	614
2000	628
2006	642
2007	643
2019	649
2005	650
2004	656
1999	671
2021	690
2020	694
1998	699
2022	713

Table 4

Zolfo Springs - Baseline Flows
Moving Seven-Year Means
Ranked by value

Year	Seven-Year Mean (cfs)
2012	249
2013	275
1990	320
2014	321
1991	340
2011	358
1992	371
1993	378
1981	395
2015	398
1989	404
1986	421
1987	431
1994	435
1982	460
2016	466
2010	469
1985	475
1988	485
2002	492
2017	507
1995	517
1984	523
1983	523
1996	547
2009	557
2001	560
2003	571
2018	583
1997	592
2008	608
2000	620
2006	636
2007	637
2019	643
2005	644
2004	649
1999	663
2021	685
2020	689
1998	691
2022	708

Tables with means and selected percentile values for both gaged and baseline flows at Zolfo Springs are presented for three time periods below, with the changes calculated as the gaged flow as a percent of baseline flow for each of these parameters. The District report states that the increases in gaged flows relative to baseline flows are due in part to flow supplementation from agricultural lands upstream of Zolfo Springs. The percentage increases are greatest at low flows in part because the flow quantities are much smaller, but excess flows from agricultural runoff would be expected to increase the low flows of the river. The values for the median flow and the higher percentile are very close or virtually the same between the baseline and gaged values.

Table 5. Mean and percentile values for baseline and gaged flows and the percent increase in each value as gaged relative to baseline at the Zolfo Springs gage for the years 1975 - 2022 (48 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	519	30	47	102	245	587	1281	1941
Gaged flow	512	37	56	111	250	596	1280	1940
Percent gain	1%	23%	19%	9%	2%	2%	0%	0%

As stated in document SF-4, since it is based on many more years of record (48 years) compared to the other two time periods, it is important to consider the percentile values in Table 5 when viewing the flow percentiles for shorter time periods, which might be biased to drier or wetter multi-year periods. Although the estimated baseline flows have sources of uncertainty and possible error, they are very valuable for they estimate the flows in the river in the absence of groundwater withdrawals and presumably the effects of recent agriculture in the basin. Given that, the long-term the baseline flow statistics in Table 5 probably best represents the natural flow characteristics of the river at the Zolfo Springs gage.

Table 6 shows the same statistics for the years for 2003 to 2018 for which the PRIM2 model was calibrated. Given that adjustments that were applied to earlier years based on water use estimates, the years from 2003 to 2018 probably represent the most accurate period for the baseline records. Although the values for median and low percentiles are slightly less than the 1975-2022 period, the values for the higher percentiles are somewhat greater, possibly due to the relative influence of the several high flow years that occurred during the 2003 to 2018 period. As with the longer term record, the statistical values for gaged flows are either greater or nearly the same as the for baseline flows.

Table 6. Mean and percentile values for baseline and gaged flows and the percent increase in each value as gaged relative to baseline at the Zolfo Springs gage for the years 2003 - 2016 (16 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	545	24	35	89	234	636	1500	2075
Gaged flow	540	29	43	93	241	639	1510	2080
Percent gain	1%	21%	23%	4%	3%	0%	1%	0%

As with the Ft. Meade gage, much higher mean and percentile values exist for seven-year period from 2016 to 2022, for as previously discussed, it included a number of years with near average or above average rainfall. For baseline flows, the mean value for this recent period listed in Table 7 below is 713 cfs, compared to mean values of 519 and 545 cfs for the other periods in Tables 5 and 6. Also, the median baseline flow for the recent period (355 cfs) is well above the long-term median of 255 cfs and the median of 234 cfs for the 2003 to 2018 period.

Table 7. Mean and percentile values for baseline and gaged flows and the percent increase in each value as gaged relatived to baseline at the Zolfo Springs gage for the years 2016 - 2022 (7 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	713	50	72	140	355	916	1778	2243
Gaged flow	708	58	78	146	359	925	1780	2250
Percent gain	1%	16%	8%	4%	1%	1%	0%	0%

As described in Document SF-4 for the Ft. Meade gage, the P5 and P10 values for the gaged values at Zolfo Springs during this recent seven-year period were much greater than for the other two periods. This is partly due the implementation of the Lake Hancock project, which came online in 2016 and stores water in the wet season and releases it to the river in the dry season. However, as described on pages 1 to 3 and also in in Document SF-4, this was generally a very wet period which affected the relatively high values listed in Table 7.

Plots are presented on the following pages for daily percent reduction values the gaged flows represent relative to baseline flows vs. the same-day rate of gaged flow at the Zolfo Springs gage. Red reference lines are shown in the graphs for the maximum percentage withdrawal rates for the four flow blocks allowed by the proposed minimum flows, which are listed in Table 8. Note that 40 cfs is the low-flow threshold below which no withdrawals are allowed.

Table 8. Flow ranges and maximum allowable percentage withdrawal rates for the four flow blocks at the Zolfo Springs gage.

Block 1	≤ 40 cfs	0%
Block 2	> 40 cfs and ≤ 274 cfs	13%*
Block 3A	> 274 cfs and ≤ 1,047 cs	9%
Block 3B	> 1,047 cfs	7%

*** A full 13% of flow cannot be taken until flows reach a rate of 46 cfs**

Daily percentages that gaged flows at Zolfo Springs are changed from baseline are plotted vs. the same-day gaged flow in Figure 1 for the 48-year period from 1975 to 2025. For comparison, the corresponding Figure from the Ft. Meade gage is presented in Figure 2. Positive values on the Y axis denote a reduction in flow from baseline to gage, whereas negative values mean a gain in gaged flow relative to baseline. Values below the reference line are meeting the percentage limits in the proposed minimum flows wife values above the line are not. These graphics demonstrate the very different relationship for meeting the minimum flows between these two index gages. Based on Figure 1, flows the Zolfo Springs gage meet the minimum flows the vast majority of the time, while they often do not at Ft. Meade except for very high flows.

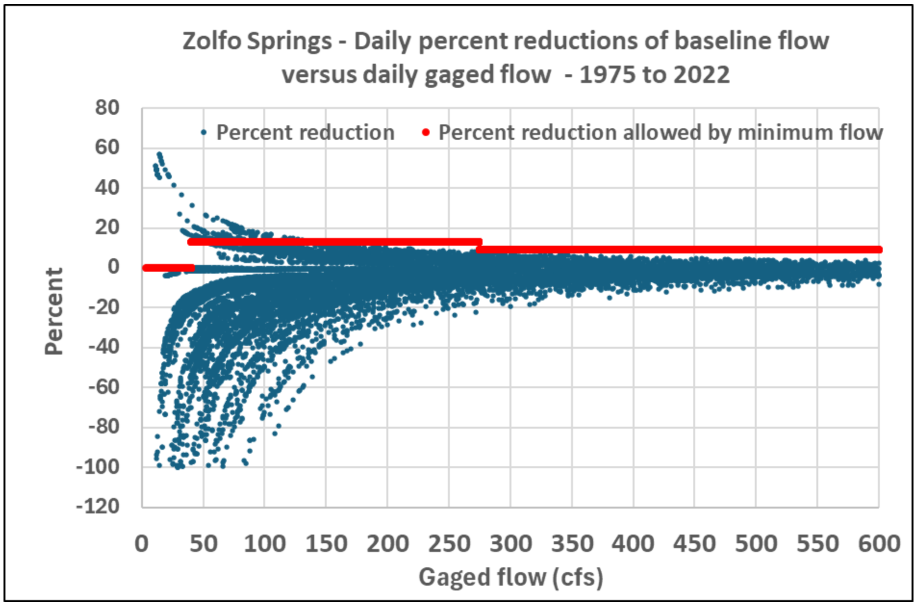

Figure 1. ZOLFO SPRINGS - Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 1975 – 2022 at the Zolfo Springs gage.

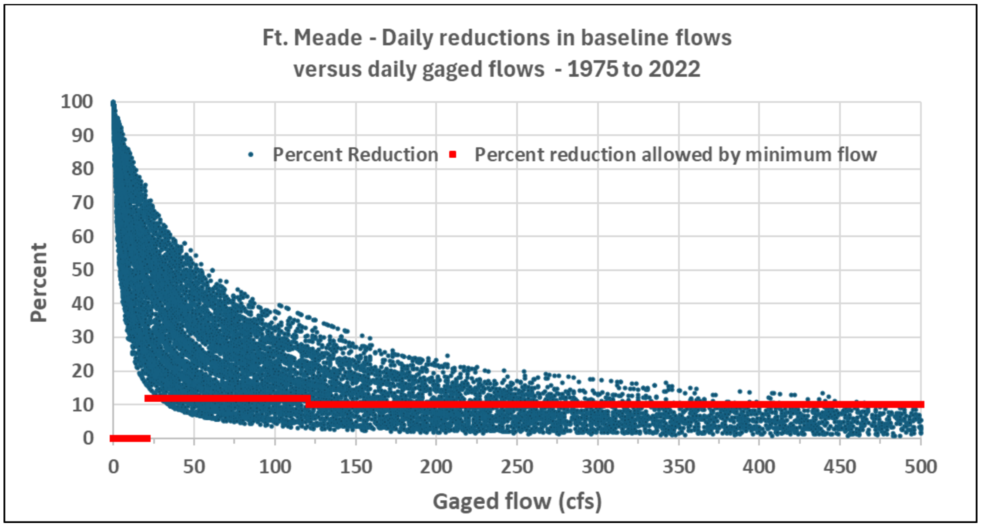

Figure 2. FT. MEADE - Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 1975 – 2022 at the Ft. Meade gage.

Similar graphs for the sixteen-year period from 2003 to 2018 at the Zolfo Springs gage is presented in Figure 3, while a graph for the recent 2016 to 2022 period is shown in Figure 4. The pattern remains that the minimum flows were almost always met at Zolfo Springs during 2003 to 2018, or entirely met during the period from 2016 to 2022. This agrees with the values presented in Tables1, 2, and 3 that indicate the gaged flows at Zolfo Springs are generally higher than the baseline flows, with the reasons for this described in the draft District report.

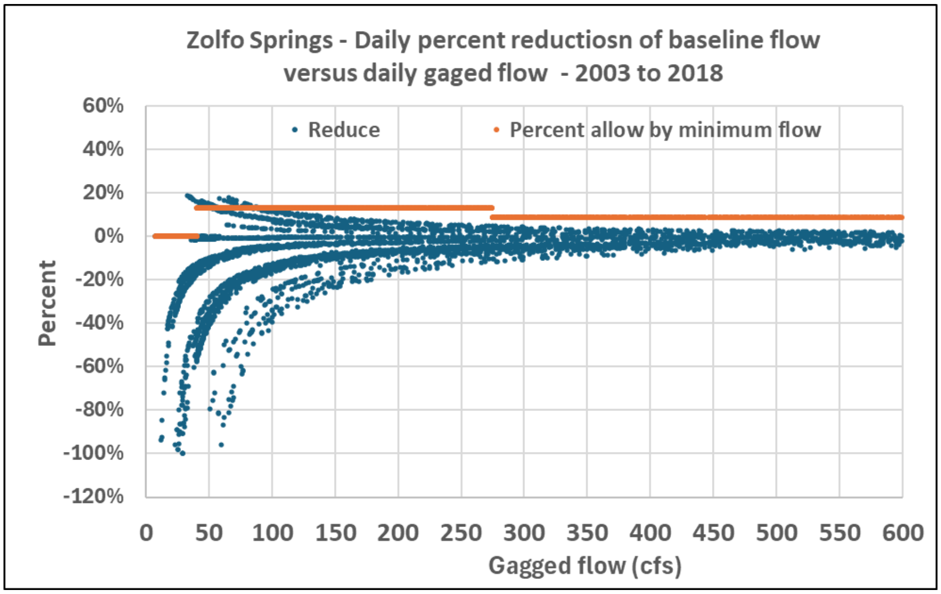

Figure 3. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 2003 – 2018 at the Zolfo Springs gage.

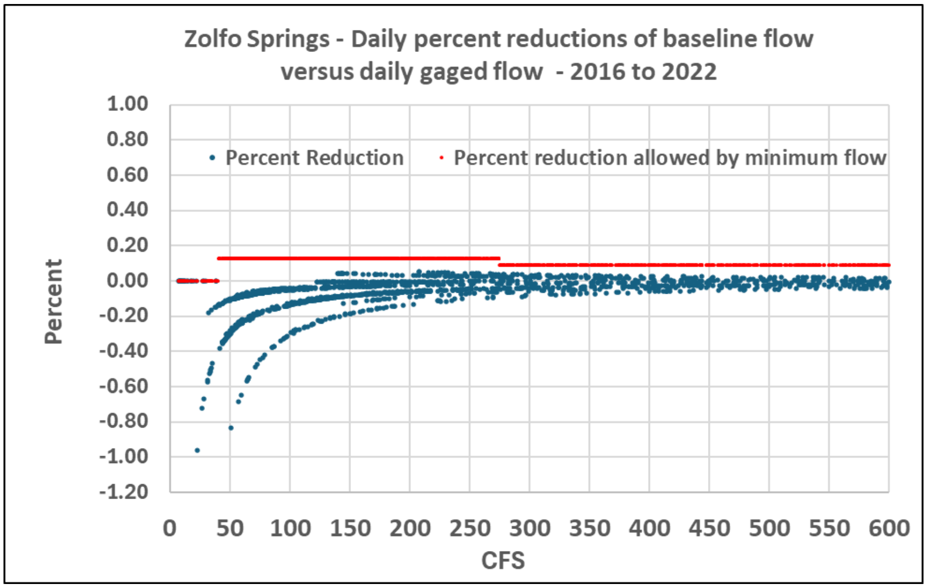

Figure 4. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 2016 to 2022 at the Zolfo Springs gage.

As was presented for Ft. Meade in Document SF-4, another way to evaluate how well the gage flows are meeting the minimum flows at Zolfo Springs is to examine the number of days within each of the flow blocks that met the percentage flow reductions allowed by the proposed minimum flows that were listed in Table 8. This was approach was done only for the two more recent periods, as the values going back to 1975 would capture some groundwater conditions that no longer apply, as there has been some recovery of groundwater conditions in the region.

The values for the period from 2003 to 2018 are listed in Table 9, calculated for days when the gaged flows were within the various flow blocks. The most important thing in Table 9 is that the minimum flows were met 99% of the days during this period. Also, it is notable that flows were in Block 1 for 9% of the time, while it was in Block 1 for 25% of the time at Ft. Meade in this same sixteen-year period, possibly reflecting improvement in low flow conditions in the river near Zolfo Springs. However, it could also be influenced on the physical features in the river that the Block 1 threshold was based on in these two sections of the river.

Table 9. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of of days within that block that the minimum flows were met at the Zolfo Springs gage for the years 2003 to 2018. Values at the bottom are for all blocks combined.

	Flow range for each Block	Total number of days in block	Percent of total days within the block	Percent of days minimum flow met in the block
Block 1	< 40 cfs	507	9%	98%
Block 2	> 40 cfs and ≤ 274 cfs	2,622	45%	97%
Block 3A	> 274 cfs and ≤ 1,047 cfs	1,779	30%	100%
Block 3B	> 1,047 cfs	936	16%	100%
All Blocks combined		5,844		99%

Values for the more recent 2016 to 2022 are listed in Table 10, in which the minimum flows were met 100% of the time in all the blocks. It is also notable that the gaged flows were in Block 1 only 2% of the time, and in the higher flow blocks of 3A and 3B a total of 57% of the time, reflecting that this was a generally wet period.

Table 10. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of days within that block that the minimum flows were met at the Zolfo Spring gage for the years 2016 to 2022. Values at the bottom are for all blocks combined.

	Flow range for each Block	Number of days in the Block	Percent of total days within the Block	Percent of days minimum flow met withinin the Block
Block 1	< 40 cfs	40	2%	100%
Block 2	> 40 cfs and ≤ 274 cfs	1,055	41%	100%
Block 3A	> 274 cfs and ≤ 1,047 cfs	905	35%	100%
Block 3B	> 1,047 cfs	557	22%	100%
All Blocks combined		2,557		100%

Text continued on the next page

The combined results for Ft. Meade in document SF-4 and the results for Zolfo Springs his document clearly demonstrate how much improved the flow regime of the Upper Peace River is near Zolfo Springs compared to Ft. Meade.   It was the conclusion of document SF-4 that the river was not meeting its minimum flows at the Ft. Meade gage, but it is at Zolfo Springs.

This also has implications for water supply. If the minimum flows at Ft. Meade are not being met, it should not be used for water supply except for possibly during very high flows, which likely would not be cost effective. In contrast, new withdrawals could be obtained near Zolfo Springs, as it is meeting its minimum flows and the flows in the river are much greater there. For example, for the sixteen-year period for 2003 to 2018, the median gaged flow at Zolfo Springs was 241 cfs compared to 70 cfs at Ft. Meade, while the average gaged flow was 540 cfs at Zolfo Springs compared to 220 cfs at Ft. Meade.

In total, these findings are technical sound represent good water management, as substantial yields from the Upper Peace River could be obtained near Zolfo Springs, while flows should be preserved without withdrawals, with the possible exception of very high flows, near Ft. Meade to prevent further harm to that reach of the Upper Peace River.

SF-7 Technical review of the draft minimum flows report for the Upper Peace River

Submitted by Sid Flannery, February 5, 2026

This document provides my review of the draft minimum flows report for the Upper Peace River that was made available to the public in December 2025. There are some sections of the report I have not yet reviewed, so I might submit more comments and post them to the minimum flows Webboard next week. However, I wanted to submit this review before the February 6th meeting of the scientific review panel for the minimum flow report so they can consider the points presented here in a timely manner.

This review covers what I consider to be key issues with the report. In my opinion, what is far and away the most pressing issue with the report is the conclusion that the minimum flows for the Upper Peace River are being met, which I disagree with. As I have communicated in writing and verbal comments at the peer review meetings, I think that is true for the reach of the river associated with the Zolfo Springs gage, but not at the reaches of the river associated with the Bartow and Ft. Meade gages. I will summarize those points again in this review after I address a few other key topics.

In that regard, I want to start off with four topics which I have not had time to adequately address as the peer review meetings due to time allotted for verbal comments, but I think they are important.

1. There needs to be much more description of the Lake Hancock Project and how it is used to provide flows to the Upper Peace River. Possibly, a new Appendix could be included with the minimum flows report that describes that project, but key elements of the Lake Hancock Project need to be discussed in some detail in the main body of the report. In particular, show a close-up map of the Lake Hancock and the adjacent treatment wetland that identifies the locations of where water exits from the lake and the treatment wetland to eventually reach the Upper Peace River.

In that same regard, flows from Lake Hancock to the lower river from all the outlets need to be better described with hydrographs and descriptions of quantities on a yearly and seasonal basis, including during unusually dry periods (e.g., the spring of 2017). Similarly, a water level hydrograph for Lake Hancock should be provided. Pumpage records from the lake to the treatment wetland should be described accompanied by a hydrograph. The relative role of discharges from the Lake Hancock to the flows in the Upper Peace River should then be discussed.

2. The report in a few places, including the Executive Summary, discusses use of an annual 95% flow exceedance parameter. Throughout the report, it is not clear how such a flow parameter would be used in a manner to simply evaluate compliance with the minimum flows, or instead, also regulate surface withdrawals from the river. In footnote to the table in the Executive Summary, does this parameter apply only to the Bartow gage? This needs to be clarified.

Ninety-five percent exceedance values can be calculated on a yearly basis or over various time intervals, including the long-term record. Because it could not adequately differentiate between the effects of water withdrawals and structural alterations on flows in the Upper Peace River, the first minimum flows report (SWFWMD 2002) used fish passage and wetland perimeter relationships to only establish low minimum flows at the Bartow, Ft. Meade, and Zolfo Springs gages.

It then recommended that these rates of flow be viewed as 95% exceedance values, meaning that flows should fall below these rates no more that 5 percent of the time each year. Obviously, that will be easier to achieve in wet years than in dry years, and it should be pointed out a this is a very low flow standard, as 95% exceedance means that flows can fall below that value about 18 days during the year.

The principal discussion of the 95% exceedance criterion in the new draft minimum flows report is found on pages 207 to 211 in relation to the low flow thresholds that are proposed for the three index gages. The low flow thresholds were based on the physical characteristics of the river, particularly fish passage and wetted perimeter relationships. The regulatory aspect of the low flow threshold is clear, that surface withdrawals will not be able to reduce flow below that amount.

In that regard, it seems that annual 95% exceedance thresholds are a way to examine how well the low flow thresholds protect the low flows in the upper river. The draft report accurately states that 95% threshold will vary greatly between wet and dry years, and may go below the low flow thresholds in some years. That discussion seems to indicate that if the low flow threshold that established for the three index gages are above the 95% exceedance values that is beneficial. In other words, the District would like for flows to not go below the low flow thresholds more than 18 days of the year.

The report presents plots the annual 95% exceedance values along with the corresponding low flow threshold as a reference line for each of the three index gages. It seems clear from those hydrographs that the annual 95% exceedance values were below the proposed low flow thresholds most years since 1975 at the Bartow and Ft. Meade gages. However, the report points out that there has been a greater frequency of the annual 95% exceedance values being above the low flow thresholds since 2016, when the Lake Hancock Project became operable.

That may well be and I am pleased to hear that, but it should also be noted that the period from 2016 to 2022 was fairly wet. I have included an Attachment A to this review, a document labeled SF-6 that was uploaded to the minimum flows Webboard. It shows that the seven-year average flow for the 2016 to 2022 period at the Ft. Meade gage had the second highest value among the 43 years for which seven-year averages could be calculated. For the Zolfo Springs gage, the 2016-2022 period had the highest ranked seven-year mean. This does negate the statement that the operation of the Lake Hancock project has benefited the low flows of the river, but there has also been a significant, beneficial climatic effect.

But that is not the key point of my comments. Rather, the report needs to be more clear in how the annual 95% exceedance values are to be applied. It does not seem that it will be used to limit withdrawals, but instead is being examined to see how well the low flow thresholds are functioning to protect the low flows of the river. If that is the case, it needs to be more clearly stated in the report. That is not indicated by the first sentence on page 208 of the report that states “Therefore, establishing an annual exceedance criterion in relation to the low-flow threshold is necessary from both operational and compliance perspectives.” Again, it needs to be more clearly stated in the report if an 95% exceedance values are to be used as a compliance mechanism to regulate withdrawals, or just as tool to evaluate how protective are the low flow thresholds established for each gage.

Regardless of how it is applied, I question the statement on page 210 in the District report with regard to the Ft. Meade gage that “Under baseline flow conditions, a low-flow threshold of 21 cfs corresponds to an annual exceedance of 98%, suggesting that setting a 95% annual exceedance may be achievable.” First, the river is not currently in baseline conditions, and percentile values for gaged flows at the Ft. Meade gage are consistently below the corresponding percentile values for baseline flows. This is shown in Tables 1, 2, and 3 in Attachment B, which show percentile values for both gaged and baseline flows at the Ft. Meade gage for three periods: 1975 to 2022, 2003 to 2018, and 2016 to 2022.

The P5 values (same as the 95% exceedance values) for gaged flows are less than the baseline values for all three periods, with the values being much closer in the 2026 to 2022 period. However, the P5 value for the 2003 to 2016 period (3 cfs) was much lower, as this period included a number of dry years and was before the implementation of the Lake Hancock Project.

Also, Figure 6-4 in the draft minimum flows report shows that the annual 95% exceedance values at Ft. Meade were below the 21 cfs low flow threshold around 40 of the 48 years shown in that Figure. I realize that his is probably a worst-case scenario, as it includes years when groundwater withdrawals in the basin were much higher. However, also see the results for

2006 to 2012 in that Figure, which covered an extended dry period when the annual 95% exceedance values were very low.

So, I have two basic comments on the discussion regarding the 95% exceedance flows in the report. It seems overly optimistic to suggest that the implementation of the Lake Hancock Project will largely keep the annual 95% exceedance values above the low flow thresholds for the Bartow and Ft. Meade gages. I hope it does, but I think that statement is overly influenced by the predominantly wet period from 2016 to 2022.

More importantly, the report needs to be more clearly describe if the annual 95% exceedance values are a means to evaluate the effectiveness of the low flow thresholds, or is it some sort of compliance standard that will be used to regulate withdrawals. As stated in the Executive Summary, if is used to operate the Lake Hancock project, that needs further explanation in the text of the report.

I would suggest that if gaged flows in the river go below the 95% exceedance flow for baseline conditions calculated for the 1975 to 2022 period at any of the three index gages, flows should be released from Lake Hancock to improve thet low flow conditions in the river. These long-term 95% exceedance values are 23 cfs at Ft. Meade and 30 cfs at Zolfo Springs, compared to the 21 and 40 cfs low flow thresholds proposed for these gages in the proposed minimum flow rule. I did not have time to calculate the 95% exceedance baseline value for the Bartow gage. Or, does the District plan to release water from Lake Hancock when flows go below the proposed low flow thresholds at the gages. Whichever seems fine, but whatever the District plans to do needs to be more clearly described in the text.

3. in relation to comment #2 above, I highly recommend that percent exceedance values for gaged flows and baseline conditions be listed in tabular form to better convey the data. Figures 6-6, 6-7. and 6-8 have flow exceedance curves for baseline and gaged flows plotted with a semi-log scale on the Y axis. These plots would be greatly improved if the tic marks, with cross hatching, were increased in closer intervals in 10 cfs increments between 10 and 100 cfs and 100 cfs increments between 100 and 1,000 cfs.

Still, exact differences between baseline and gaged flows are difficult to discern on plots with semi-log scales, so listing these values in tables would be very helpful. I did this for three different time periods for the Ft. Meade and Zolfo Springs gages, which are listed in Tables in Attachments A (Zolfo Springs) and Attachment B (Ft. Meade). This type of data presentation is effective for showing how the flow duration characteristic of the Upper Peace River have changed over time.

4. Assumptions and approximations in the application of the PRIM2 model

The District sponsored a great deal of work in developing the Peace River Integrated Models 1 and 2. The PRIM2 model is a very useful tool and I have not reviewed Appendix in the report associated with it, but I do have two basic concerns about the model that make me think it may have underestimated the baseline flows in the river. However, as I will say a couple of times, if this is so, I don't think if hinders the findings of the report if the results are adequately analyzed, with my recommendations on that described in next topic (#5).

These concerns are partly identified in a technical memorandum I prepared for the January 23rd, peer review meeting that was ultimately canceled, which is attached as Attachment C. It discusses that the PRIM2 model was used to estimate streamflow under existing (100%) withdrawals and 50% withdrawal conditions. This report states that the predicted increases in streamflow using the PRIM2 model increase in a linear manner, so the differences in gains in streamflow between these 100% and 50% withdrawal scenarios were then doubled to estimate streamflow under zero withdrawal conditions.

I am no modeler, but this seems like a big leap of faith. In a river which is closely connected to the Floridan aquifer, such as the Upper Peace River near Bartow and Ft. Meade, it seems that as groundwater levels rise above the bed of the river the rate on streamflow increase would rise, but this modeling approach does not seem to account for that.

I do know that many areas of Upper Peace River basin have been highly altered by phosphate mining, as the draft report says that approximately 25% of the Upper Peace river basin is comprised of mined lands, most of which differ in their state of reclamation.

Much of this mining in earlier years occurred in very close proximity to the river channel, with extensive clay settling ponds occurring on many areas of previously mined lands. Clay settling ponds are well known to have very low infiltration and recharge rates, and they can also disrupt the near surface geology near the river channel which impedes shallow groundwater flow to the river. It is my observation that the reaches of the Upper Peace River that have the most highly impacted flows are in the sections of river in which phosphate mining occurred near the river channel.

Again, I have not closely reviewed Appendix B for the draft minimum flows report that deals with the PRIM2 model, but I wonder to what degree for the baseline scenario did the consultants attempt to mimic the geologic characteristic of the phosphate mined lands before they were mined. The report does say the PRIM2 model was calibrated to flows during the years 2003 to 2016, which represents a period when flows in parts of the Upper Peace River basin were already highly impacted by mining. I do not know if attempts were made to correct for these alterations in the modeling of baseline flows, as the current situation represents somewhat of an impacted condition. If the pre-ming geology was not simulated (which I do not know), it seems like this would contribute to the model underpredicting baseline flows.

I again reiterate that I don't think that any errors in the modeling process impair sound decisions regarding whether the current flows are within the flow reduction limits of the proposed minimum flows. I do believe the modeling results should be considered along with the hard data we know about the Upper Peace River, including the flow trends, the occurrence of karst features that have formed in the river channel and floodplain, and the significant alterations of the upper river basin.

As described below, I think that appropriate analyses of the baseline and gaged flow records strongly indicate that the minimum flows are not being met at the Ft. Meade gage, which matches very well with what is known about the Upper Peace River.

5. The Upper Peace River is not meeting the proposed minimum flows at the Ft. Meade gage

As I have stated at two peer review meeting on January 30th and February 6th, the data I have analyzed indicate the Upper Peace River is not meeting its minimum flows at the Ft. Meade gage. I did not have time to examine this at the Bartow gage, but if the minimum flows are not being met at Ft. Meade, that would preclude withdrawals at upstream sites. However, as described in Attachment A, the minimum flows are being met at the Zolfo Springs gage.

My findings and conclusions that the minimum flows are not being met at the Ft. Meade gage are described in technical memoranda and verbal comments I submitted to the scientific review panel for the draft minimum flows report. These memoranda are attached to the end of this review as Attachments A, B, and C, with transcripts of related verbal comments as Attachments D and E. Those attachments should be closely reviewed, plus I describe some of their principal findings and conclusions below.

The transcript for the February 6th meeting (Attachment E) provides a good summary of my views on this subject, with supporting analyses presented in Attachments A, B and C.   Those analyses show the minimum flows for the Ft. Meade gage are not being met for a large majority of the time over much of the flow regime of the river at that location. However, it could be considered that the minimum flows are being met at Ft. Meade at flows above 200 cfs or so, which occur on average about 30 percent of the time.

Practical considerations for establishing minimum flows in relation to potential water supply withdrawals from the Upper Peace River are also discussed in Attachment E. Overall, these findings conclude that there is considerable water available for supply near the Zolfo Springs gage, but the practicality of obtaining significant water supplies near the Bartow and Ft. Meade gages is very limited if the limits established in the proposed minimum flows for the river near those gages are not to be exceeded even further than what have already occurred.

6. Further review I consider this review to cover the most critical issues regarding the draft minimum flows report. However, I have found a number of instances in the text where editorial changes or slight modifications of some language could provide greater clarity to the report. I will submit those recommended edits to the District during the week of February 9th. I may also have some suggested modifications of sections of the report I have not yet closely reviewed (Water Quality). If I do have some additional suggestions to offer, I will try to have them submitted to the District before February 13th.

Attachment A

Analysis of days minimum flows were met at Zolfo Springs gage and flow duration statistics

Document SF-6 on the minimum flows Webboard

SF-6 A. Flow duration analysis at the Zolfo Springs gage

B. Analysis of the frequency and magnitude that the proposed minimum flows for the Upper Peace River are being met at the Zolfo Springs gage

Submitted by Sid Flannery, February 7, 2026

This document presents graphical and statistical analyses of the frequency and magnitude that proposed minimum flows are being met the USGS Peace River at Zolfo Springs gage, which is one of the three index gages used for applying the minimum flows for the Upper Peace River. As will be described on pages 7 to 10 the minimum flows are clearly being met at the Zolfo Springs gage.

However, in order to better interpret those findings, it is helpful to first describe and compare the flow characteristics for the Ft. Meade and Zolfo Springs gages. Data were presented for the Ft. Meade gage in Document SF-4, and similar statistics for the Zolfo gage are presented in this document.

As with document SF-4, flow data are analyzed for three time periods, all of which are discussed in the draft District report. The first is the entire period for which baseline flows were calculated, which is the period from 1975 to 2022. The second period is the years from 2003 to 2018 over which the Peace Rive Integrated Model (PRIM2) was calibrated. The third is the period from 2016 to 2022, during which time the Lake Hancock project became operable which improved the low flow characteristics of the river.

First, as a follow-up to the scientific peer review meeting that was held on January 30, 2026, data are first presented for the most recent 2006 to 2022 period. At that meeting, one of the panel members suggested that the improvement in low flows at the Bartow and Ft. Meade gages may have been party due in part to climatic factors, in addition to operation of the Lake Hancock structure. Based on analysis of the flows during this final period, my document SF-4 similarly stated that some of the improvement in flow flows at Ft. Meade was due to a series of years with average or above average during the 2016 to 2022 period.

To examine this further, seven-year moving average flows were calculated for gaged and baseline flows for both the Ft. Meade and Zolfo Springs gages. The seven-year period was chosen because it was the length of time that the Lake Hancock was operable during the period for which baseline flows were calculated, which ended in 2022.

Seven-year average flows for both gaged and baseline flows at the Ft.. Meade gage are listed in Tables 1 and 2. Seven-year average flows can be calculated for 43 years in the 48-year period from 1975 to 2022 for which both gaged and baseline flows were available. During this period, the seven-year mean gaged flow for 2022 (305 cfs) was tied with period ending in 2020 for the second from highest value, with these same two years tied for third highest value (320 cfs) for baseline flows. It is not surprising that these two years had similar values as they had five over-lapping years.

Table 1

Ft. Meade - Gaged Flows Moving Seven-Year Means Ranked by value

Year	Seven-Year Mean (cfs)
2012	70
2013	79
2014	104
1991	107
1990	108
1992	124
2011	135
1993	136
2015	137
1981	148
1989	156
1994	157
1986	161
1987	167
2016	170
1982	181
2017	188
1988	189
2010	193
1995	193
1985	199
1983	213
2002	218
1984	222
1996	223
2018	226
2003	248
2009	248
2001	250
1997	250
2019	264
2008	274
2007	277
2006	278
2000	283
2005	284
2004	287
2021	297
1999	303
2022	305
2020	305
1998	315

Table 2

Ft. Meade - Baseline Flows Moving Seven-Year Means Ranked by value

Rnked	Seven-Year Mean (cfs)
2012	89
2013	97
2014	121
1991	133
1990	135
1992	149
2011	153
2015	154
1993	162
1981	177
1989	181
1994	182
1986	185
2016	187
1987	191
2017	204
1982	208
2010	211
1988	214
1995	217
1985	224
1983	238
2002	240
2018	243
1996	246
1984	247
2009	266
2003	270
1997	272
2001	272
2019	280
2008	292
2007	296
2006	298
2000	305
2005	305
2004	308
2021	312
2022	320
2020	320
1999	324
1998	336

Similar results are presented for the Zolfo Springs gage in Tables 3 and 4. At that location the seven-year mean flows both the gaged and baseline records were the highest among the 43 years that were available for analysis.

These results show the period for which the Lake Hancock project was available was generally very wet. As described in my Document SF-4, there is a serial effect with streamflow that carries over between seasons, especially for rivers where streamflow is closely linked to groundwater levels in the Floridan aquifer such as the Upper Peace River. Prolonged wet periods tend to bring aquifer levels up which can benefit flows in the dry season. It appears this was likely occurring during the period of operation of the Lake Hancock project. As I discussed in document SF-4, the effectiveness of the Lake Hancock project for raising low flows in the upper river should be revisited in drier years or series of dry years that have more frequent and prolonged dry conditions than what occurred in in the 2016 to 2022 period.

The sixteen-year period from 2003 to 2018, for which the PRIM2 model was calibrated was a very different situation, as it captured one of the most prolonged dry periods in the last few decades, that being a series of seven consecutive years with below average rainfall from 2006 to 2012. Figure 2-37 in the draft District report shows that rainfall deficits were particularly large in 2006 and 2007, with the 5-year moving average rainfall in 2010 being the lowest in the 104 years of record shown in that Figure. Similarly, Figure 2-31 in the District report shows that the five-year average flows at all three index gages reached their lowest values on record in 2010, with some rebound in recent years.

These effects of these dry and below average rainfall years are reflected in the flow statistics that were shown for 2003 to 2018 at the Ft. Meade gage in document SF-4. Although the period contained some wet years including 2004, 2025, and four consecutive years with above average rainfall from 2015 to 2018, the flow statistics for this sixteen-year period were lower at Ft. Meade for the 1975-2022 period and considerably lower than the more recent 2026 to 2022 period.

Flow statistics similar to those presented for Ft. Meade in document SF-4 are presented for the Zolfo Springs gages on the following pages. The findings for Zolfo Springs show similar trends as Ft. Meade for the three periods, with the 2003 to 2018 period having the lowest values for the P5 to P50 percentiles and the 2016 to 2022 period having the highest values for all the statistical metrics.

However, all of values are much higher for the Zolfo Springs gage compared to Ft. Meade, as the flows increase greatly between Ft. Meade and Zolfo Springs due to a number of factors. Also, in the following tables it is important to note that the all the statistical values for gaged flows at Zolfo Springs are greater than or nearly equal to the values for baseline flows. This is very different than at the Ft. Meade gage, where the gaged values were consistently lower than the baseline values, often by considerable amounts, reflecting that the flows of the upper river near the Ft. Meade gage are highly impacted.

Table 3

Zolfo Springs - Gaged Flows Moving Seven-Year Means Ranked by value

Year	Seven-Year Mean (cfs)
2012	255
2013	280
2014	327
1990	329
1991	349
2011	364
1992	381
1993	387
2015	404
1981	405
1989	413
1986	429
1987	439
1994	444
1982	470
2016	472
2010	475
1985	484
1988	493
2002	499
2017	513
1995	525
1984	532
1983	532
1996	556
2009	563
2001	567
2003	577
2018	589
1997	600
2008	614
2000	628
2006	642
2007	643
2019	649
2005	650
2004	656
1999	671
2021	690
2020	694
1998	699
2022	713

Table 4

Zolfo Springs - Baseline Flows Moving Seven-Year Means Ranked by value

Year	Seven-Year Mean (cfs)
2012	249
2013	275
1990	320
2014	321
1991	340
2011	358
1992	371
1993	378
1981	395
2015	398
1989	404
1986	421
1987	431
1994	435
1982	460
2016	466
2010	469
1985	475
1988	485
2002	492
2017	507
1995	517
1984	523
1983	523
1996	547
2009	557
2001	560
2003	571
2018	583
1997	592
2008	608
2000	620
2006	636
2007	637
2019	643
2005	644
2004	649
1999	663
2021	685
2020	689
1998	691
2022	708

Tables with means and selected percentile values for both gaged and baseline flows at Zolfo Springs are presented for three time periods below, with the changes calculated as the gaged flow as a percent of baseline flow for each of these parameters. The District report states that the increases in gaged flows relative to baseline flows are due in part to flow supplementation from agricultural lands upstream of Zolfo Springs. The percentage increases are greatest at low flows in part because the flow quantities are much smaller, but excess flows from agricultural runoff would be expected to increase the low flows of the river. The values for the median flow and the higher percentile are very close or virtually the same between the baseline and gaged values.

Table 5. Mean and percentile values for baseline and gaged flows and the percent increase in each value as gaged relative to baseline at the Zolfo Springs gage for the years 1975 - 2022 (48 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	519	30	47	102	245	587	1281	1941
Gaged flow	512	37	56	111	250	596	1280	1940
Percent gain	1%	23%	19%	9%	2%	2%	0%	0%

As stated in document SF-4, since it is based on many more years of record (48 years) compared to the other two time periods, it is important to consider the percentile values in Table 5 when viewing the flow percentiles for shorter time periods, which might be biased to drier or wetter multi-year periods. Although the estimated baseline flows have sources of uncertainty and possible error, they are very valuable for they estimate the flows in the river in the absence of groundwater withdrawals and presumably the effects of recent agriculture in the basin. Given that, the long-term the baseline flow statistics in Table 5 probably best represents the natural flow characteristics of the river at the Zolfo Springs gage.

Table 6 shows the same statistics for the years for 2003 to 2018 for which the PRIM2 model was calibrated. Given that adjustments that were applied to earlier years based on water use estimates, the years from 2003 to 2018 probably represent the most accurate period for the baseline records. Although the values for median and low percentiles are slightly less than the 1975-2022 period, the values for the higher percentiles are somewhat greater, possibly due to the relative influence of the several high flow years that occurred during the 2003 to 2018 period. As with the longer term record, the statistical values for gaged flows are either greater or nearly the same as the for baseline flows.

Table 6. Mean and percentile values for baseline and gaged flows and the percent increase in each value as gaged relative to baseline at the Zolfo Springs gage for the years 2003 - 2016 (16 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	545	24	35	89	234	636	1500	2075
Gaged flow	540	29	43	93	241	639	1510	2080
Percent gain	1%	21%	23%	4%	3%	0%	1%	0%

As with the Ft. Meade gage, much higher mean and percentile values exist for seven-year period from 2016 to 2022, for as previously discussed, it included a number of years with near average or above average rainfall. For baseline flows, the mean value for this recent period listed in Table 7 below is 713 cfs, compared to mean values of 519 and 545 cfs for the other periods in Tables 5 and 6. Also, the median baseline flow for the recent period (355 cfs) is well above the long-term median of 255 cfs and the median of 234 cfs for the 2003 to 2018 period.

Table 7. Mean and percentile values for baseline and gaged flows and the percent increase in each value as gaged relatived to baseline at the Zolfo Springs gage for the years 2016 - 2022 (7 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	713	50	72	140	355	916	1778	2243
Gaged flow	708	58	78	146	359	925	1780	2250
Percent gain	1%	16%	8%	4%	1%	1%	0%	0%

As described in Document SF-4 for the Ft. Meade gage, the P5 and P10 values for the gaged values at Zolfo Springs during this recent seven-year period were much greater than for the other two periods. This is partly due the implementation of the Lake Hancock project, which came online in 2016 and stores water in the wet season and releases it to the river in the dry season. However, as described on pages 1 to 3 and also in in Document SF-4, this was generally a very wet period which affected the relatively high values listed in Table 7.

Plots are presented on the following pages for daily percent reduction values the gaged flows represent relative to baseline flows vs. the same-day rate of gaged flow at the Zolfo Springs gage. Red reference lines are shown in the graphs for the maximum percentage withdrawal rates for the four flow blocks allowed by the proposed minimum flows, which are listed in Table 8. Note that 40 cfs is the low-flow threshold below which no withdrawals are allowed.

Table 8. Flow ranges and maximum allowable percentage withdrawal rates for the four flow blocks at the Zolfo Springs gage.

Block 1	≤ 40 cfs	0%
Block 2	> 40 cfs and ≤ 274 cfs	13%*
Block 3A	> 274 cfs and ≤ 1,047 cs	9%
Block 3B	> 1,047 cfs	7%

*** A full 13% of flow cannot be taken until flows reach a rate of 46 cfs**

Daily percentages that gaged flows at Zolfo Springs are changed from baseline are plotted vs. the same-day gaged flow in Figure 1 for the 48-year period from 1975 to 2025. For comparison, the corresponding Figure from the Ft. Meade gage is presented in Figure 2. Positive values on the Y axis denote a reduction in flow from baseline to gage, whereas negative values mean a gain in gaged flow relative to baseline. Values below the reference line are meeting the percentage limits in the proposed minimum flows wife values above the line are not. These graphics demonstrate the very different relationship for meeting the minimum flows between these two index gages. Based on Figure 1, flows the Zolfo Springs gage meet the minimum flows the vast majority of the time, while they often do not at Ft. Meade except for very high flows.

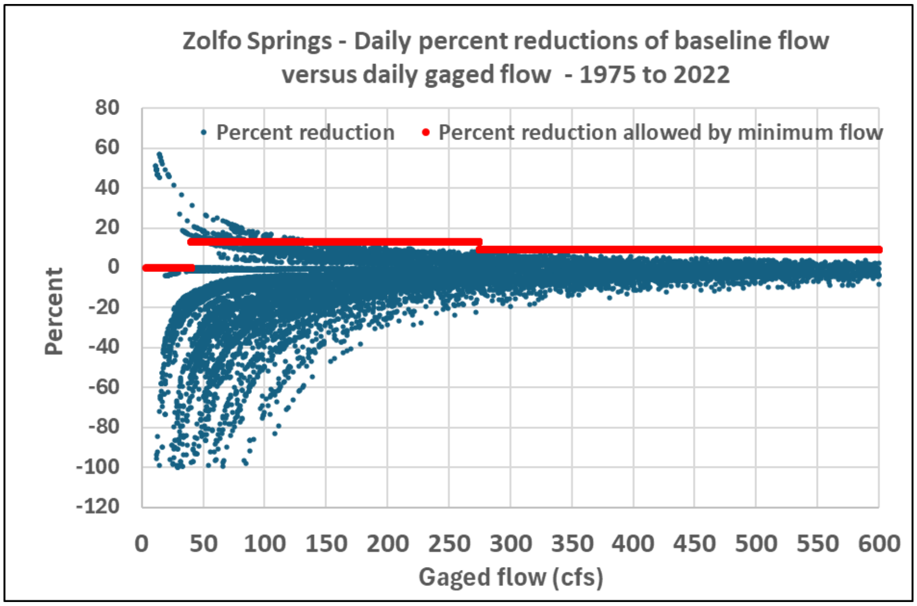

Figure 1. ZOLFO SPRINGS - Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 1975 – 2022 at the Zolfo Springs gage.

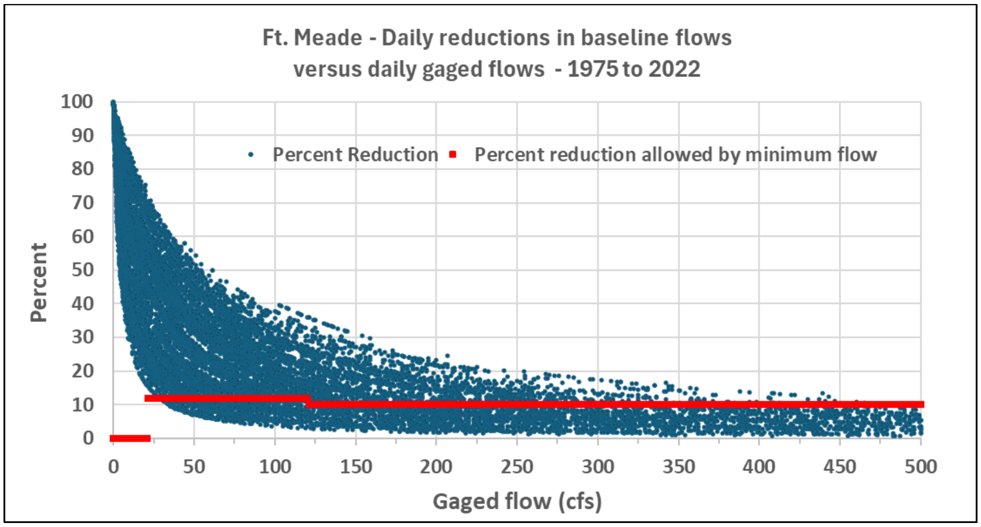

Figure 2. FT. MEADE - Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 1975 – 2022 at the Ft. Meade gage.

Similar graphs for the sixteen-year period from 2003 to 2018 at the Zolfo Springs gage is presented in Figure 3, while a graph for the recent 2016 to 2022 period is shown in Figure 4. The pattern remains that the minimum flows were almost always met at Zolfo Springs during 2003 to 2018, or entirely met during the period from 2016 to 2022. This agrees with the values presented in Tables1, 2, and 3 that indicate the gaged flows at Zolfo Springs are generally higher than the baseline flows, with the reasons for this described in the draft District report.

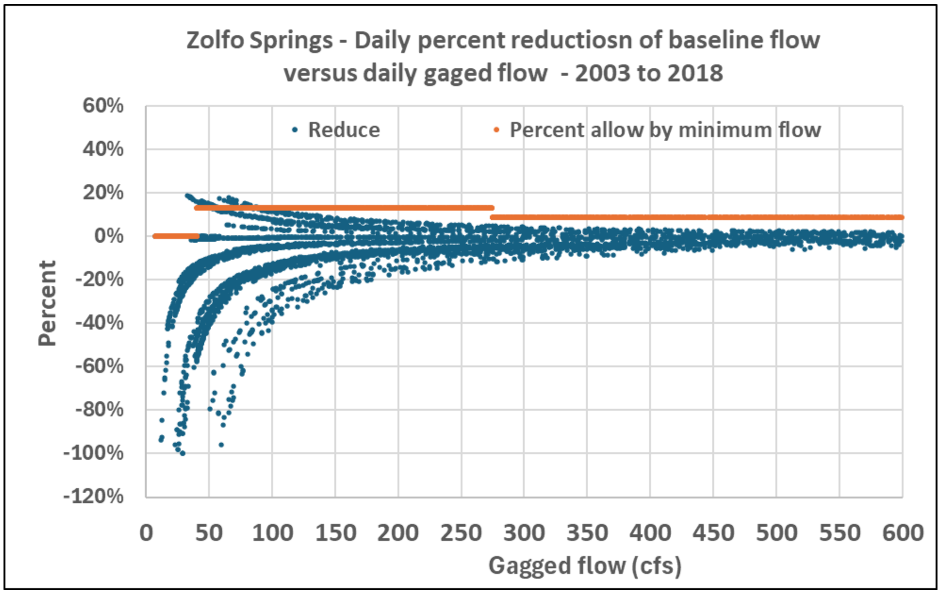

Figure 3. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 2003 – 2018 at the Zolfo Springs gage.

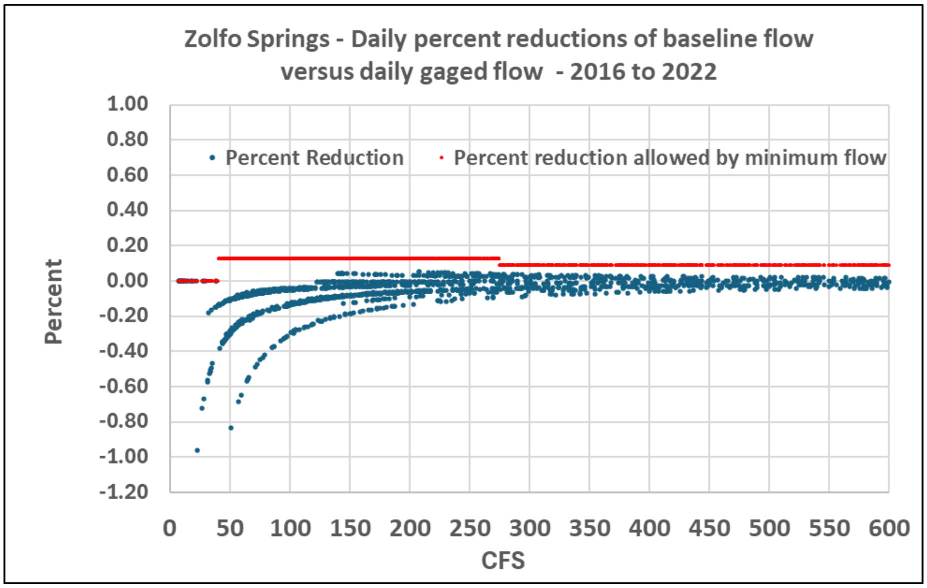

Figure 4. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 2016 to 2022 at the Zolfo Springs gage.

As was presented for Ft. Meade in Document SF-4, another way to evaluate how well the gage flows are meeting the minimum flows at Zolfo Springs is to examine the number of days within each of the flow blocks that met the percentage flow reductions allowed by the proposed minimum flows that were listed in Table 8. This was approach was done only for the two more recent periods, as the values going back to 1975 would capture some groundwater conditions that no longer apply, as there has been some recovery of groundwater conditions in the region.

The values for the period from 2003 to 2018 are listed in Table 9, calculated for days when the gaged flows were within the various flow blocks. The most important thing in Table 9 is that the minimum flows were met 99% of the days during this period. Also, it is notable that flows were in Block 1 for 9% of the time, while it was in Block 1 for 25% of the time at Ft. Meade in this same sixteen-year period, possibly reflecting improvement in low flow conditions in the river near Zolfo Springs. However, it could also be influenced on the physical features in the river that the Block 1 threshold was based on in these two sections of the river.

Table 9. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of of days within that block that the minimum flows were met at the Zolfo Springs gage for the years 2003 to 2018. Values at the bottom are for all blocks combined.

	Flow range for each Block	Total number of days in block	Percent of total days within the block	Percent of days minimum flow met in the block
Block 1	< 40 cfs	507	9%	98%
Block 2	> 40 cfs and ≤ 274 cfs	2,622	45%	97%
Block 3A	> 274 cfs and ≤ 1,047 cfs	1,779	30%	100%
Block 3B	> 1,047 cfs	936	16%	100%
All Blocks combined		5,844		99%

Values for the more recent 2016 to 2022 are listed in Table 10, in which the minimum flows were met 100% of the time in all the blocks. It is also notable that the gaged flows were in Block 1 only 2% of the time, and in the higher flow blocks of 3A and 3B a total of 57% of the time, reflecting that this was a generally wet period.

Table 10. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of days within that block that the minimum flows were met at the Zolfo Spring gage for the years 2016 to 2022. Values at the bottom are for all blocks combined.

	Flow range for each Block	Number of days in the Block	Percent of total days within the Block	Percent of days minimum flow met withinin the Block
Block 1	< 40 cfs	40	2%	100%
Block 2	> 40 cfs and ≤ 274 cfs	1,055	41%	100%
Block 3A	> 274 cfs and ≤ 1,047 cfs	905	35%	100%
Block 3B	> 1,047 cfs	557	22%	100%
All Blocks combined		2,557		100%

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The combined results for Ft. Meade in document SF-4 and the results for Zolfo Springs his document clearly demonstrate how much improved the flow regime of the Upper Peace River is near Zolfo Springs compared to Ft. Meade.   It was the conclusion of document SF-4 that the river was not meeting its minimum flows at the Ft. Meade gage, but it is at Zolfo Springs.

This also has implications for water supply. If the minimum flows at Ft. Meade are not being met, it should not be used for water supply except for possibly during very high flows, which likely would not be cost effective. In contrast, new withdrawals could be obtained near Zolfo Springs, as it is meeting its minimum flows and the flows in the river are much greater there. For example, for the sixteen-year period for 2003 to 2018, the median gaged flow at Zolfo Springs was 241 cfs compared to 70 cfs at Ft. Meade, while the average gaged flow was 540 cfs at Zolfo Springs compared to 220 cfs at Ft. Meade.

In total, these findings are technical sound represent good water management, as substantial yields from the Upper Peace River could be obtained near Zolfo Springs, while flows should be preserved without withdrawals, with the possible exception of very high flows, near Ft. Meade to prevent further harm to that reach of the Upper Peace River.

Attachment B

Analysis of days that the minimum flows were met at the Ft. Meade gage

Document SF-4 on the minimum flows Webboard

SF 4 – Analysis of the frequency and magnitude that the proposed minimum flows for the Upper Peace River are being met at the Ft. Meade gage

Submitted by Sid Flannery, January 29, 2026

This document presents graphical and statistical analyses of the frequency and magnitude that proposed minimum flows are being met the USGS gage Peace River at Ft. Meade, which is one of the three index stations used for applying the minimum flows for the Upper Peace River. I think the Ft. Meade gage is key for assessing this question, for as described in the draft District report, the Peace River can be a losing stream on many days between the Bartow and Ft. Meade gages.

The Ft. Meade gage can also be a limiting factor for any withdrawals upstream, including those based on the Bartow gage, as they would have to also comply with the minimum flows for the downstream gages including Ft. Meade. This memo does not discuss the frequency that the minimum flows are being met at the Zolfo Springs gage, for the flows in the river are in much better shape at Zolfo Springs, and based on the material presented in the draft District report it appears the river is meeting the minimum flows requirements at that site.

As will be shown in graphics on the following pages, there is a very clear pattern with the gaged flows at Ft. Meade being below the baseline flows by the greatest percentage amounts at low and medium flows, with flow deficits being much less at high flows. For that reason, it is important to examine the flow duration characteristics of the time periods over which evaluations of the adequacy of the minimum flows are made.

The deficits in the gaged flows relative to baseline flows at Ft. Meade are described for three time periods in this memo, all of which are discussed in the draft District report. The first is the entire period for which baseline flows were calculated, which is the period from 1975 to 2022. The second period is the years from 2003 to 2018 over which the Peace Rive Integrated Model (PRIM2) was calibrated. The third is the period from 2016 to 2022, during which time the Lake Hancock project became operable which improved the low flow characteristics of the river.

Tables with the means and selected percentile values for both the gaged and baseline flows are presented for these three time periods, with the percent reduction in daily baseline flows represented by the gaged flows listed for each of these parameters.

The table of values for the 1975 to 2022 period is shown on the following page.

Table 1. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 1975 - 2022 (48 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	230	14	23	45	102	255	615	945
Gaged flow	209	3	7	26	78	230	591	923
Percent reduction	9%	79%	70%	42%	24%	10%	4%	2%

Because it is based on many more years of record (48 years) compared to the other two time periods, it is important to consider the percentile values in Table 1 when viewing the flow percentiles for shorter time periods, which might be biased to drier or wetter multi-year periods. Although the estimated baseline flows have sources of uncertainty and possible error, they are very valuable for they estimate the flows in the river in the absence of groundwater withdrawals. As described in the draft District report, there have been reductions in groundwater use in the Upper Peace River basin over this nearly 50 year period. As such, the effects of groundwater withdrawals on flows in the river have varied as well. Given that, the baseline flow record probably best represents the natural flow characteristics of the river at the Ft. Meade gage.

Note that the median flow for Ft. Meade is 102 cfs, with an interquartile range (25th to 75th percentiles) of 45 to 255 cfs. Although this period covers a long period of record over which impacts to the flows of the river have likely changed, the percent reductions in the baseline flows are very large. For example, the median gaged flow (78 cfs) represents a 24% reduction in the median baseline value. The reductions in low flow percentiles (P5 and P10) are much greater, at 79 and 70 percent, respectively. This is not surprising, as the formation of karst features in the river channel and floodplain and groundwater drawdowns have caused large reductions in the low flows of the river.

Table 2 shows the same statistics for the years for 2003 to 2018 for which the PRIM2 model was calibrated. Given that adjustments that were applied to earlier years based on water use estimates, the years from 2003 to 2018 probably represent the most accurate period for the baseline predictions. This 16-year period had some high flow years (2004 and 2005), but included a several dry years (see Figure 2-3 in District report) and values for the median and lower flow percentiles (P5 to P25) are somewhat lower than for the long-term period shown in Table 1. However, as with the longer period, there are still substantial reductions from baseline conditions for the median and lower percentile flows.

Table 2. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 2003 - 2016 (16 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	237	11	18	39	87	267	696	1008
Gaged flow	220	3	6	21	70	246	675	986
Percent reduction	7%	73%	67%	46%	20%	8%	3%	2%

Much higher mean and percentile values exist for seven-year period from 2016 to 2022, as it included a number of years with near average or above average rainfall. For baseline flows, the mean value for this recent period listed in Table 3 below is 320 cfs, compared to mean values of 230 and 237 cfs for the other periods in Tables 1 and 2. Also, the median flow for the recent period (145 cfs) is well above the long-term median of 102 cfs (Table 1) and the median value of 87 cfs for the 2003 to 2018 period (Table 2).

Table 3. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 2016 - 2022 (7 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	320	40	44	61	145	417	860	1273
Gaged flow	305	31	34	49	127	400	835	1250
Percent reduction	5%	22%	23%	20%	12%	4%	3%	2%

It is notable that the P5 and P10 values for the gaged values during this recent seven-year period were much greater than for the other two periods. This is partly due the implementation of the Lake Hancock project, which came online in 2016 and stores water in the wet season and releases it to the river in the dry season.

However, the P5 and P10 values for baseline flows were also much greater in this recent period compared to the other two periods. At the time of this writing, I did not know if the baseline scenario produced by the PRIM2 model for these later years included Lake Hancock discharges (I would think not), but regardless, there appears to be a major climatic factor for the high P5 and P10 values in Table 3 as this was a fairly wet seven-year period. There is serial effect to flows in that wet years and high flows tend to bring up aquifer levels, which may slow the rate of groundwater loss from the river to the underlying aquifer during dry periods.

In that regard, I offer a cautionary note to the District and readers of the minimum flows report, in that the encouraging results from the last several years seem to have been influenced by a strong climatic effect in addition to the release of water from Lake Hancock. Similarly, in viewing the graphics presented on the following pages, keep the long-term flow statistics of the river (Table 1) in mind when considering how well the river is meeting it minimum flows over the typical flow range of the river.

Text continued on the following page

Plots are presented on the following pages for daily percent reduction values the gaged flows represent relative to baseline flows vs. the same-day rate of gaged flow at the Ft. Meade gage. Red reference lines are shown in the graphs for the maximum percentage withdrawal rates for the four flow blocks allowed by the proposed minimum flow rule, which are listed in Table 4. Note that 21 cfs serves as a low-flow threshold below which no withdrawals are allowed.

Table 4. Flow ranges and maximum allowable percentage withdrawl rates for the four flow blocks at the Ft. Meade gage.		
Block 1	≤ 21 cfs	0%
Block 2	>21 cfs and ≤120 cfs	12%*
Block 3A	> 121 cfs and ≤ 529 cs	10%
Block 3B	> 529 cfs	7%

*** A full 12% of flow cannot be taken until flows reach a rate of 24 cfs**

Daily percentages that gaged flows are reduced from baseline flows are plotted vs. the same-day flow rate for the gaged flow in Figure 1 for the 48-year period from 1975 to 2025. There is a strong nonlinear relationship in the greatest flow reductions occur at low flows and substantial reductions occur over range of medium flows. Keep in mind the median gaged flow for this period is 102 cfs.

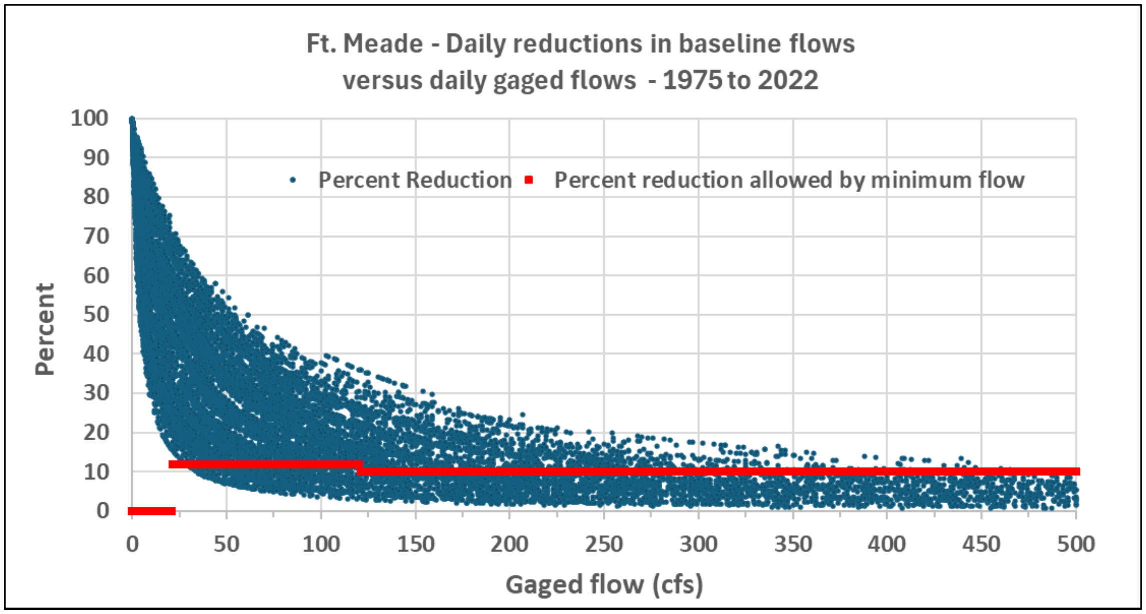

Figure 1. Daily values for percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 1975 – 2022.

It is clear there is a strong nonlinear pattern for the percent reductions in baseline flows as the most severe reductions are at low flows, as it has been well documented in several studies that the low flows in the river have been highly impacted near the Ft. Meade gage. Analysis for this period found that 91 percent of the days below the median flow of 102 cfs were not meeting the minimum flows and 82 percent of they days below the 75th percentile flow of 255 cfs were not meeting the minimum flows.

However, this could be viewed as a worst-case scenario, as the impacts to the river at Ft. Meade might have been most pronounced a number of years ago. So, to assess more recent conditions, graphs were also created for two later periods previously described. A similar graph for the sixteen-year period 2003 to 2018 is presented in Figure 2.

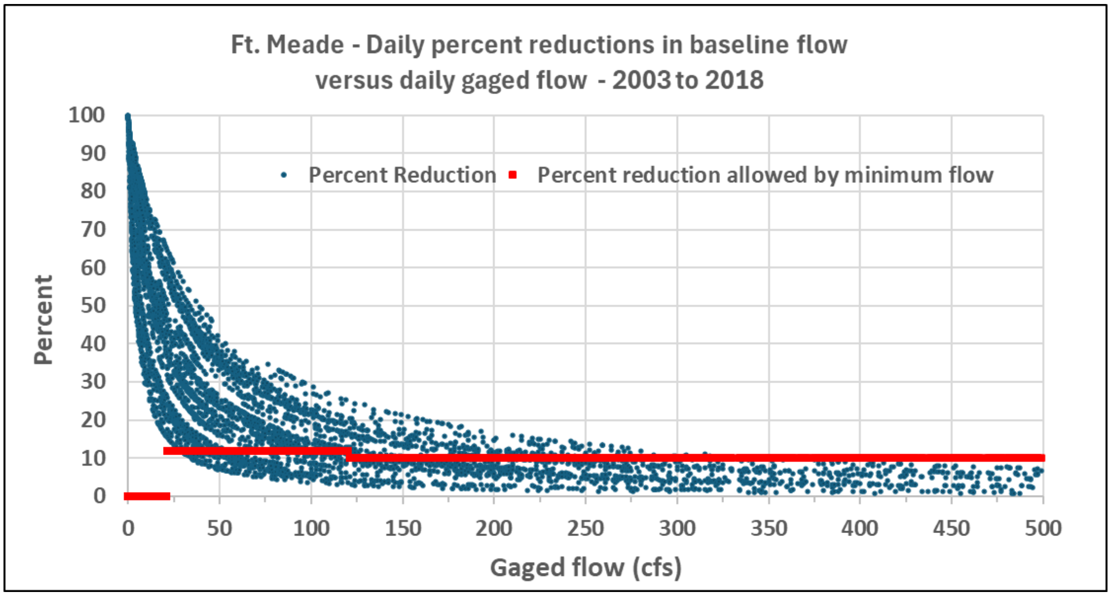

Figure 2. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 2003 – 2018.

The same pattern emerges as there are dramatic reductions in baseline flows at low flows, with substantial reductions in extending to medium flows. For this period, 90 percent of the days below the median long-term median flow of 102 cfs were not achieving their minimum flows, while 79 percent of the days below the long-term 75th percentile value were not meeting the minimum flows.

However, in both Figures 1 and 2 there is clear pattern of the percent reductions being within the minimum flow percentages at higher flow rates. Flows above 500 cfs occurred during both study periods, but are not shown here in order to give better resolution on the X axis. As will be discussed, even though the allowable withdrawals go down to seven percent at flow rates above 529 cfs, the river continued to comply with the minimum flow limits above that flow. Graphics were also generated plotting the daily percent reductions vs. the same-day baseline flows, but the patterns and interpretation are very similar to the plots presented here.

A similar graph for the seven-year period from 2016 to 2022 is shown in Figure 3. It is obvious from this graph that this period included much less that data than the other two evaluation periods. Also, as previously discussed, the gaged flows (and corresponding baseline flows) were generally higher during this period, so there is not as much data at low and low-medium flows.

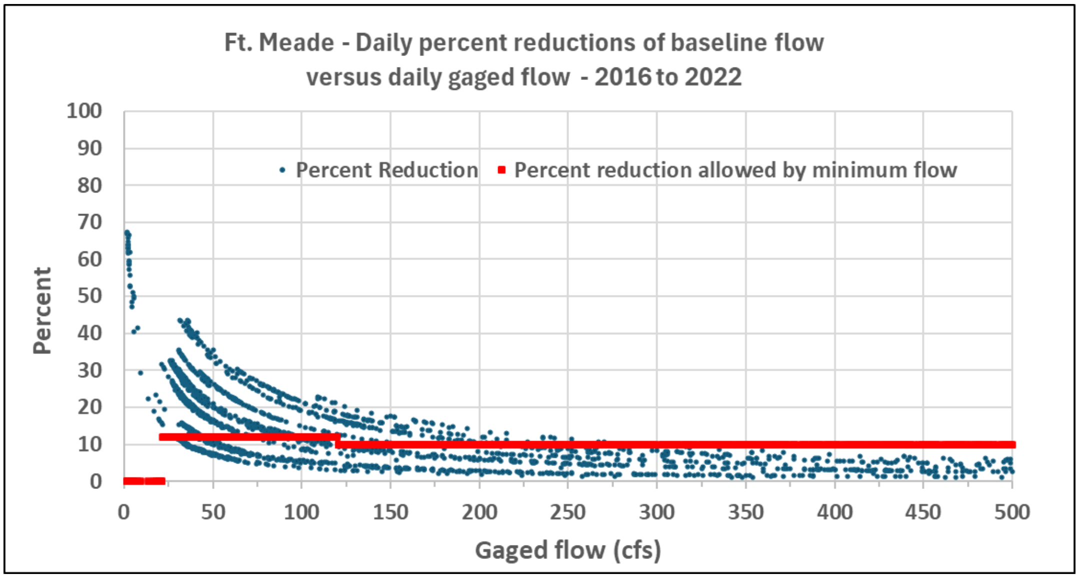

Figure 3. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow for the years 2016 to 2022.

Still, the same patterns emerge as percentage reductions in baseline flows are greatest at low flow and extend to medium flows. Seventy-two percent of the days below the long-term median flow of 102 cfs did not meet the minimum flows, while 63% of the days below the long-term 75th percentile flow of 255 cfs did not meet the minimum flows during this period.

As previously described, this was generally a wet period and this may have helped keep groundwater levels somewhat higher near the river which benefited dry season flows. The Lake Hancock project also seemed to benefit the low flows in the river, as the reductions in gaged flows in Block 1 (< 21 cfs) maxed out at percentages between 60 and 70 percent, whereas the other two time periods had many days with flow reductions between 70 and 100 percent at very low flows. Also, it should be noted that when the baseline flow is very small (less than 10 or so cfs), so relatively small reduction in flow can result in large percentage changes.

The District report states there was a very dry spring in 2017, which is when most of the flows in Block 1 occurred within this seven-year period. During that dry spring, flows ceased completely for a brief period of time at the Clear Springs gage, which is located about a quarter of the way downstream from Bartow toward the Ft. Meade gage. The evidence indicates the Lake Hancock project is benefitting the low flows of the upper river, but the effectiveness of the project should be revisited in drier years or a series of years that have more prolonged dry conditions than what occurred in the 2016 to 2022 period.

Another way to evaluate the effectiveness of the minimum flows is to examine the number of days within each of the flow blocks that met the percentage flow reductions allowed by the proposed minimum flows listed in Table 4. This was approach was done only for the two more recent periods, as the values going back to 1975 would capture some groundwater conditions that no longer apply, as there has been some recovery of groundwater conditions in the region.

The values for the period from 2003 to 2018 are listed in Table 5, calculated for days when the gaged flows were within the various flow blocks. It is notable that during this period, which included some low flow years, the gaged flows in river at Ft. Meade were in the low flow Block 1 twenty-five percent of the time, which is quite a lot.

Block 2 is very important for the ecology of the river, as it based on habitats and communities that are in the river channel, which are closely related to the water levels and current velocities of the river. During this 16-year period, only 20% of the flows at Ft. Meade would have met the minimum flows in Block 2.

A total of 37% of the days in this period were in Blocks 3A and 3B, which correspond to flows that inundate the floodplain of the river. The percentages that the minimum flows were met were much higher for these blocks, at 70% for Block 3A and 100% for Block 3B. This is keeping with the data shown in Figures 1, 2, and 3 that the percent reductions in baseline flows are much less at high flows in the river. Finally, for all the blocks combined, basically all days in the period, the minimum flows were only achieved 40 percent of the time during this sixteen-year period.

Table 5. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of days within that block that the minimum flows were met at the Ft. Meade gage for the years 2003 to 2018. Values at the bottom are for all blocks combined.

	Flow range for each Block	Total number of days in block	Percent of total days within the block	Percent of days minimum flow met in the block
Block 1	< 21 cfs	1,457	25%	0%
Block 2	> 21 cfs and ≤ 120 cfs	2,179	37%	20%
Block 3A	> 120 cfs and ≤ 529 cfs	1,436	24%	75%
Block 3B	> 529cfs	772	13%	100%
All Blocks combined		5,884		40%

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As it was during a generally wetter period, the results for the period from 2016 to 2022 are much different (Table 6). The first very striking point is the smaller percentage of days in Block 1, which was partly due to climate, and possibly due operation of the Lake Hancock structure. However, the baseline flows only had 33 days in Block 1. As previously discussed, generally weather helps groundwater levels in the region, and most of the days in Block 1 in this period occurred in the spring of 2017, which was the driest stretch of time during this seven-year period.

Nearly half for the total number of days in this period occurred in Block 2, again demonstrating the importance of this flow block to the ecology of the river. The minimum flows were met only 30% of the time in Block 2, which clearly means the minimum flows oriented to the health of the river channel were not adequately met. As with the 2003 to 2018 period, the percentages of days that met the minimum flows were much higher for Blocks 3A and 3B, with 100 percent compliance in Block 3B. The minimum flows were met for 59% of all the days in this recent seven-year period, which is a surprisingly low number, given that it was a relatively wet period.

Table 6. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of days within that block that the minimum flows were met at the Ft. Meade gage for the years 2016 to 2022. Values at the bottom are for all blocks combined.

	Flow range for each Block	Number of days in the Block	Percent of total days within the Block	Percent of days minimum flow met withinin the Block
Block 1	< 21 cfs	37	1%	0%
Block 2	> 21 cfs and ≤ 120 cfs	1,197	47%	30%
Block 3A	> 120 cfs and ≤ 529 cfs	840	33%	81%
Block 3B	> 529cfs	483	19%	100%
All Blocks combined		2,557		59%

Collectively, the findings presented in this memo strongly suggest that it would be incorrect for the District to conclude in the minimum flows report that the minimum flows for the Ft. Meade gages are being met. As previously discussed, this also has application to the river near the Bartow gage, as withdrawals from that reach of the river would have to also comply with the minimum flow limits at Ft. Meade. I will likely add more perspective on this topic when I submit my final review comments on the draft report to the District, which I hope to do before the peer review meeting scheduled for February 6th.

Attachment C

Technical input prepared for the January 23rd meeting of the scientific review panel for the Upper Peace River minimum flows report

Document SF-1 on the minimum flows Webboard

S. Flannery #1 - Technical input prepared for the January 23rd meeting of the scientific review panel for the draft Upper Peace River minimum flows report

Submitted by Sid Flannery

Overview

Similar to my verbal comments to the scientific review panel on January 16th, 2026, this memo starts by discussing mathematical uncertainties in the modeling approach used to determine whether the Upper Peace River is currently meeting the proposed minimum flows. It also discusses how some graphics and tabular information presented in the draft District report, do or do not, indicate the proposed minimum flows for the Upper Peace River are currently being met. As will be discussed, it appears to me that the proposed minimum flows are not being met for much of the time at the Bartow and Ft. Meade gages. However, I suggest there is a technically sound approach for the minimum flows that can be pursued that would make water supplies available while minimizing impacts to the ecology of the Upper Peace River.

Mathematical approaches used in the modeling of baseline flows in the Upper Peace River that would result from reductions in groundwater withdrawals.

The Upper Peace River is a very complex system for the modeling of groundwater interactions with streamflow, in large part because of the extensive physical alterations to its watershed, particularly widespread phosphate mining as mined lands currently comprise 25% of upper river basin. Much of these mined lands are in very close proximity to the river, including large areas of clay setting ponds which have very little recharge to the Floridan aquifer and also disrupt localized groundwater flow to the river.

There have been large changes in groundwater use in the upper river basin, much of which occurred when water use records were not nearly as complete as today. Given these factors, for the modeling of changes in groundwater interactions with the river and the calculation of baseline flows, the Upper Peace River represents one of the most complex basins in the District.

The consultants who worked on the Peace River Integrated Model (PRIM2) made a series of assumptions and mathematical estimates that could be applied in the modeling process to estimate baseline flows. Section 5.4 in the District report describes three steps that were taken to facilitate the modeling used to estimate baseline flows the Upper Peace River corrected for the effects of groundwater withdrawals.

1. The PRIM2 model was run for existing groundwater pumpage rates and a 50 percent reduction in groundwater pumpage for the years 2003 to 2018. Daily streamflow values generated by the modeling were then averaged to monthly flow values within each of the simulation years.

2. The monthly differences in flows between these two scenarios where then doubled to estimate flows for no withdrawal conditions.

> Comment – It seems odd to assume that the effect on river flow between the 100% groundwater pumping scenario (existing withdrawals) and the 50% pumpage reduction scenario would be the same as the effect between the 50% reduction scenario and a complete elimination of withdrawals. The District claims the relationship between groundwater levels and streamflow is linear, but it seems that as groundwater levels become much higher with a complete elimination of withdrawals, in some areas rising above the bed of the river, the rate of streamflow increase would rise.

3. Because the PRIM2 model was only run for the years 2003 to 2018, adjustments were needed to simulate baseline flows for the desired period of 1975 to 2022. So, yearly adjustment rates were determined by dividing the estimated total groundwater use in each of the baseline years to average water use for the 16-year PRIM2 modeling period. These yearly adjustments were then applied to the average monthly adjustment factors for the PRIM2 modeling period, then these final factors were applied to the daily gaged record of the river to estimate daily baseline daily flows for the 1975 – 2022 period.

I don't know why the District wanted to have such a long period of baseline flows for the minimum flows analysis, as other minimum flows assessments have used shorter periods of record. Although it may have some attributes, the estimation of baseline flows going back nearly fifty years poses challenges which calls for some assumptions and adjustments. I think the three types of adjustments described above have considerable mathematical uncertainty and potential error, and the estimated long-term baseline flows using this method should be viewed as approximations.

The streamflow estimates for the 2003 to 2018 period that were directly modeled should be more accurate, but the Upper Peace River basin has experienced large physical alterations, including to its near surface geology in some areas, for which the effects on streamflow could be difficult to simulate.

As I said on January 16th, for evaluating the effects of human caused changes to flows in the Upper Peace River, these modeled changes in flows should be considered along with the data we have for flow trends in the river, the occurrence of karst features in the both the river channel and its floodplain, and the large physical alterations of the watershed including the widespread clay settling ponds many of which are very near the river. Declining flows in the Upper Peace River have been described by many studies, and all of these factors should be considered to determine if flows in the Upper Peace River have sufficiently rebounded from previous impacts and are now within the proposed minimum flows for the upper river.

The District report does provide some useful graphics of the modeled baseline flows versus the gaged flow records for the river that are helpful for assessing this question. A hydrograph for the Ft. Meade gage taken from Figure 5-9 in the draft District report is reprinted below, showing median flow values for each day of the year for both the modeled baseline flows and the gaged flows for the river at that site.

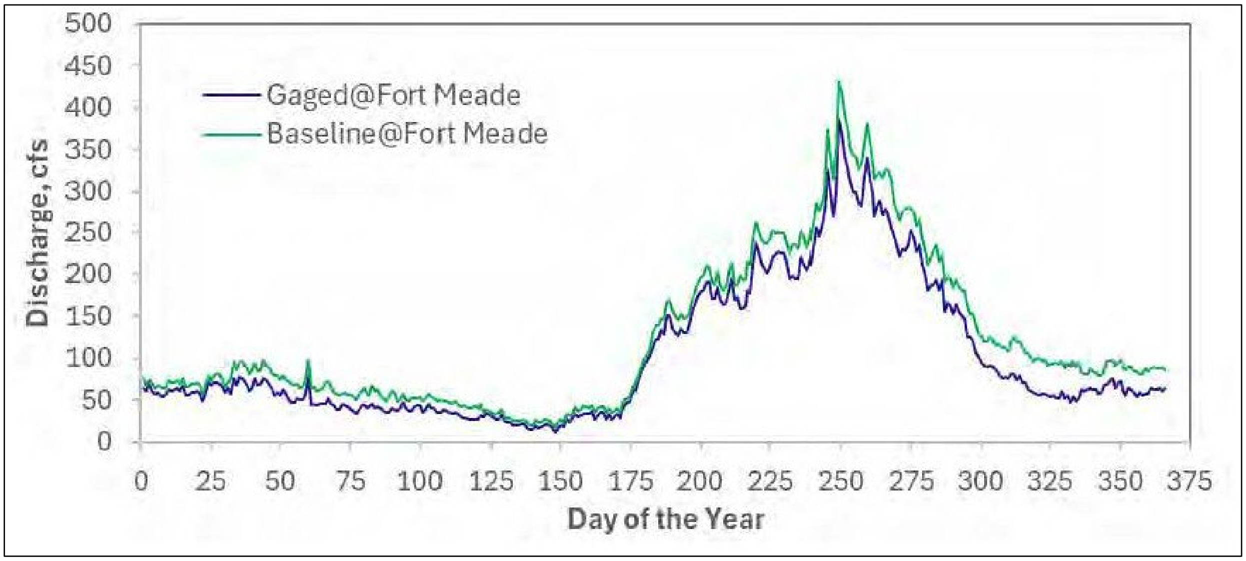

Figure 1. Median daily flows for the baseline flows and the gaged flows for the Peace River at Ft. Meade gage calculated for the years 1975-2022. Taken from Figure 5-9 in the draft District report.

From this graphic it appears that at least for daily median flow conditions, the gaged flows at Ft. Meade are already below the baseline flows more than the proposed minimum flows would allow for much of the year. For example, the proposed minimum flows at Ft. Meade allow for a 12% flow reduction at flows between 21 and 120 cfs, and a 10% reduction at flows between 120 and 529 cfs. For many of the days it appears the difference between the daily median baseline flows and the median gaged flows exceed these percentages.

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Other useful graphics in the draft District report are flow duration curves for baseline flows and gaged flows. Figure 6-6 for the Ft. Meade gage taken from the District report is shown below. The Y axis is on a semi-log scale, so additional tic marks and cross hatching in the figure would be helpful to identify the flow quantities. However, for much of the flow range it appears that gaged flows are less than the baseline flows by amounts exceeding the percentages allowed by the proposed minimum flows. In my final review of the report, I am going to request that the scale for the Y axis in this figure be improved and flow percentiles values for these two flow scenarios be reported in a table in five percentile increments.

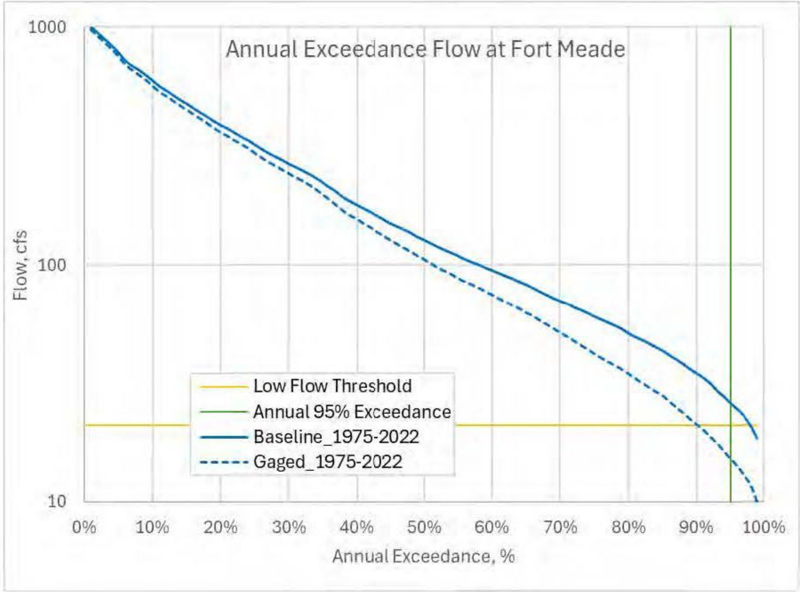

Figure 6-6. Annual exceedance flow for the USGS Peace River gage at Fort Meade for the periods 1975-2022, comparing baseline and gaged flows in relation to the low flow threshold.

Given these results and what is widely known about the physical alterations and impacts to flows in the Upper Peace River that have been reported in previous studies, I think the statement by the District that the Upper Peace River is meeting its minimum flows at the Bartow and Ft. Meade gages is not supported by the material presented in the report.

In that same regard, the material presented in Chapter 7 (Minimum Flows Status Assessment, Implementation, and Conclusions) is much too brief as this chapter is only two pages long. On page 233 It contains a three-sentence paragraph that states that the recommended minimum flows for the upper river are currently being met, with the first two sentences reprinted below.

> “Table 5-6 presents estimated monthly adjustment flows due to withdrawal-related effects over a 16-year assessment period. Collectively, these findings indicate the recommended minimum flows for the Upper Peace River are currently being met.”

Table 5-6 referred to in this paragraph is reprinted below. First, the heading of the table is unclear and needs to be revised. However, the text on page 179 states these are the monthly adjustment rates for a zero-pumping condition (baseline flows) for the modeling period from 2003 to 2018. As described earlier, these values were based on doubling the differences between the 100% (existing) and 50% pumping reduction scenarios, which I think may underestimate the true adjustment rate.

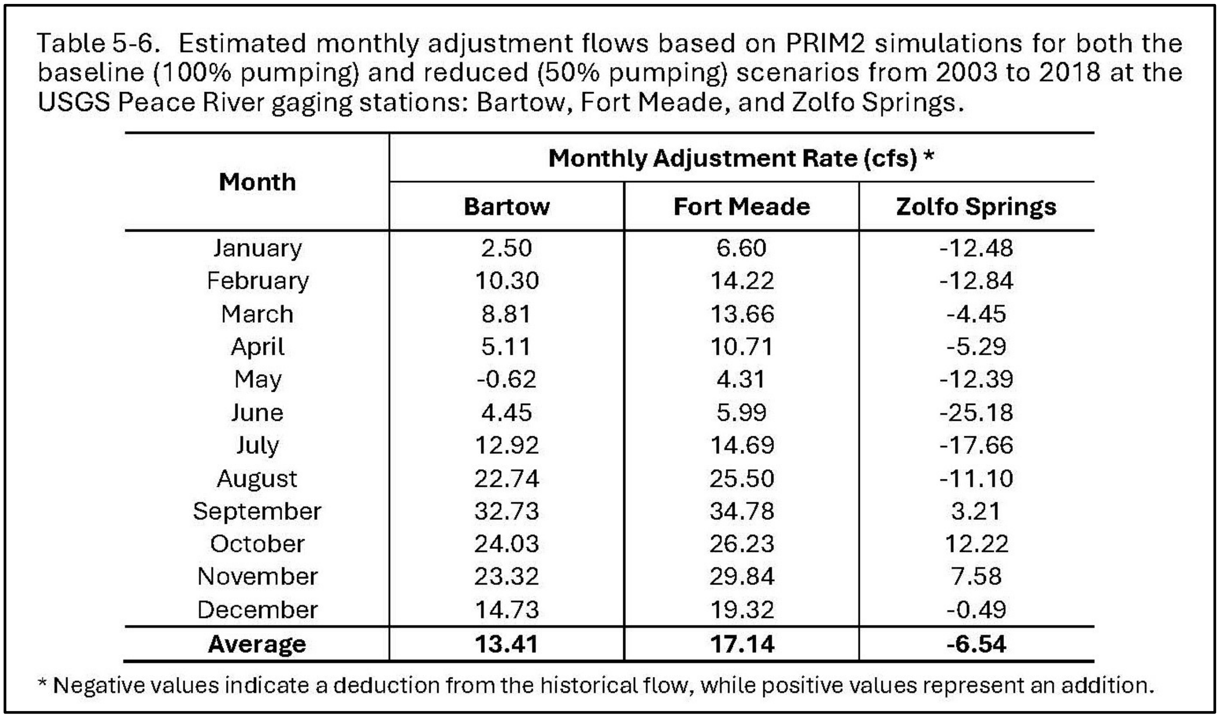

Table 5-6. Estimated monthly adjustment flows based on PRIM2 simulations for both the baseline (100% pumping) and reduced (50% pumping) scenarios from 2003 to 2018 at the USGS Peace River gaging stations: Bartow, Fort Meade, and Zolfo Springs.

Month	**Monthly Adjustment Rate (cfs) ***		
	Bartow	**Fort Meade**	**Zolfo Springs**
January	2.50	6.60	-12.48
February	10.30	14.22	-12.84
March	8.81	13.66	-4.45
April	5.11	10.71	-5.29
May	-0.62	4.31	-12.39
June	4.45	5.99	-25.18
July	12.92	14.69	-17.66
August	22.74	25.50	-11.10
September	32.73	34.78	3.21
October	24.03	26.23	12.22
November	23.32	29.84	7.58
December	14.73	19.32	-0.49
Average	**13.41**	**17.14**	**-6.54**

* Negative values indicate a deduction from the historical flow, while positive values represent an addition.

Whether these are underestimates or not, the values in this table indicate that the minimum flows at the Bartow and Ft. Meade gages are not being met for much of the year. For example, the amount of flow reduction allowed in the medium flow block in the proposed minimum flow rule for the Ft. Meade gage is 12% at flows between 21 and 121 cfs. The median flow at Ft. Meade for this same 16-year period was 70 cfs or midway in this range. How can the yearly average flow adjustment of 17.14 cfs for Ft. Meade at the bottom of Table 5-6, which equals 24% of the median flow for the river at the Ft. Meade gage during that period, not result in flow reductions greater than the minimum flows for much of the year.

Similarly, the median flow for March at Ft. Meade during that period was 30 cfs. How can an average flow adjustment of 13.66 for March not greatly exceed the allowable flow reductions during that month for much of the time. The middle flow range is used as an example, and exceedances of the allowable flow reductions in the higher flow ranges at Ft. Meade (10 and 7 percent) probably frequently occur as well.

In sum, the legend for Table 5-6 is unclear, but more importantly, the rationale that the values in this table support the statement that the Upper Peace River is meeting its minimum flows is either flawed or needs more explanation. At this time, I don't think the results provided in this report indicate the proposed minimum flows for the Upper Peace River are being met at the Bartow and Ft. Meade gages.

Management applications

On a related note, how would the information presented in Table 5-6 be used to regulate new withdrawals from the Upper Peace River and determine new allowable percentage withdrawals that account for the existing flow reductions in the river. As the report points out on page 17, the percent-flow-approach is currently used to regulate large withdrawals on three rivers in the District; the Lower Peace, the Lower Alafia and the Little Manatee Rivers. The percent-of-flow approach has been widely viewed as success, using a progressive method to meet water supply and also protect the environment. By the way, I worked extensively on the ecological and hydrologic justification and regulatory limits for applying the percent-of-flow approach on these rivers.

In all of these of three rivers, the daily withdrawals are based as a percentage of the preceding day's flow at a nearby gage, which as the report correctly points out, is how percent-of-flow approach is supposed to be applied. Based on the findings presented in the draft report, it is unclear how the District would determine allowable percentage withdrawal schedules for new water users based on flows at the Bartow or Ft. Meade gages, but a method could be derived, possibly using a ratio of gaged flows to baseline flows.

An alternative, technically sound plan for the minimum flows and water supply on the Upper Peace River

I believe there is a reasonable, technically sound solution to the determination and application of minimum flows for the Upper Peace River. In 2018, I submitted to the District a report I prepared that evaluates a watershed based approach for obtaining water supplies from the Peace and Alafia Rivers. This report was uploaded to the District minimum flows webboard along with this technical memorandum (S. Flannery #2- Report, Watershed based approach for withdrawal sites on the Peace and Alafia Rivers).

That report points out that as the Peace River progresses downstream from Ft. Meade, the impacts to flows proportionately diminish, the flow regime of the river greatly improves, the morphology of the river and floodplain change, and potential for obtaining water supplies from the river without causing significant environmental harm increases.

The District report cites my report and on pages 64 to 67 presents updated flow statistics for gages on the Upper Peace River similar to the information that I presented. In relation to using the Upper Peace River for water supply, Table 2-9 in the District report lists the median flow at Zolfo Springs at 250 cfs, compared to 78 cfs at Ft. Meade and 56 cfs at Bartow. To maximize both water supply yields and environmental protection, it makes sense to obtain water supplies from the Upper Peace close to Zolfo Springs.

Again, I don't think the data and information presented in the District report indicate the Upper Peace River is meeting the proposed minimum flows at the Bartow and Ft. Meade gages. Knowing the extensive physical changes and impacts in the northern reaches of Upper Peace River, I believe that any new withdrawals should not be allowed in those reaches of the river.

This is supported by what appears to be a technically sound conclusion that the river reaches associated with the Bartow and Ft. Meade gages are not meeting their proposed minimum flows. Conversely, new withdrawals could be considered near the Zolfo Springs gage. I suggest that the findings provided in the District report actually support this conclusion and the report could be revised accordingly, as this would be a much better application of the minimum flows for the Upper Peace River.

Attachment D

Verbal comments presented to the January 30th meeting of the scientific review panel for the Upper Peace River minimum flows report

Document SF-5 on the minimum flows Webboard

SF-5 Verbal comments presented to the January 30, 2026 meeting of the Upper Peace River minimum flows scientific review panel by Sid Flannery

This morning the District uploaded to the minimum flows WebBoard five documents I hope you will review. Two of these documents were previously uploaded to the WebBoard, but they were uploaded again today to make them easy to find along with the three new documents.

Four of these documents focus on the Ft. Meade gage, as it is the key index station for establishing minimum flows for the northern reaches of the Upper Peace River, as any new withdrawals near Bartow would also have to comply with the minimum flow limits at Ft. Meade.

Document 1 discusses two hydrographs presented in the draft District report that I think indicate the minimum flows are not being met at Ft. Meade for significant amounts of time. It also disagrees with the statement on page 233 in the minimum flows report, that states that Table 5-6 in the report indicates that the minimum flows for the Upper River are being met. Document 1 also questions the assumption that there is linear rate of increase in the relationship between groundwater levels and streamflow in the PRIM modeling approach.

Document 2 is a transcript of the verbal comments I had hoped to give at last week's peer review meeting that got canceled.

Document 4 is particularly important, for on Monday I requested from the District, records for the baseline and gaged flows for three USGS gages that they analyzed for the minimum flow report. Using those data, Document 4 contains graphical and statistical analyses of the amount of time the gaged flows at Ft. Meade have been within the flow reduction limits specified in the proposed minimum flows. As that document demonstrates, the minimum flows are not being met for significant periods of time at the Ft. Meade gage, and I think it is incorrect for the District to claim the minimum flows are being met in that reach of the Upper Peace River. I do think the minimum flows are being met at the Zolfo Springs gage. I hope you read all of these documents, but document 4 is particularly critical.

Document 5 is simply the written transcript of what I am saying to you today, in case you want to consult it as a guide to these documents.

Finally, Document 3 is a report that I wrote and submitted to the District in 2018, which examines flow quantities and trends in the Peace River and discusses human impacts to flows in the Upper Peace River. That report presents a technically sound approach for the establishment of minimum flows in the Peace River, for although flows in the northern reaches of the Upper Peace River have been highly impacted, the flow regime of the river greatly improves as you proceed downstream from Ft. Meade, and new withdrawals in compliance with minimum flows could be obtained near Zolfo Springs.

Again, I don't think the minimum flows are being met in the reach of the river near Ft. Meade and Bartow, and a credible position needs to be taken on this matter in order to properly manage the natural resources of the Upper Peace River and apply the percent-of-flow method, which the District has worked on very conscientiously for a long time to develop and implement.

Attachment E

Verbal comments presented to the January February 6th meeting of the scientific review panel for the Upper Peace River minimum flows report

Document SF-9 on the minimum flows Webboard

SF – 9 Verbal comments presented to the scientific review panel for the draft Upper Peace River on February 6, 2026

Submitted by Sid Flannery

This morning, the District uploaded to the minimum flows WebBoard four short documents that I hope you can review. The first, labeled Document SF-6, is a technical memo I prepared that covers two topics. The first is the period after 2016 when the Lake Hanock project became operative, was fairly wet, which benefitted how well the Upper Peace River met the existing, low minimum flows. The other analyses presented in document 7 clearly show that the upper river is meeting the minimum flows at the Zolfo Springs gage.

The second document labeled SF-7 is my technical review of the District report at this time. It covers just a few important topics, including one that I want to quickly mention today. That is much more information needs to be presented in the District report on how much water is contributed from Lake Hancock to the upper river, both at structure P-11, and discharges into and out of the treatment wetland associated with the lake.

Document eight also briefly revisits the critical subject of whether the upper river meeting its minimum flows at the Ft. Meade gage. It includes as appendices, two documents I prepared that were posted on the Webboard last Friday, which clearly shows the minimum flows are not being the majority of time at the Ft. Meade gage, including a very large majority of time at critical low and medium flows.

In that regard, I want to share a few thoughts on the proper application of the percent-of-flow method with you today. Based on extensive data collection and research, the District's development and application of the percent-of-flow method goes back to the late 1980s

Document SF-8 is a journal article I wrote along with a professor from the University of South Florida and a consultant who did considerable work on the Lower Peace River. That article, which was published in 2002, describes the conceptual and practical application of the percent-of-flow method. I hope you can read the abstract, which describes the approach that is still be applied today.

It also provides case examples from three rivers where the percent-of-flow method is currently being applied to major water supply withdrawals; which are the Alafia, the Little Manatee, and the Lower Peace River. I was directly involved in the scientific evaluation and regulatory application of those permitted withdrawals, and can tell you that the hydrologic analyses, water supply simulations, regulatory limits, and the assessment of the withdrawals on the rivers' ecology all involved assessing changes in flows on a daily basis as a function of flow. It was not as if changes in flows were assessed on an average monthly or average yearly basis to assess compliance.

At this time, the analyses presented in the draft District report are not adequate to demonstrate the minimum flows for the Upper Peace River are being met. My document number 1, which that was reposted to the WebBoard last Friday, makes the point that the reference to Table 5-6 on page 233 in the summary chapter of the draft report is way off base in making the claim that the minimum flows are being met. In fact, there is very little evidence presented in the District report that demonstrates that the minimum flows are being met using standard criteria.

Instead, the analyses that were uploaded to the WebBoard last Friday as part of my document SF-4, show the flows at Ft. Meade have been reduced beyond the minimum flow limits a large majority of the time over most of the flow regime of the river. The minimum flows at Ft. Meade are being at high flows, above about 200 cfs, but they would be available for withdrawal only about 30% of the time on average, probably making them impractical for water supply.

I did not have time to analyze the data for the Bartow gage, but they would probably behave similarly, and if the minimum flows are not being met at Ft. Meade, that would preempt any upstream withdrawals near Bartow. Again, my document number 6, which was uploaded today, shows that the minimum flows are being met at the Zolfo Springs gage.

In that regard, these technically sound findings represent good water management, in that much greater water supplies are available at Zolfo Springs due to the much greater flow volumes there. For example, the median flow at Zolfo Springs over the last 30 years was 239 cfs compared to 78 cfs at Ft. Meade.

Finally, any apprehension about the need for possible additional recovery strategy measures for the Upper Peace River should not prohibit the District from making technically valid conclusions about whether the minimum flows are being met. The District has implemented the Lake Hancock project and I am sure the State of Florida and the District Governing Board would be reasonable in determining if any further recovery steps are needed.

A written transcript of the comments I have presented today were uploaded to the Webboard as document SF-9, and I hope the review panel will continue to monitor the Public Domain link on the WebBoard over the next couple of weeks, to see if I or any others contribute new material related to the minimum flows for the Upper Peace River.

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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 geomorphological and ecological characteristics of rivers (Hill et al. 1991; Poff et al. 1997; Richter et al. 1997). There is also evidence that naturally occurring patterns of freshwater inflow are important for maintaining the structure and productivity of estuarine ecosystems. Suspended sediments transported by periodic pulses of high river discharge are a major factor controlling the geomorphological structure of river deltas and bays (Kennish 1986; Jay and Simenstad 1996; Day et al. 1997). The productivity of coastal fisheries is positively related to freshwater inflow (Browder 1985; Drinkwater 1986; Day et al. 1989), and alterations to inflow regimes have caused dramatic declines and recoveries in fish stocks (Moyle and Leidy 1992; Mann and Lazier 1996; Sinha et al. 1996). Significant relationships have been found between fishery yields of estuarine-dependent species and preceding freshwater inflow terms calculated over 2-mo or 3-mo intervals, indicating that the seasonality of inflow can have a significant effect on fish abundance (Browder 1985; Longley 1994). Wilber and Bass (1998) also found that oyster harvests were negatively correlated with the number of low-flow days that occurred 2 yr prior, indicating that alteration of one component of a flow regime can have an effect on a specific stage of an organism's life history.

As groundwater sources reach their sustainable limits in southwest Florida, there is growing emphasis on using rivers for water supply. Many major rivers in Florida are not impounded and have not been used for water supplies in the past (Jue 1989; Fernald and Purdum 1998). Based on a series of studies of the freshwater inflow relationships of estuaries in the region, the Southwest Florida Water Management District (SWFWMD) has implemented a management approach for unimpounded rivers that limits withdrawals to a percentage of streamflow at the time of withdrawal. This approach considers the natural flow regime of a river to be the baseline for assessing the effects of withdrawals. Trends in various streamflow parameters

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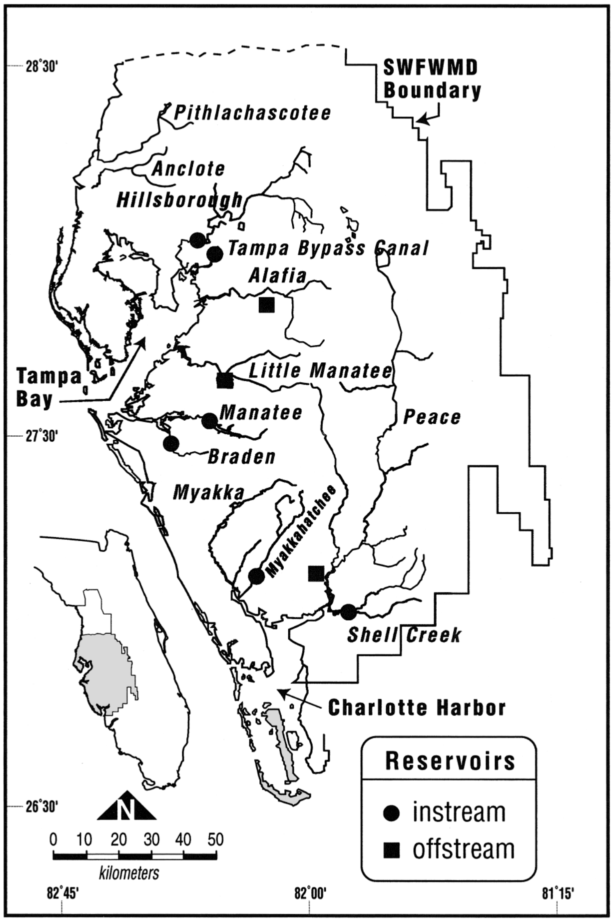


Fig. 1. Location of rivers in the Southwest Florida Water Management District extending from the Tampa Bay area to Charlotte Harbor, including the location of instream and offstream reservoirs used for water supply.

are evaluated to determine if any components of a river's flow regime have changed. Estuarine relationships with freshwater inflow are then examined within seasons and flow ranges in order to determine percentage withdrawal limits that do not result in adverse environmental impacts. We review the theoretical and empirical framework on which the percent-of-flow approach is based and describe how it is applied in the water management setting. Analyses supporting this approach have emphasized hydrobiological relationships within tidal-river zones of larger estuarine systems in southwest Florida. Representative findings from these tidal rivers are reviewed to illustrate key ecological relationships and applications to the management of freshwater inflow.

Hydrologic Setting of the Region

West-central Florida contains 14 named rivers and numerous small streams that flow to the Gulf of Mexico. The flow regimes of several rivers north of Tampa Bay are dominated by groundwater discharges from large artesian springs, whereas flows in rivers from just north of Tampa Bay southward (Fig. 1) are dominated by surface runoff (Estevez et al. 1991). The region receives an average rainfall of about 1.35 m yr^{-1} with about 60% occurring from June through September. The temporal variability of streamflow in spring-fed rivers is typically more subdued than seasonal variations in rainfall, while average monthly flows in rivers dominated by surface runoff exhibit greater seasonal variability than monthly rainfall (Fig. 2). In rivers dominated by surface runoff, low flows occur in April and May when rainfall is low and potential evapotranspiration rates are increasing (Bidlake and Boetcher 1997; Lee and Swancar 1997); peak flows typically occur in August or September when depressional storage is full and water tables are high. The interaction of this seasonal streamflow pattern with estuarine processes forms the hydrobiological setting for managing freshwater inflows in these systems.

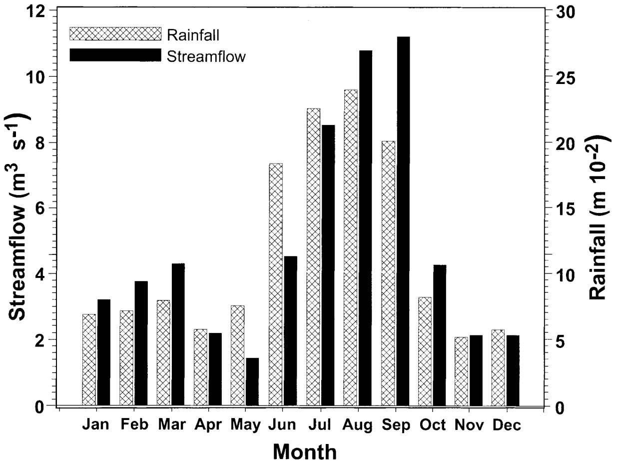


Fig. 2. Mean monthly rainfall at Bradenton, Florida and streamflow (U.S. Geological Survey gauge 02300500) for the Little Manatee River basin for the period 1940–2000.

Detecting Changes in Inflow from Unimpounded Rivers

The water supply planning and regulation programs administered by the SWFWMD are designed to maintain the physical structure and ecological characteristics of the region's unimpounded rivers. Municipal water supplies are obtained from five instream impoundments in southwest Florida (Fig. 1), including major reservoirs on the Hillsborough and Manatee Rivers and small, low-head structures that serve as salinity barriers on three smaller streams (Braden River and Shell and Myakkahatchee Creeks). Water supplies are also obtained from the Tampa Bypass Canal, which is a regulated flood control waterway that was constructed in the channel of the Palm River. With the exception of the Tampa Bypass Canal, all of these impoundments were constructed before 1965. Since the mid-1970s, the SWFWMD (1992, 2001b) has emphasized the use of alternative water storage methods for the development of water supplies from unimpounded rivers in order to avoid impacts to riverine systems that can result from impoundment (Petts 1984; Ligon et al. 1995; Collier et al. 1996). Water supply storage from unimpounded rivers has been achieved using offstream reservoirs, which are diked or excavated areas located away from the river channel, and aquifer storage and recovery facilities, in which treated surface waters are pumped into underground aquifers for storage and subsequent retrieval.

The initial step for evaluating potential withdrawals (and resulting reductions in freshwater inflow) from an unimpounded river involves the assessment of historical changes in the river's flow regime. Many factors, such as changes in land use or surface water-groundwater relations in a river basin, can affect flow regimes in the absence of impoundment or direct withdrawals (Newson 1994; FISRWG 1998). Richter et al. (1996) developed a series of quantifiable indicators of hydrologic alteration that can be used to evaluate trends in different components of a flow regime over time. Another useful technique for evaluating changes in low or high flows is trend analysis of daily flow percentiles within each year (Lins and Slack 1999). Using one or more of these hydrologic indicators, historical streamflow records are evaluated to identify trends in different components of a flow regime or changes in seasonal flows. If changes have occurred, analytical effort is directed toward distinguishing the relative effects of climatic variability and anthropogenic influences, which can occur either as distinct events or as gradual changes through time. A series of hydrologic studies have been conducted on the three unimpounded rivers in southwest Florida that are currently allocated for water supply (Peace, Alafia, and Little Manatee; see Fig. 1) in order to assess trends in long-term flows (Hammett 1990; Flannery et al. 1991; Flannery and Barcelo 1998; SDI Environmental Services 1998), seasonal flows (Flannery et al. 1991; Coastal Environmental 1996a), low and high flows (Flannery et al. 1991; Stoker et al. 1996; Flannery and Barcelo 1998), and to compare the effects of anthropogenic influences and climatic variability on streamflow (Hammett 1990; Coastal Environmental 1996b; Flannery and Barcelo 1998; SDI Environmental Services 1998). The findings of these studies have been used to help define the baseline flow regime against which projected withdrawals and potential ecological effects are evaluated.

Defining Interactions Between Stationary and Dynamic Features in Tidal Rivers

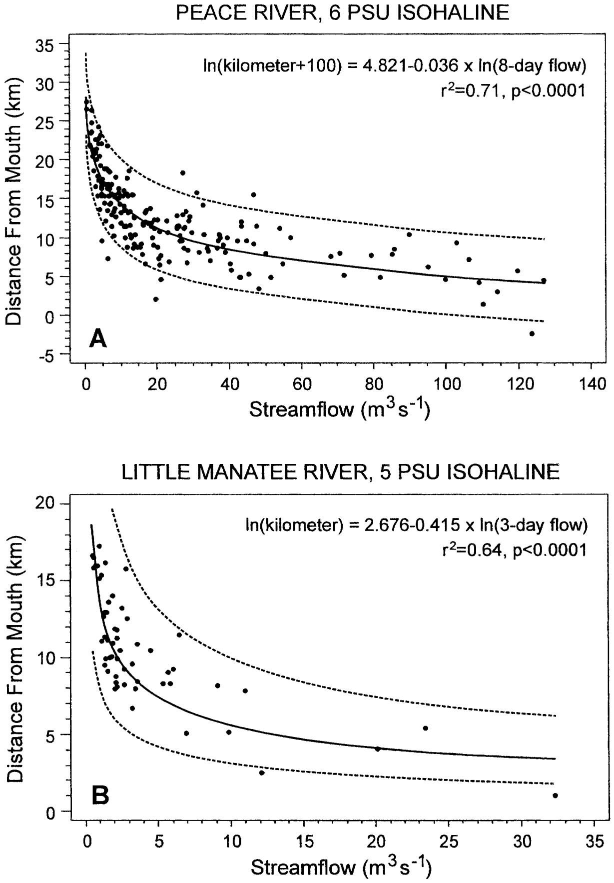
The SWFWMD's approach to evaluating estuarine responses to freshwater inflow has been based on a series of literature reviews, workshops, and field studies that have been conducted since the mid-1970s. Two years after being delegated the authority to manage consumptive water use, the SWFWMD sponsored a literature review of the role of freshwater inflow in estuarine systems (Snedaker et al. 1977) and a workshop on the relationships of freshwater inflow to the resources of the Florida coast (Seaman and McLean 1977). A few years later, the proceedings of a national symposium on freshwater inflow to estuaries (Cross and Williams 1981) produced many valuable papers, including one by Browder and Moore (1981), who suggested that fishery recruitment is maximized when there is optimal overlap between stationary and dynamic habitats (i.e., salinity). Stationary components of estuarine habitat include features associated with the geomorphological structure of an estuary plus biological features, such as oyster reefs and tidal wetlands, that change relatively slowly over periods of years. Dynamic components of estuarine habitat include characteristics that can change rapidly as a function of freshwater inflow, such as circulation patterns, turbidity maxima, salinity distributions, and dissolved oxygen concentrations. Biological processes that move within the estuary in response to freshwater inflow can also be considered part of the dynamic component of estuarine systems. The management strategies employed by the SWFWMD are oriented to the conceptual model of Browder and Moore (1981), as the withdrawal of freshwater can move dynamic components away from what are structurally the most productive regions of an estuary.

The stationary components of estuarine habitats have been characterized by mapping and quantifying the distribution of important physical features in tidal rivers such as estuarine volume, the area of deep and shallow habitats, shoreline length, and the area of contiguous wetlands. Salinity distributions are then superimposed over these features to derive the area or volume of habitats within various salinity zones (Peebles and Flannery 1992; Estevez and Marshall 1997; PBS&J 2001). The distribution and salinity relations of tidal wetlands have been emphasized due to the important functions these communities have with regard to habitat structure and the abundance of fish and wildlife associated with estuaries (Odum et al.

1984; Lewis et al. 1985; Coultas and Hsieh 1997). The Florida Marine Research Institute (1997, 1999) used aerial imagery to map the distribution of major wetland communities within tidal freshwater, brackish marsh, salt marsh, and mangrove zones in seven rivers for which salinity data were available. Clewell et al. (2002) investigated the relationships of salinity distributions to plant species composition at 462 shoreline sites in these tidal rivers.

Other investigations of relationships between largely stationary ecological features and freshwater inflow have involved the distribution of mollusk populations and macroinvertebrate communities associated with oyster reefs. Mote Marine Laboratory (2001a) compared the distribution of live and dead mollusk shells in the Peace River and found that as a severe drought progressed, living shells aligned with relict shell footprints, reflecting the effect of periodic droughts on mollusk distributions. Sprinkel (1986) sampled oyster reefs extending off the mouths of four spring-fed rivers and found that the largest oysters were at inshore reefs where mean salinity values were in the range of 11 to 16 psu. On these same rivers, Gorzelany (1986) found there was greater similarity (Morisita's index) among macroinvertebrate communities associated with inshore oyster reefs from different rivers than among communities from inshore, middle, and offshore reefs from the same river.

To address the dynamic component of estuarine systems, a series of studies of the salinity characteristics of tidal rivers in west-central Florida was initiated in the late 1970s, including several that developed regression models to predict the locations of various isohalines as a function of freshwater inflow. These studies indicated that isohalines respond to freshwater inflow in a largely linear manner in five spring-dominated rivers north of Tampa Bay (Yobbi and Knochemus 1989a,b), but respond in a curvilinear manner in seven rivers dominated by surface runoff located farther south (Giovannelli 1981; Stoker et al. 1989; Fernandez 1990; Hammett 1992; Peebles and Flannery 1992; Coastal Environmental 1996b; Estevez and Marshall 1997; Janicki Environmental 2001). The shape of the relationship between isohaline location and freshwater inflow for the Peace and Little Manatee Rivers is typical of this southern region, in that relatively small reductions in freshwater inflow during the dry season can result in dramatic upstream movement of isohalines (Fig. 3). This characteristic response is due to the funnel shape of these tidal rivers, in which the cross-sectional area and volume of the estuary increase rapidly with distance downstream.


PEACE RIVER, 6 PSU ISOHALINE

LITTLE MANATEE RIVER, 5 PSU ISOHALINE

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 curvilinear response of isohaline locations to freshwater inflow was a principal finding used by SWFWMD to develop the percent-of-flow approach for managing withdrawals. Limiting withdrawals to a fixed percentage of streamflow results in relatively small isohaline movements (< 0.8 km) at low, medium, and high inflows (Table 1), preventing major changes to salinity distributions throughout the year. Although isohaline movements for a given percentage flow reduction may be slightly greater at low inflows, the reduction in water volume within a given salinity zone (e.g., < 5 psu) may be greater at higher inflows due to the isohalines being located in a broader region of the estuary. Since the percent-of-flow approach was first implemented, the SWFWMD has emphasized the development of hydrodynamic models to simulate salinity distributions in tidal river estuaries, including the Manatee (Camp, Dresser and McKee, Inc. 1995), Hillsborough (Chen et al. 2000),

TABLE 1. The locations and upstream movements of low-salinity surface isohalines in four rivers in response to 10% reductions of streamflow at flows equal to the 10th, 50th, and 90th percentile flows in the long-term streamflow records. Locations were predicted using regressions developed for the Peace (Janicki Environmental 2001), Myakka (Hammett 1992), Little Manatee (Peebles and Flannery 1992), and Anclote Rivers (Fernandez 1990).

River	Isohaline (psu)	Location + Upstream Movement (km from River Mouth)		
		10th Percentile	50th Percentile	90th Percentile
Peace	6	18.39 + 0.45	12.76 + 0.43	5.69 + 0.41
Myakka	0.5	33.95 + 0.55	21.64 + 0.35	16.18 + 0.26
Little Manatee	5	17.67 + 0.79	11.35 + 0.51	5.57 + 0.25
Anclote	5	14.37 + 0.18	12.47 + 0.18	7.54 + 0.18

Alafia (Chen 2001), and Palm (Myers et al. 2002) Rivers.

Primary Production as a Management Criterion

Phytoplankton populations are among a suite of parameters than can be considered to be dynamic habitat components, as their abundance and distribution can respond quickly to changes in freshwater inflow. To investigate the influence of freshwater inflow on abundance and distribution of phytoplankton, a suite of parameters including chlorophyll *a* (chl *a*) and phytoplankton species counts has been collected at four surface isohalines (0.2 or 0.5, 6, 12, and 18 or 20 psu) in the Peace, Little Manatee, and Alafia Rivers (Vargo et al. 1991; PBS&J 1999a; SWFWMD 2002b). With the exception of the Little Manatee, where chl *a* concentrations were highest near the boundary with tidal freshwater (0.5 psu), mean chlorophyll values were greatest and concentrations most variable at the 6 and 12 psu isohalines, whereas lower values typically occurred in higher salinity waters (Table 2).

The most extensive data for examining phytoplankton response to freshwater inflow are from the Peace River, where phytoplankton production (^{14}C uptake) and chl *a* have been monitored monthly since 1984, with taxonomic cell counts conducted since 1988 (PBS&J 1999a). McPherson et al. (1990) concluded that maximum phytoplankton production and biomass in the Peace River and Charlotte Harbor estuarine system occurs in mid-salinity zones, where freshwater inflow increases the availability of nutrients, but organic color of riverine origin is diluted, allowing for increased light penetration. There is also a positive response to water temperature and presumably photoperiod, as the highest monthly mean values for chl *a* tend to occur in warm waters with moderate amounts of color (PBS&J 1999a). Monthly mean chl *a* concentrations generally increase with water temperature from February through April, but decline or are relatively stable during May and June (Fig. 4). Freshwater inflow typically declines from April through mid-June, reducing nutrient delivery from the watershed. As inflow and nutrient loads increase during the summer rainy season, chl *a* values increase at the 6, 12, and 20 psu isohalines.

These data indicate that reductions of inflow and nutrient loading during the spring dry season could act to limit phytoplankton biomass in the tidal river. Because isohaline locations are sensitive to movement during periods of low inflow, reductions in freshwater inflow during the springtime could move areas of maximum phytoplankton abundance farther upstream with implications for secondary production. Depending on dry-season nutrient loads, increased residence times resulting from reductions in freshwater inflow could act to increase phytoplankton biomass in zones of a tidal river (Ingram et al. 1985; Vallino and Hopkinson 1998). Current SWFWMD efforts are directed toward better defining the roles of light penetration, nutrient loading, and residence time in controlling phytoplankton abundance in tidal rivers in the region, including the highly eutrophic Alafia.

Fish Nursery Use as a Management Criterion

An important component of the SWFWMD's management approach to tidal rivers has involved the response of zooplankton, benthic macroinver-

TABLE 2. Mean (± standard deviation) and number of surveys (n) for chlorophyll *a* concentrations (μg L^{-1}) at four surface isohalines in the Peace, Alafia, and Little Manatee Rivers. Values for the 0.2 and 20 psu isohalines in the Peace River are listed with the 0.5 and 18 psu isohalines, respectively (data from Vargo et al. 1991; PBS&J 2001; SWFWMD 2002b).

River	n	Isohaline (psu)			
		0.5	6	12	18
Peace	208	9.6 (11.2)	23.7 (27.4)	23.3 (32.5)	12.7 (18.8)
Alafia	24	13.1 (15.7)	78.7 (135.2)	106.0 (163.6)	47.2 (41.1)
Little Manatee	28	22.1 (14.9)	15.9 (8.6)	10.7 (8.4)	5.6 (2.0)

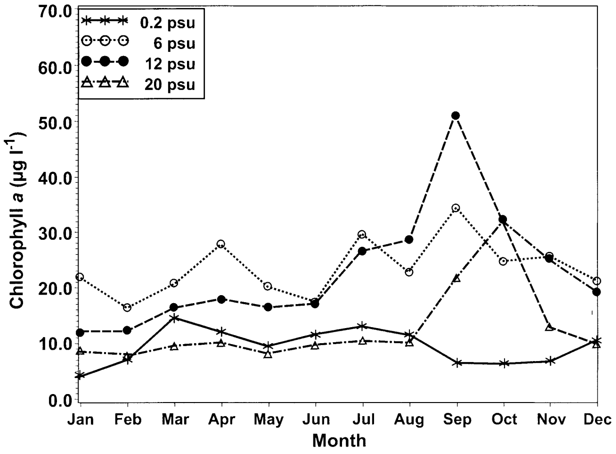


Fig. 4. Monthly mean concentrations of chlorophyll *a* at four surface isohalines in the lower Peace River for the period 1984–2000 (data from PBS&J 2001).

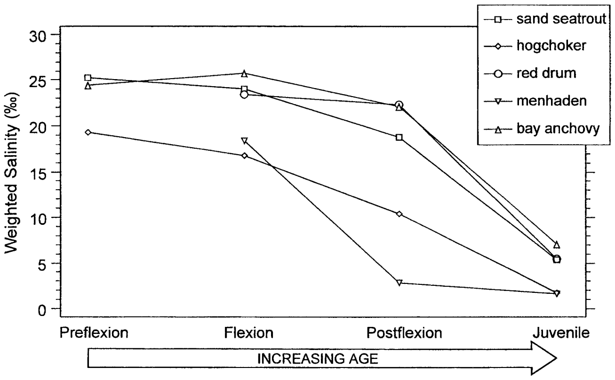


Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

tebrates, and fishes to freshwater inflow. These studies have been primarily directed toward young or short-lived organisms, particularly the estuarine-dependent fishes that use tidal rivers as juvenile nursery habitat and the prey organisms that these fishes depend on while occupying such habitats. Because tidal-river habitats are small and are directly affected by watershed runoff, the potential for an inflow-related influence on fish recruitment success would appear to be strong. Juvenile estuarine-dependent fishes are generally described as being seasonal migrants (Merriner et al. 1976; Peters and McMichael 1987; McMichael et al. 1989; Barry et al. 1996; Livingston 1997), which is a status that subjects them to inflow variations at subannual time scales.

Rast et al. (1991) found that most zooplankters have peak densities in the downstream, higher-salinity reaches of the Little Manatee River, making them abundantly available as prey for the early life stages of fishes that are spawned near the mouth of the river or migrate there from more seaward locations. Within the tidal river, larval fishes tend to be most abundant near this downstream zooplankton maximum (Peebles and Flannery 1992). As the larvae develop into juveniles, a number of species move into areas of reduced salinity in the interiors of the tidal rivers (Fig. 5). This estuarine-dependent life history pattern is associated with growth-related diet shifts, such as the shift from copepods and other zooplankton to bottom-dwelling organisms, notably mysids, amphipods, and deposit-feeding invertebrates in general (Peters and McMichael 1987; McMichael and Peters 1989; McMichael et al. 1989; Barry et al. 1996; Peebles 1996). Deposit-feeding invertebrates have been observed to be abundant within organically enriched regions of the upper estuary, both locally (Mote Marine Laboratory 2001a,b; Grabe et al. 2002) and elsewhere (McBee and Brehm 1982; Holland et al. 1987; Gaston and Nasci 1988).

Phytoplankton biomass is often maximal either within or immediately upstream of the organically enriched oligohaline and mesohaline areas that are used as juvenile fish nursery habitat (Table 2; Fig. 4). Some species, such as menhaden, appear to associate directly with the chlorophyll maximum in other estuaries (Hughes and Sherr 1983; Friedland et al. 1996). Although the estuarine-dependent pattern of habitat use would appear to increase food availability in many cases (Barry et al. 1996; Peebles 1996; Livingston 1997), various alternative explanations have also been proposed to explain this phenomenon, including benefits associated with reduced predator diversity, reduced predator access to shallow water, and increased structural complexity (Reis and Dean 1981; Weinstein and Brooks 1983; Miller et al. 1985; Day et al. 1989; Hoss and Thayer 1993). Regardless of the cause, the estuarine-dependent life history places the juvenile fishes and their prey within relatively small, semi-confined areas of tidal rivers that constitute focal points for watershed runoff.

The locations occupied by both the fishes and their prey shift upstream and downstream in apparent response to changes in freshwater inflow (Table 3; Fig. 6). This response has been observed in both planktonic forms and active swimmers. For estuarine-resident and estuarine-dependent organisms, movement upstream during low-inflow periods usually involves movement into river reaches that have reduced volumes (Peebles and Flannery 1992; Peebles 2002a,b), which raises the possibility that carrying capacities could also be reduced by low inflow.

The abundances of many estuarine-resident and

TABLE 3. Organism distribution (mean km weighted by CPUE) responses to same-day freshwater inflow ($\ln m^3 s^{-1}$) into the tidal Alafia River, ranked by linear regression slope (b). Other regression statistics are the number of monthly transects in which each taxon was encountered (n), intercept (a), slope probability (p), and fit (r^2, as %). DW identifies possible serial correlation (x indicates $p < 0.05$ for Durbin-Watson statistic). Gear codes: P = 500-μm mesh, 0.5-m mouth plankton net deployed surface to bottom over about 400 m of channel length during nighttime flood tide, S = 21.3-m center-bag seine with 3.2-mm mesh deployed at shoreline during day under variable tide stage, T = 6.1-m otter trawl, 38-mm stretched mesh and 3.2-mm liner, deployed over about 180 m of channel bottom during day under variable tide stage (adapted from Peebles 2002a).

Gear	Taxon	Common Name	n	a	b	p	r^2	DW
S	*Gobiosoma bosc*	naked goby	18	5.22	1.57	0.0275	27	
P	calanoids	copepods	21	−0.05	−0.31	0.0224	25	x
P	all dipteran larvae	flies, mosquitoes	26	11.33	−0.45	0.0384	17	
P	*Anchoa* spp. flexion larvae	anchovies	20	1.36	−0.62	0.0333	23	
P	dipterans, chironomid larvae	midges	26	11.56	−0.64	0.0060	27	
P	odonates, zygopteran larvae	damselflies	12	13.11	−0.64	0.0438	35	
P	*Anchoa* spp. preflexion larvae	anchovies	19	1.42	−0.65	0.0440	22	
S	*Achirus lineatus*	lined sole	20	2.95	−0.67	0.0333	23	
S	*Fundulus seminolis*	Seminole killifish	21	12.58	−0.68	0.0020	40	
P	trichopteran larvae	caddisflies	17	13.71	−0.69	0.0389	25	
T	*Farfantepenaeus duorarum*	pink shrimp	21	3.97	−0.76	0.0245	24	
P	*Lucifer faxoni*	shrimp	25	1.81	−0.80	0.0121	24	x
T	*Callinectes sapidus*	blue crab	23	4.70	−0.84	0.0146	25	x
S	*Oligoplites saurus*	leather jack	15	4.78	−0.89	0.0501	26	
S	*Eucinostomus gula*	silver jenny	20	2.57	−0.92	0.0104	31	
S	*Cynoscion nebulosus*	spotted seatrout	16	3.34	−0.93	0.0189	33	x
T	*Menticirrhus americanus*	southern kingfish	19	3.64	−0.96	0.0028	42	
P	*Erichsonella attenuata*	isopod	12	2.91	−1.01	0.0092	51	
P	copepods, freshwater cyclopoids	copepods	14	13.65	−1.02	0.0122	42	
P	cumaceans	cumaceans	26	2.94	−1.05	0.0002	44	x
P	*Anchoa mitchilli* adults	bay anchovy	26	5.36	−1.07	0.0050	28	x
P	cladocerans, daphniid	water fleas	11	14.14	−1.09	0.0071	57	
T	*Cynoscion arenarius*	sand seatrout	20	6.07	−1.10	0.0190	27	
P	*Anchoa mitchilli* juveniles	bay anchovy	26	8.00	−1.13	0.0005	40	
S	*Farfantepenaeus duorarum*	pink shrimp	23	4.38	−1.14	0.0091	28	x
P	coleopterans, elmid adults	riffle beetles	18	13.47	−1.18	0.0469	22	x
P	gobiid preflexion larvae	gobies	16	5.44	−1.21	0.0243	31	
P	*Anchoa mitchilli* postflexion larvae	bay anchovy	18	3.78	−1.21	0.0103	35	
P	decapod zoeae	crab larvae	26	3.91	−1.23	0.0261	19	x
P	mysids	opossum shrimp	26	5.85	−1.23	0.0120	24	
P	polychaetes	worms	26	7.93	−1.25	0.0006	39	
P	hydracarina	water mites	20	13.98	−1.26	0.0002	54	
S	*Cynoscion arenarius*	sand seatrout	14	5.45	−1.33	0.0082	45	x
S	*Symphurus plagiusa*	blackcheek tonguefish	14	4.42	−1.34	0.0408	30	
S	*Callinectes sapidus*	blue crab	20	5.29	−1.36	0.0012	45	
P	branchiurans, *Argulus* spp.	fish lice	18	10.55	−1.41	0.0065	38	
S	*Synodus foetens*	inshore lizardfish	12	3.36	−1.52	0.0036	59	
P	*Limulus polyphemus* larvae	horseshoe crab	13	3.93	−1.52	0.0260	38	
P	*Cynoscion arenarius* juveniles	sand seatrout	14	7.04	−1.56	0.0036	52	
S	*Membras martinica*	rough silverside	12	4.75	−1.57	0.0040	58	
P	*Microgobius* spp. postflexion larvae	gobies	18	4.70	−1.60	0.0098	35	
S	*Menidia* spp.	silversides	23	9.36	−1.65	0.0031	35	
S	*Menticirrhus americanus*	southern kingfish	17	5.01	−1.70	0.0025	47	
P	*Edotea triloba*	isopod	25	8.08	−1.75	0.0000	59	
P	isopods (grouped)	isopods	26	7.92	−1.76	0.0000	57	
P	cymothoid sp. a (*Lironeca*)	isopod	26	7.79	−1.80	0.0000	53	
P	*Gobiosoma* spp. postflexion larvae	gobies	20	6.72	−1.87	0.0234	25	
S	*Cyprinodon variegatus*	sheepshead minnow	14	7.26	−1.94	0.0129	41	x
P	*Trinectes maculatus* juveniles	hogchoker	19	9.89	−2.04	0.0024	43	
P	*Trinectes maculatus* postflexion	hogchoker	18	8.66	−2.11	0.0002	60	
P	*Syngnathus louisianae* juveniles	chain pipefish	10	5.76	−2.16	0.0235	49	x
P	*Trinectes maculatus* flexion larvae	hogchoker	12	6.85	−2.36	0.0141	47	
S	*Brevoortia* spp.	menhaden	10	10.42	−3.49	0.0034	68	

young estuarine-dependent species appear to decline during low-inflow periods (Figs. 7 and 8; Table 4). This trend could raise concern over calculation artifacts because river-segment volume is strongly influential in the calculation of total number and organisms typically move downstream into regions with larger volume-weighting factors during high inflow periods. For many taxa in Table 4,

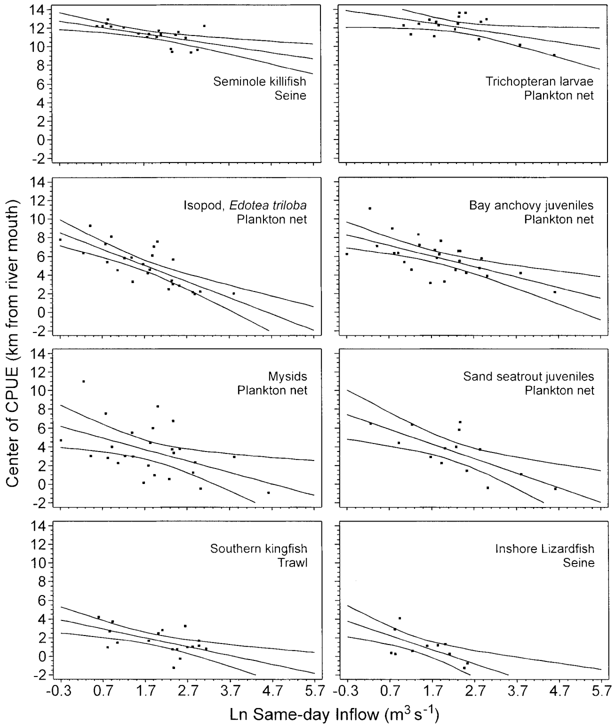


Fig. 6. Regressions of organism distribution against freshwater inflow into the tidal Alafia River, with 95% confidence limits for predicted means. Center of catch per unit effort (CPUE) is the mean location of capture during monthly transects, with the mean being weighted by CPUE. During each transect, the seine and plankton net were deployed at 12 stations and trawls were deployed at four stations. CPUE is either the number per deployment for seines and trawls or the number per volume filtered by the plankton net. Regression statistics are presented in Table 3 (adapted from Peebles 2002a).

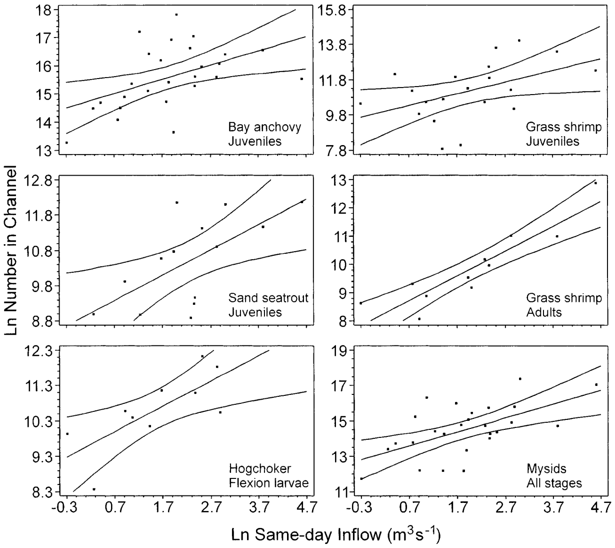


Fig. 7. Regressions of organism number against freshwater inflow into the tidal Alafia River, with 95% confidence limits for predicted means. Number was calculated for each monthly transect by summing the products of mean organism density (ind m^{-3}) and a volume weighting factor (m^3) for six contiguous river segments. All data are from plankton net deployments, which were made at 12 stations per transect. Regression statistics are presented in Table 4 (adapted from Peebles 2002a).

the positive inflow relationship also exists when total catch is used (no volume-weighting factor), suggesting that the response is not merely a calculation artifact. For other taxa, the relationship is also likely to be real, as the approach for estimating total number is conceptually robust. It should be kept in mind that the number estimated is actually the number of individuals that are vulnerable to the collection gear within the channel's water column, and this number may be affected by influx from the shoreline, bottom, or downstream directions. The relationships in Fig. 7 represent the ascending limb of a broader response curve; very high flows could decrease abundance in the tidal river.

Other studies (e.g., Jassby et al. 1995; Kimmerer et al. 2001) have documented abundance responses to inflow-related variables by comparing annual averages, which would tend to eliminate the influence of recruitment seasonality and would strongly reduce the effects of short-term time lags in the response. Figures 7 and 8 indicate that abundance responses can also be identified within sub-annual time intervals for a variety of organisms, and often without any indication of serial correlation (Table 4). Several factors encourage synchrony between the inflow and abundance observations. Because the regressions are based on plankton-net data, most of the animals in the analysis are short-lived species. Longer-lived fish and crustacean species

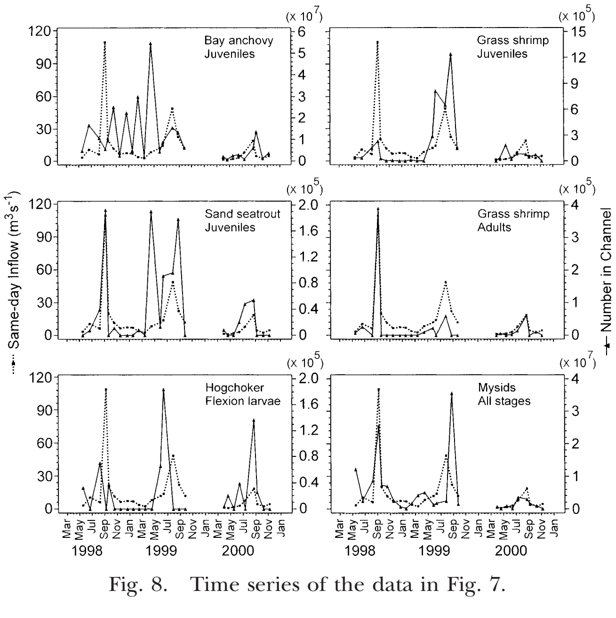


Fig. 8. Time series of the data in Fig. 7.

TABLE 4. Response of total estimated number (ln number of individuals) to same-day freshwater inflow (ln $m^3 s^{-1}$) into the tidal Alafia River, ranked by linear regression slope (b). Other regression statistics are the number of monthly transects in which each taxon was encountered (n), intercept (a), slope probability (p), and fit (r^2, as %). DW identifies possible serial correlation (x indicates $p < 0.05$ for Durbin-Watson statistic). Total number was estimated by summing the products of mean plankton-net density (individuals m^{-3}) and water-level-corrected volume across 6 contiguous river segments (adapted from Peebles 2002a).

Taxon	Common Name	n	a	b	p	r^2	DW
dipteran, *Chaoborus punctipennis*	phantom midge	16	7.47	1.43	0.0058	43	
pinnotherid juveniles	pea crabs	18	11.50	1.40	0.0035	42	
crabs (grouped)	crabs	24	10.90	1.32	0.0049	31	
freshwater cyclopoids	copepods	14	7.50	1.31	0.0000	78	
ephemeropterans	mayflies	22	7.94	1.10	0.0001	56	
Palaemonetes pugio adults	daggerblade grass shrimp	11	8.06	0.88	0.0001	83	
coleopterans, dytiscid adults	predaceous diving beetles	13	7.30	0.88	0.0064	51	
mysids	opossum shrimps	26	13.01	0.79	0.0016	35	
Cynoscion arenarius juveniles	sand seatrout	14	8.85	0.72	0.0131	41	
Trinectes maculatus flexion	hogchoker	10	9.46	0.72	0.0139	55	
Palaemonetes pugio juveniles	daggerblade grass shrimp	20	9.84	0.66	0.0375	22	x
dipterans, pupae	flies, mosquitoes	25	10.07	0.63	0.0092	26	x
coleopterans (grouped)	beetles	21	8.72	0.57	0.0053	34	
Anchoa mitchilli juveniles	bay anchovy	26	14.63	0.51	0.0114	24	
dipterans (grouped)	flies, mosquitoes	26	10.98	0.42	0.0064	27	x
alphaeid postlarvae	snapping shrimps	14	13.35	−0.41	0.0386	31	x
Lolliguncula brevis juveniles	bay squid	13	11.49	−0.49	0.0458	32	
cymothoid sp. a (*Lironeca*)	isopods	26	16.03	−0.53	0.0079	26	x
isopods (grouped)	isopods	26	15.73	−0.58	0.0069	27	x
gobiid preflexion larvae	gobies	15	13.00	−0.66	0.0051	46	
gobiid flexion larvae	gobies	17	11.90	−0.91	0.0129	35	
calanoids	copepods	21	19.47	−1.15	0.0219	25	

were partitioned into shorter developmental stages before analysis and abundance was assessed independently for each stage. For such species, the rate of passage though various larval stages is fast relative to the monthly sampling frequency. Even for the potentially long-lived juvenile stages of larger species (e.g., *Cynoscion arenarius*), a combination of gear avoidance and natural mortality (larger individuals becoming rare) dramatically abbreviated the age range observed in the plankton-net data.

Most of the abundance regressions remained significant when inflows from the previous month's collection dates were used, indicating that the response is not as spontaneous as Figs. 7 and 8 might imply. In the relationships illustrated by these figures, significance was generally lost when a 2-mo lag was used, which suggests that the relationships with inflow had durations of less than 2 mo. Explanations for the decreased abundance include reductions in reproductive effort (Peebles 2002c) and survival rates during low-inflow periods.

From a management perspective, the shape of the abundance response curves can be used to identify inflow ranges that have proportionately large influences on abundance. The non-transformed data represented by the regression statistics in Table 4 are described by the power function $y = ax^b$, which is differentiated as $dy/dx = abx^{(b-1)}$. The value of the slope determines the shape of the non-transformed abundance response to variations in inflow. Organisms with slopes < 0 undergo proportionately large decreases in number as low-end inflows increase. This is characteristic of animals that often occupy the higher salinities near the river mouth. Members of the second group, which includes freshwater, estuarine-resident, and estuarine-dependent taxa, have slopes between 0 and 1 and undergo proportionately large increases in number as low-end inflows increase, although the abundance increase becomes more constant for organisms with slopes near 1. Members of the third group, which is primarily composed of freshwater organisms, are characterized by slopes > 1. Freshwater taxa may either wash into the tidal river at a fairly constant rate (e.g., ephemeropteran larvae in Table 4) or, at even larger slopes, increase dramatically in number during floods (freshwater cyclopoids and *Chaoborus punctipennis*). Floods may also cause burrowing marine-derived animals (e.g., the pinnotherid crab *Pinnixa sayana*) to emerge from their burrows in large numbers, producing a very similar pattern.

Because most estuarine-resident and estuarine-dependent taxa tend to have a group-2 response (proportionately large increases in number at the low end of the inflow range), protection of low inflows becomes important. By scaling withdrawals to the concurrent rate of streamflow, the percent-of-flow approach provides a general safeguard against dramatic changes in organism abundance that could result from large withdrawals during periods of low freshwater inflow.

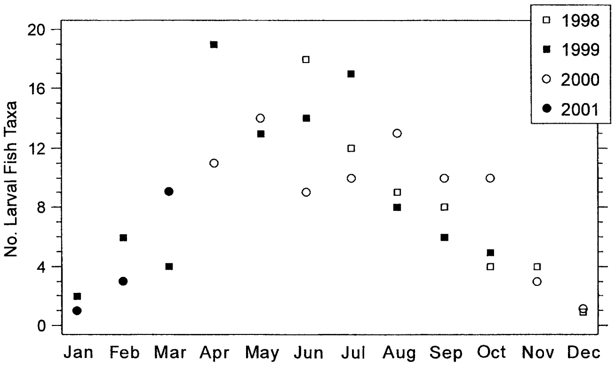


Fig. 9. The seasonal distribution of approximate larval richness in the tidal Alafia River (data from Peebles 2002a).

Most estuarine-dependent fishes have been found to exhibit very regular seasonality in their use of low-salinity habitats, further emphasizing the importance of a seasonal component to inflow management. The spawning-season durations of individual species range from a few months to year-round. Those with shorter seasons generally demonstrate regular seasonality in their spawning. It is interesting that spawning seasons and overall trends in larval taxonomic richness do not conform to the local seasonal rainfall pattern, which can be very different from the pattern in other parts of these species' ranges. Richness is very high during April and May (Fig. 9), which are among the driest months of the year (Fig. 2), and does not change appreciably during the transition to the summer wet season. Richness starts to decline in August and gradually reaches its minimum during December and January. This pattern has been observed repeatedly at various locations since 1988.

The potential for a strong influx of juvenile estuarine-dependent fishes into low-salinity nursery habitats is very high during the spring dry season, making management of freshwater inflow particularly sensitive during that time of year. Although the seasonal pattern of larval richness in Fig. 9 suggests that this sensitivity may diminish during winter, many of the spring and summer larval migrants are still present during winter as older juveniles. There is no season when inflow management becomes less relevant to low-salinity nursery use, although spring appears to be a particularly sensitive season. Any limiting effects associated with the naturally low springtime inflows could be amplified by relatively small freshwater withdrawals.

Applications to the Management of Freshwater Withdrawals

In the late 1980s, the SWFWMD first began to implement a management approach of limiting withdrawals from rivers to a percentage of streamflow at the time of withdrawal. The goals of this approach were to make withdrawals mimic the temporal characteristics of the flow regimes of the streams used for water supply and to protect the estuaries from the effects of large freshwater withdrawals during the ecologically vulnerable dry season. Findings initially used to support the approach included the curvilinear response of isohaline locations to freshwater inflow (Flannery 1989) and the influence of inflow on the location of the center of catch per unit effort (CPUE) for a number of key organisms, a relationship that was first documented in the Little Manatee River (Peebles and Flannery 1992). Studies of the Lower Peace River and Charlotte Harbor estuarine system also demonstrated that the response of residence time to freshwater inflow in that system is strongly curvilinear (Stoker et al. 1989; Miller and McPherson 1991). Reduction of freshwater inflow of a fixed quantity would result in a much greater increase in residence time during periods of low inflow, with possible negative effects on water quality.

The percent-of-flow approach was first applied to the Peace River, where withdrawals for public water supplies began in 1980. The Peace River is not impounded and withdrawals from the river are either pumped directly to the customers after treatment or are stored in an offstream reservoir or the groundwater system using aquifer storage and recovery facilities. Prior to 1989, withdrawals from the Peace River were regulated by the SWFWMD in a manner similar to a groundwater withdrawal, with limitations on maximum-daily and yearly average withdrawal rates. Maximum-daily withdrawals could be taken when flows in the river were above minimum flow rates that were specified for each month. Given this regulatory schedule, withdrawals could take up to 25% of streamflow on low-flow days during the dry season. Based on recommendations of ecologists from both the water supply utility and SWFWMD, the withdrawal schedule was changed in 1989 so that withdrawals could not exceed 10% of the average streamflow from the preceding day as measured at an upstream gauge.

The percent-of-flow approach was also recently applied to allocated withdrawals from the Alafia River, from which withdrawals are scheduled to begin in 2003. These withdrawals by the water supply utility cannot exceed 10% of the streamflow from the preceding day as measured at the intake site, and withdrawals in excess of immediate customer needs will be stored in an offstream reservoir. Withdrawals for cooling water for an electrical power plant have been diverted to an offstream reservoir from the Little Manatee River since 1975. These withdrawals have been regulated as a percentage of streamflow at the time of withdrawal, but at higher percentage rates than allowed for the

Peace or Alafia Rivers (up to 47% on some days during high flows). This power plant has been operating at approximately one-third of capacity since its construction and withdrawals from the Little Manatee River have been relatively infrequent (28% of days) and well below the allocated percentage quantities. In a recent application to convert the power plant from fuel oil to natural gas and increase power production, the utility has requested that the diversion limit be reduced to 10% of the daily flow at the intake site in anticipation of more frequent, but smaller, withdrawals (Florida Power and Light 2002). Findings to support this change in the diversion limit included simulations of changes in salinity distributions and movements of the locations of the center of CPUE for key organisms in the Little Manatee River.

Application of the percent-of-flow approach to these unimpounded rivers has included the use of low-flow cutoffs, or rates of streamflow below which no withdrawals are allowed. These low-flow cutoffs correspond to the long-term 13th percentile flow on the Peace, the 21st percentile flow on the Alafia, and the 36th percentile flow on the Little Manatee. Criteria for determining these low-flow cutoffs have varied, but are generally based on inflections in the response of key variables to freshwater inflow. Data for the Peace River indicate that salinity distributions in the upper estuary are especially sensitive to reductions in freshwater inflow below the low-flow cutoff of 3.7 $m^3 s^{-1}$. During droughts, streamflow in these rivers can be below their low-flow cutoffs for several consecutive months, during which time water supplies must come entirely from storage.

During high flows, the capacities of the diversion structures on these rivers do not allow the utilities to take their full percentage quantities. The effect of regulated percentage withdrawals, including the range of flows over which a full 10% of flow can be diverted, is shown for the Peace River during a typical year (Fig. 10). Due to these regulatory and physical constraints, seasonal and annual reductions in streamflow that result from the percent-of-flow approach are often considerably less than the percent daily limit. Since the streamflow gauges used to calculate the percentage withdrawals do not account for freshwater inflow below the gauging sites, percent reductions of total inflows to the tidal rivers are even less. The drainage areas for the gauges used to calculate percent daily withdrawal limits on the three rivers range from 58% of the total river basin for the Peace River to 91% of the total river basin for the Alafia. Current efforts are directed to modeling the ungauged streamflow in these river basins, so that the actual percentage flow reductions to the tidal rivers can be more closely quantified (Tara et al. 2001).

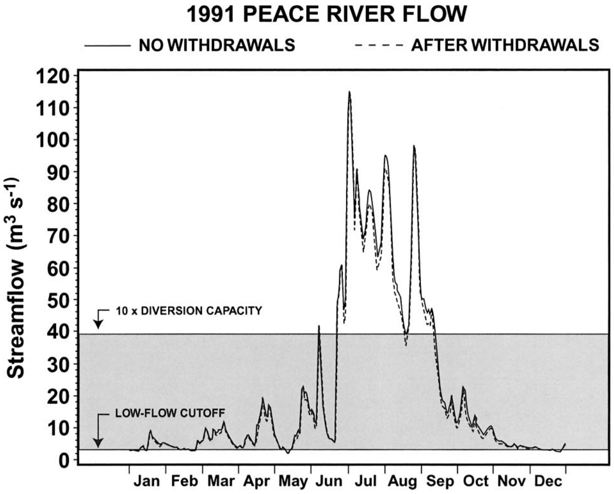


Fig. 10. Daily streamflow values for the Peace River during 1991 (U.S. Geological Survey gauge 02296750), with and without maximum possible withdrawals calculated using the 10% of flow daily limit, combined with a low-flow cutoff of 3.7 $m^3 s^{-1}$ and a diversion capacity of 3.9 $m^3 s^{-1}$. The shaded area represents the range of flows over which a full 10% of streamflow can be diverted.

Ongoing Refinements to the Percent-of-flow Approach

The natural flow regimes of unimpounded rivers and their documented ecological responses provide important information on when estuarine resources are most vulnerable to the effects of reductions in freshwater inflow. Withdrawal quantities that can result in ecological impacts may be markedly smaller during some seasons than others. The findings from southwest Florida estuaries indicate that reductions of freshwater inflow should be most limited during the spring. Historically, the withdrawal of water from rivers has not accounted for the seasonal needs of downstream ecosystems. Rozengurt and Hedgpeth (1989) reported a 12% reduction in the estimated mean annual runoff to the Lower Volga-Caspian Sea ecosystem, but reductions in springtime flows had decreased by as much as 37%. Similarly, water use in southwest Florida also typically peaks during the spring dry season due to increased domestic and agricultural irrigation (SWFWMD 2001a), and percent flow reductions in the region's impounded rivers are greatest during that time of year. The adoption of minimum flow releases that can account for seasonal variations have been scheduled for these impounded rivers (SWFWMD 2002a). It is expected that all new surface water withdrawals in the region will come from unimpounded rivers, for which the

SWFWMD has endorsed the percent-of-flow approach (SWFWMD 1992, 2001b). With the exception of the Little Manatee River, applications of the percent-of-flow approach have used the same percentage rate throughout the year. Current SWFWMD efforts are directed toward evaluating percentage withdrawal limits on a seasonal basis to better account for seasonality in the life histories of various organisms.

The evaluation of potential freshwater withdrawals should also account for the frequent nonlinear response of key estuarine characteristics to freshwater inflow. Changes in residence times, isohaline locations, and salinity at different locations in an estuary can be much greater for a given volume of freshwater withdrawal if it occurs during periods of low freshwater inflow (Miller and McPherson 1991; Uncles and Stephens 1993; Sklar and Browder 1998; Vallino and Hopkinson 1998). The relationships presented herein indicate there can often be a larger decrease in organism numbers if withdrawals of a given quantity are made during low freshwater inflows. A goal of the percent-of-flow approach is to adjust for such nonlinear relationships by scaling withdrawals to the rate of freshwater inflow. The SWFWMD is investigating sliding withdrawal percentages that differ among flow ranges based on changes in the responsiveness of the estuarine variables of concern. In cases where increasing freshwater inflows exacerbate a problem condition such as hypoxia (e.g., Breitburg 2002), percentage withdrawal limits can be adjusted to account for such processes. If high flows cause dispersion of estuarine-dependent organisms away from productive zones of an estuary (e.g., Peebles et al. 1996; Peebles 2002c), this can be factored into the withdrawal management strategy.

Although the percent-of-flow approach uses the flow regime of the contributing river as the basis for determining withdrawals, it is the inflow relationships of the living resources in the estuary that are the final determinant of percentage withdrawal limits. The ambient flow record (without any withdrawals) is used to assess the spatial and seasonal variation of physico-chemical and biological variables within the estuary that are related to freshwater inflow. Percentage withdrawals can then be applied to evaluate responses in the estuary under a range of inflow conditions. For those variables in the estuary that can be modeled, values can be simulated in order to compare the effects of different withdrawal scenarios to the ambient flow record (PBS&J 1998, 2001; Janicki Environmental 2001).

Development of the percent-of flow approach has largely emphasized tidal rivers because most oligohaline and mesohaline zones and nursery habitats in southwest Florida estuaries are located upstream of the tributary mouths. The withdrawal quantities that have been evaluated for unimpounded rivers using the percent-of-flow approach have been relatively small. We have assumed that the physico-chemical effects of these withdrawals and their related biological responses are most strongly manifest within the tidal rivers, due to their small water volumes relative to the open bays. This assumption is periodically reviewed and as the pressure for larger withdrawals increases, the strategy of examining more far-field effects will be increasingly employed.

The percent-of-flow approach lends itself to the process of adaptive management, in which continued data collection can be used to refine management strategies as the body of information expands over time. The SWFWMD requires the monitoring of hydrologic and ecological variables for permits for large surface-water or groundwater withdrawals. At present, extensive monitoring programs are required for withdrawals from both the Peace and Alafia Rivers (PBS&J 1999b, 2001). The findings of these programs can be used to modify percentage withdrawal schedules to better manage the resource, as the findings from the Peace River monitoring program were used to develop the percent-of-flow concept in 1989.

In addition to issuing individual water use permits, the SWFWMD must also establish minimum flow and level rules for flowing water courses which are defined in Florida Statutes (Chapter 373.042) as ''the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.'' Minimum flows and levels address not only existing withdrawals, but also the potential effects of future withdrawals and are important for water supply planning. The adoption of minimum flows and levels for the Peace and Alafia rivers could develop percentage withdrawal limits that differ from the 10% regulations currently in effect. The determination of significant harm in the minimum flow and level process rests with Governing Board of the SWFWMD, who are appointed by the Governor of the State of Florida. The role of ecologists is to identify those ecological features, processes, and organisms that can be affected by reductions in freshwater inflow and to develop quantifiable relationships among these variables so that policy makers can determine how much ecological change is to be allowed. The SWFWMD is applying the percent-of-flow approach to evaluate alterations of natural streamflow regimes and to determine how much water may be available for supply without causing adverse impacts to estuarine resources.

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Received for consideration, December 13, 2001
Accepted for publication, September 17, 2002

SF – 9 Verbal comments presented to the scientific review panel for the draft Upper Peace River minimum flows report on February 6, 2026

Submitted by Sid Flannery

This morning, the District uploaded to the minimum flows Webboard four short documents that I hope you can review. The first, labeled Document SF-6, is a technical memorandum I prepared that covers two topics. The first is the period after 2016 when the Lake Hanock project became operative. That recent period was fairly wet, which benefitted how well the Upper Peace River met the existing, low minimum flows over that time frame. The other analyses presented in document 6 clearly show that the upper river is meeting the minimum flows at the Zolfo Springs gage.

The second document labeled SF-7 is my technical review of the draft District report so far. It covers just a few important topics, including one that I want to quickly mention today. That is much more information needs to be presented in the District report on how much water is contributed from Lake Hancock to the Upper Peace River at structure P-11, plus pumpage into and discharge out of the treatment wetland associated with the lake.

Document seven also briefly revisits the critical subject of whether the Upper Peace River is meeting its minimum flows at the Ft. Meade gage. It includes as attachments, two documents I prepared that were posted on the Webboard last Friday, which clearly show the minimum flows are not being the majority of the time at Ft. Meade, including a very large majority of the time during critical low and medium flows.

In that regard, I want to share a few thoughts on the proper application of the percent-of-flow method with you today. Based on extensive data collection and research, the District's development and application of the percent-of-flow method goes back to the late 1980s.

Document SF-8 is a journal article I co-wrote along with a professor from the University of South Florida and a consultant who did considerable work on the Lower Peace River. That article, which was published in 2002, describes the conceptual and practical application of the percent-of-flow method. I hope you can read the abstract, which describes the method that is still being applied today.

That article also provides case examples from three rivers where the percent-of-flow method is currently being applied to major water supply withdrawals; which are the Alafia, the Little Manatee, and the Lower Peace River. I was directly involved in the scientific evaluation and regulatory application of those permitted withdrawals, and can tell you that the hydrologic analyses, water supply simulations, regulatory limits, and the assessment of the withdrawals on the rivers' ecology all involved assessing changes in flows on a daily basis as a function of flow. Changes in flows were not assessed on an average monthly or average yearly basis to assess compliance.

At this time, the analyses presented in the draft District report are not adequate to demonstrate the minimum flows for the Upper Peace River are being met. My document number 1, which was reposted to the Webboard last Friday, makes the point that the reference to Table 5-6 on page 233 in the summary chapter of the draft report is way off base in making the claim that the minimum flows are being met.

Instead, the analyses that were uploaded to the Webboard last Friday as part of my document SF-4, show the flows at Ft. Meade have been reduced beyond the minimum flow limits a large majority of the time over most of the flow regime of the river. The minimum flows at Ft. Meade are being met at high flows, above about 200 cfs, but they would be available for withdrawal only about 30% of the time on average, probably making them impractical for water supply.

I did not have time to analyze the data for the Bartow gage, but they would probably behave similarly, and if the minimum flows are not being met at Ft. Meade, that would preempt any upstream withdrawals near Bartow. Again, my document number 6, which was uploaded today, shows that the minimum flows are being met at the Zolfo Springs gage.

In that regard, these technically sound findings represent good water management, in that much greater water supplies are available at Zolfo Springs due to the much greater flow volumes there. For example, the median flow at Zolfo Springs over the last 30 years was 239 cfs compared to 78 cfs at Ft. Meade.

Finally, any apprehension about the need for possible additional recovery strategy measures for the Upper Peace River should not prohibit the District from making technically valid conclusions about whether the minimum flows are being met. The District has implemented the Lake Hancock project and I am sure the State of Florida and the District Governing Board would be reasonable in determining if any further recovery steps are needed.

A written transcript of the comments I have presented today were uploaded to the Webboard as document SF-9, and I hope the review panel will continue to monitor the Public Domain link on the WebBoard over the next couple of weeks, to see if I or any others contribute new material related to the minimum flows for the Upper Peace River.

SF-10 – Follow-up to the scientific review panel meeting for the draft Upper Peace River minimum flows report held on February 6, 2016

Submitted by Sid Flannery

This correspondence follows up on three points that arose from today's meeting of the scientific review panel for the draft Upper Peace River minimum flows report.

As I mentioned at the end of my comments today, the Lake Hancock Project is mainly used to address compliance with the low flow thresholds for each gage. However, the minimum flows that are proposed for the Upper Peace River cover the entire flow range of the river and the analyses I have submitted clearly show the current gaged flows at Ft. Meade are not meeting the proposed minimum flows over much of the flow range of the river at that location.

As I also brought up, my analyses indicate the Upper River is easily meeting the minimum flows at the Zolfo Springs gage, so considerable water supplies are available from the river at that location. As such, the valid conclusion that the upper river is not meeting the minimum flows at the Ft. Meade gage does not create some sort of future water shortage crisis.

I was also very surprised to hear that the panel hopes to have a draft report by the end of next week, with an initial draft for review by the panel possibly by the end of this weekend. I suggest the panel slow this process up and take time to consider the substantive points I have raised about proper application of the percent-of-flow method, which has gone very well for a few decades now.

The Upper Peace River presents a critical juncture in the implementation of the percent-of-flow method. Again, I suggest the panel take sufficient time to consider the important points that need to be resolved about whether the minimum flows are being met at the Ft. Meade gage and delay the schedule for completion of the draft report if needed. The timelines for the peer review process and can be adjusted by the District.

From: Angel Martin
To: Kristina Deak
Subject: Upper Peace River MFL Peer Review Meeting 3--Feb. 6, 2026
Date: Friday, February 6, 2026 12:56:36 PM

Below is a summary of my comments from the subject meeting.

1. I totally agree with Dr. Munson concerning his comments concerning uncertainty in the materials used to establish the MFL. I suggest that some additional discussion be added to the report discussing the uncertainty and limitations especially of the models used in MFL determination.
2. Additional discussion is needed in the report concerning the MFLs being met at all applicable streamgages since 2020, especially considering the rainfall distribution and groundwater pumpage quantities during this period.
3. Additional discussion is needed and the possible inclusion of references on the relation between groundwater pumpage and streamflow in the Upper Peace River.

Thank you for the opportunity to comment on the subject MFL process. Please contact me if you need any additional information or clarification .

____

Angel Martin Jr.
813-767-6944

Outlook

Mfl draft comment Upper Peace River

From charlescook05@gmail.com <charlescook05@gmail.com>
Date Fri 2/6/2026 1:37 PM
To Lei Yang <Lei.Yang@swfwmd.state.fl.us>

[You don't often get email from charlescook05@gmail.com. Learn why this is important at https://aka.ms/LearnAboutSenderIdentification]

[EXTERNAL SENDER] Use caution before opening.

Sent from my iPhone
I wanted to note the importance of a greater consideration of the spatial distribution of wells and drawdown effects on the UPR. Studies (Tihansky) have shown that 85% of ground water sources to well are derived from 15% of a geographic area. I believe the PRIM model needs better refinement and calibration with sensitivity to the actual effects of specific wells via subflow away from the upper peace river. This is evidenced cessation of flows at the Clear Spring gage at times of low flows and high groundwater demand.
Below, Gator Sink level always craters with the advent of freeze pumping.
Per Bill Llewelling, USGS, Gator sink levels reflect the Upper Floridan Aquifer System locally.

From: charlescook05@gmail.com
To: Kristina Deak
Subject: Re: MFL draft comments Upper Peace River 5yr review
Date: Friday, February 6, 2026 2:28:17 PM

Thank you Kristina! I sent the link to the Gator Sink levels per USGS real-time gage.
Please allow consideration of these additional comments. Thanks for any help with formatting improvements.
Sincerely,
Charles

1. Please clarify the difference between baseflow and interflow. Baseflow (limestones)as from River valley, interflow from river (surface aquifer). The river has increasing baseflow in middle reaches. Also, more interflow from ag and industrial discharges. These discharges are often sourced from the capture of groundwater via subflows from the upr aquifers.
2. Re Hancock, on most calm days there is a nascent layer of clear water that if decanted would supply better quality to the river.
3. Fundamentally, system recovery needs better headwater flood storage and treatment with incremental increase in annual groundwater base level between Bartow and Ft Meade. This provides increased rejected recharge and surface flows.
4. A new source of supply might include the calculated waste water yield resulting from “new” quantities obtained from the new LFA deep wells.

1. re modifications to karst (Downing) this idea was rejected after it was revealed excessive karstic void’s were impractical to fill.
2. J. Keifer study concluded it was impractical to bypass karst features as historical examples showed probable failure in the geomorphology plan.

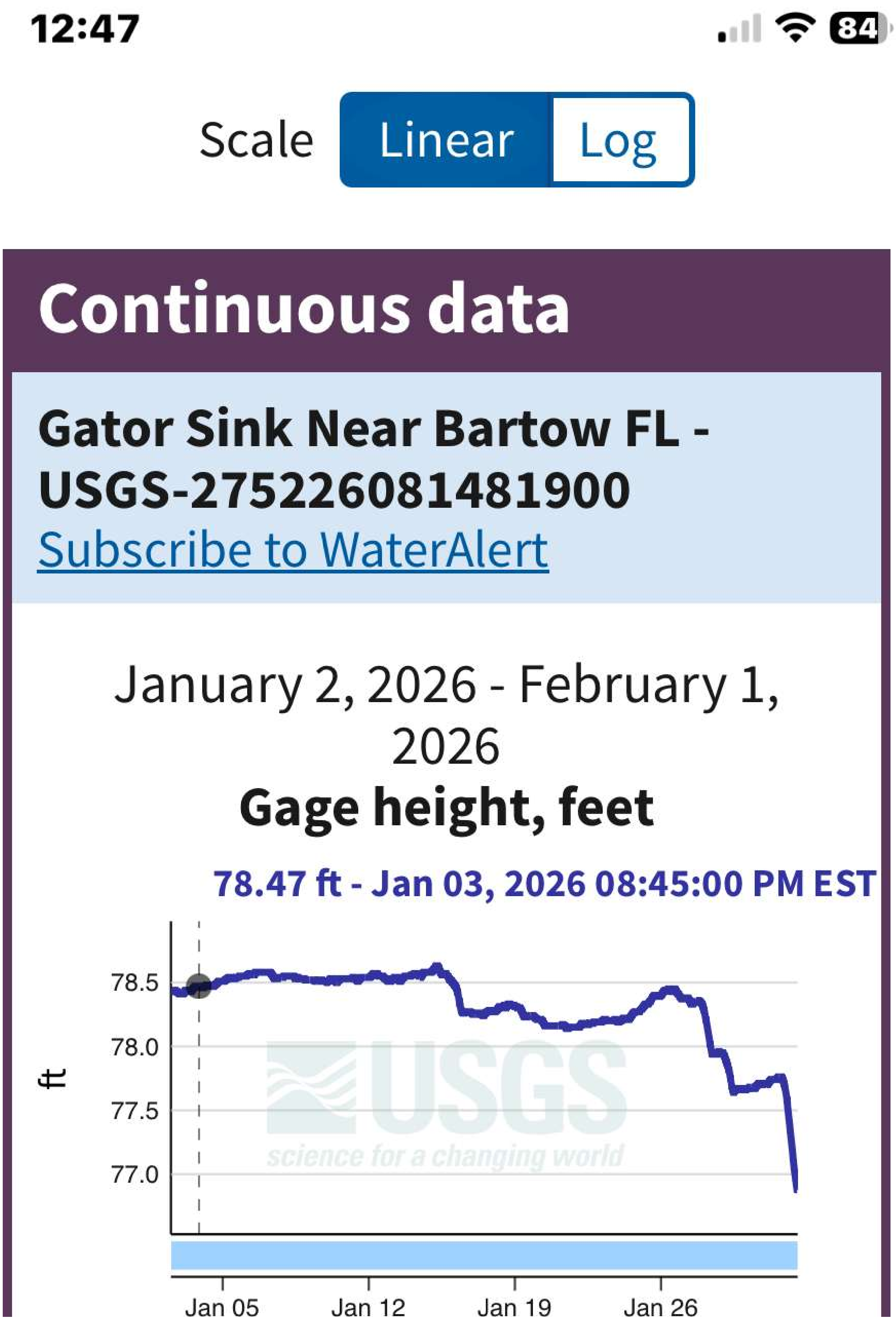
Summary: The upper peace river runs coast parallel due to historic aquifer baseflow maintained by a potentio metric level above the river Valley floor (White, FGS).
The upper peace river Valley thalweg it’s approximately 88 feet MSL.
Therefore, 88 feet MSL minimum aquifer level is needed to assure upper peace river MFLs.

Sent from my iPhone

> On Feb 6, 2026, at 1:57 PM, Kristina Deak <Kristina.Deak@swfwmd.state.fl.us> wrote:
>
> Hi Mr. Cook,
>
> I received your comments through our website; however, it looks like the image you wished to attach of Gator Sink did not come through. Would you mind sending

it again directly to this email address?

Thank you!
Kristina Deak, PhD
Lead Environmental Scientist
Environmental Flows and Levels
Southwest Florida Water Management District
7601 US 301, Tampa, FL 33637
813.328.3544



Scale Linear

Continuous data

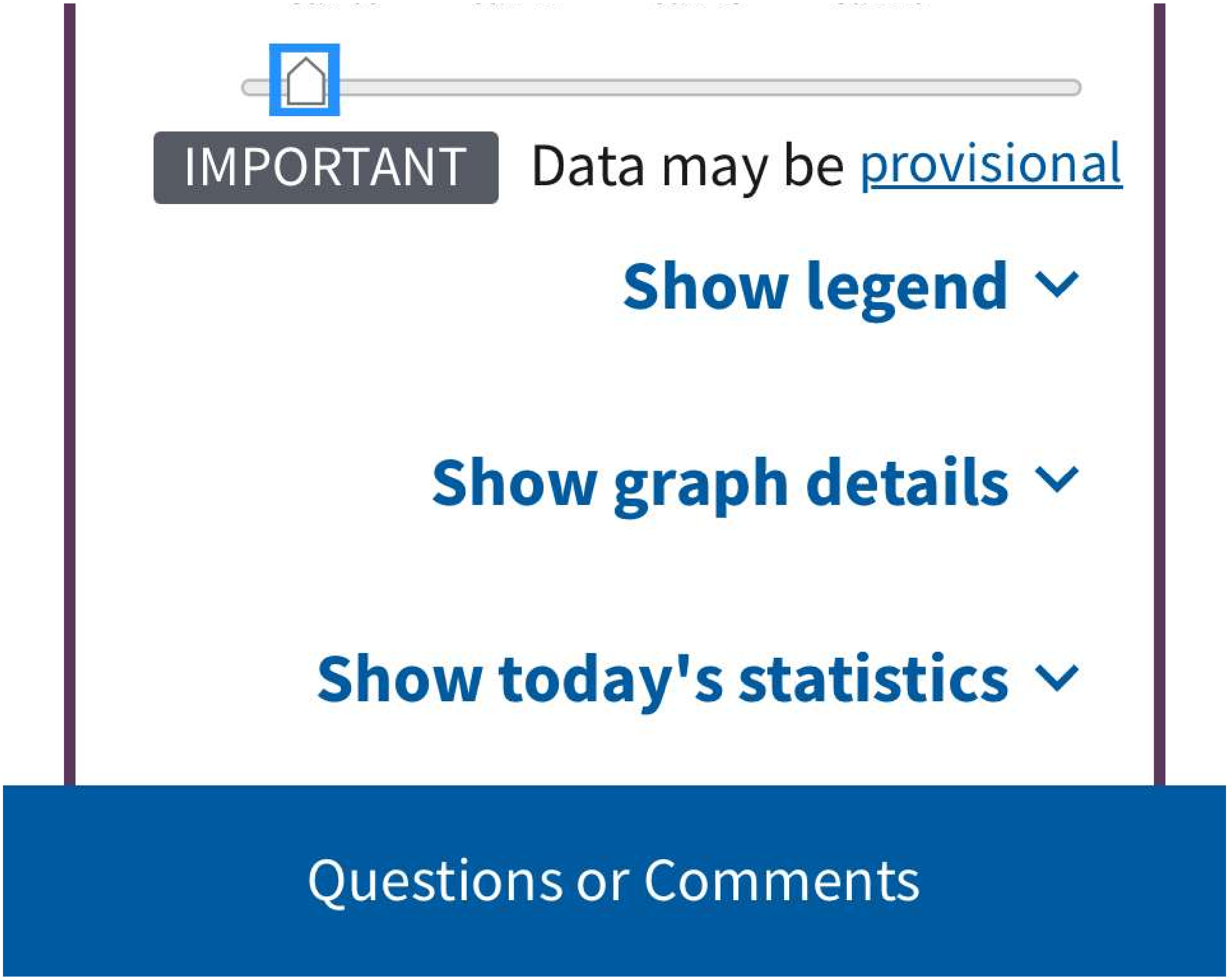
Gator Sink Near Bartow FL - USGS-275226081481900

Subscribe to WaterAlert

January 2, 2026 - February 1, 2026

Gage height, feet

78.47 ft - Jan 03, 2026 08:45:00 PM EST



IMPORTANT Data may be provisional

SF-11 Ft. Meade Gage - Time series plots of daily percent reductions in baseline flows represented by gaged flows

Submitted by Sid Flannery, February 10, 2026

This short but important document presents time-series plots of daily values for percent reductions in baseline flows represented by gaged flows at the Peace River at Ft. Meade gage. These plots are presented for the period 2003 to 2022 which covers the period for which the baseline flows were calibrated (2003 to 2018), and also includes the most recent years for which baseline flows were calculated and the Lake Hancock Project was in operation (2016 to 2022).

The data are presented by the flow-based blocks for the Ft. Meade gage identified in the draft minimum flows report for the Upper Peace River, which are listed in Table 1 including the maximum percent allowable flow reductions within each block.

Table 1. Flow ranges and maximum allowable percentage withdrawl rates for the four flow blocks at the Ft. Meade gage.

Block 1	≤ 21 cfs	0%
Block 2	>21 cfs and ≤120 cfs	12%*
Block 3A	> 121 cfs and ≤ 529 cs	10%
Block 3B	> 529 cfs	7%

*** A full 12% cannot be taken until flows reach 24 cfs**

Text continues on the next page

The graphic for Block 2 is presented first in Figure 1, as this is a critical block for the river's ecology as it corresponds to habitats and biological communities within the river channel, as does Block 1. However, I consider the flow reductions in Block 2 to be more problematic. As discussed on page 3, the Lake Hancock Project primarily benefits flows in Block 1, but Block 2 is equally important to the ecology of the river.

It is important to note the during the 20-year period covered by the three graphics in this report, gaged flows were in Block 2 thirty-nine percent of the time. As can be seen in Figure 1, percent flow reductions can be vey high in Block 2, as the maximum percent allowable flow reductions in daily flows for Block 2 is twelve percent (Table 1), which is shown by the red reference line in Figure 1. If a daily gaged flow was greater than the corresponding baseline flow it would show up as negative value, but there were no days in this 20-year period when a gaged flow at Ft. Meade was higher than baseline flow in any of the blocks.

Daily flow reductions in excess of 50% occurred in a number of dry years. As discussed by the scientific review panel and other documents I have prepared (SF-4 and SF-6), the period after 2016 was generally wet, although a dry spring occurred in 2017. It is notable that flow reductions in excess of 30% occurred late in 2016 and the spring of 2017, but also briefly in 2018 and at the end of 2021. Percent flow reductions in excess of 20% were common in the first part of 2022.

It is clear that the minimum flows are frequently not being met during Block 2 at the Ft. Meade gage. The minimum flows in Block 2 were met (percent reductions at or less than the maximum allowable limit) only 24% of the time during this 20-year period. As described in my document SF-4, the minimum flows were only met 30% of the time in Block 2 during the wet period from 2016 to 2022 when the Lake Hancock Project was in effect. The results for Block 2 at Ft. Meade alone support my disagreement with the conclusion in the draft District report that the minimum flows for the Upper Peace River are being met.

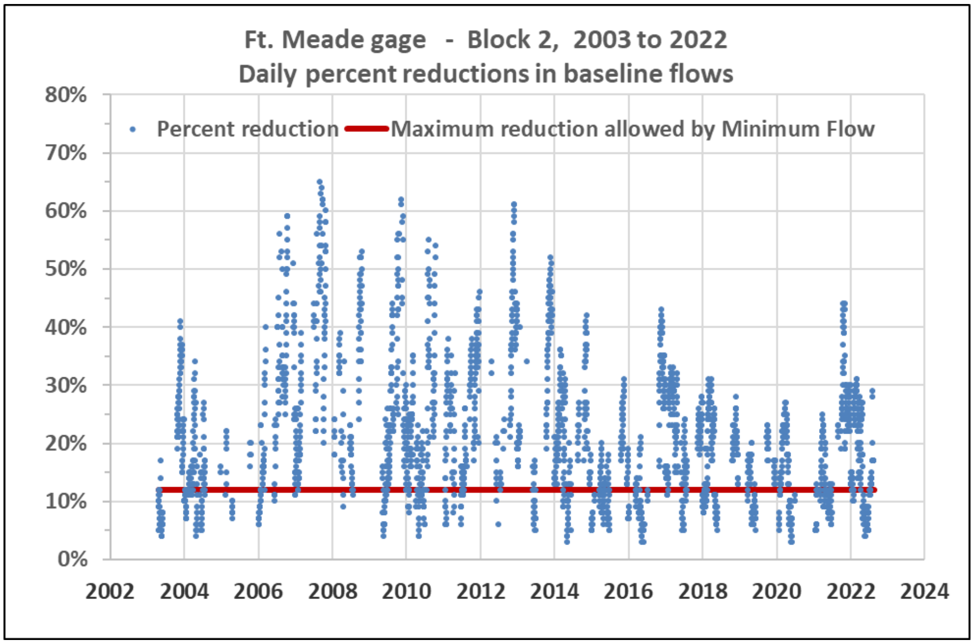


Figure 1. Time series of daily percent flow reductions at the Ft. Meade gage for Block 2 for 2003 to 2022. Percent reductions are calculated from the gaged flow as a percentage of the same-day baseline flow.

The time-series plot Block 1 for this same twenty-year period is shown in Figure 2. As listed in Table 1, Block 1 represents a low flow cutoff as no surface water withdrawals are allowed when flows are at or below 21 cfs at the Ft. Meade gage, thus the red reference line at 0% in Figure 2. The data shown in Figure 2 end in 2017, for there were no days after that year when the gaged flows were at or below 21 cfs. This was due in part to the operation of the Lake Hanock Project, but as previously described, this was also a generally wet period which also contributed to the river at the Ft. Meade gage largely staying above the ≤ 21 cfs threshold for Block 1.

However, in the dry spring of 2017, flows went to as low as 2 cfs at the Ft. Meade gage and 36 continuous days of zero flow were recorded at the USGS gage at Clear Springs, located about 10 miles upstream of Ft. Meade. It is important to note that dry years and sometimes series of consecutive dry years periodically occur in the Peace River basin. As described in my documents SF-4 and SF-6, a series of consecutive years with low or slightly below average rainfall occurred from 2006 to 2012 when percent reductions in baseline flows during Block 1 were frequently very high.

It is good that the Lake Hancock Project is helping increase the very low flows in the Upper Peace River. However, the occurrence of high percentage flow reductions in Block 1 shown below, particularly in the recent dry spring of 2017 and the fact that series of dry years periodically occur in the upper river basin, support my conclusion that the District's statement that the minimum flows for the Upper Peace River are being met is not correct, at least for Blocks 1 and 2 at the Ft. Meade gage.

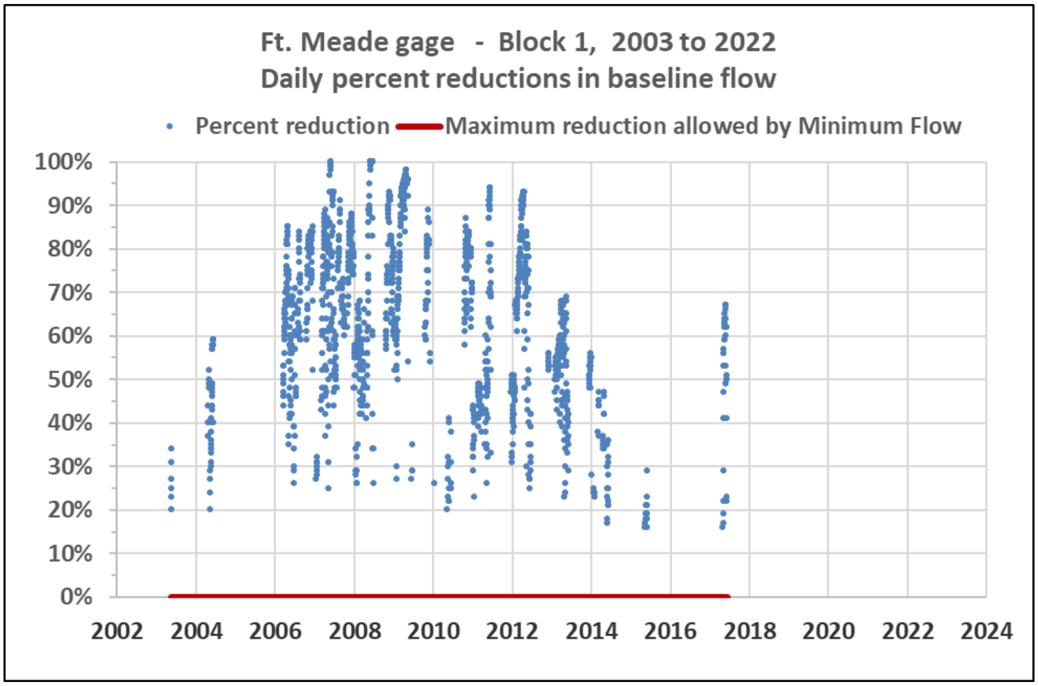


Figure 2. Time series of daily percent flow reductions at the Ft. Meade gage for Block 1 for 2003 to 2022. Percent reductions are calculated from the gaged flow as a percentage of the same-day baseline flow.

The results for Block 3A for this same twenty-year period are shown in Figure 3. Block 3A corresponds to fairly high flows between 122 cfs and 529 cfs at the Ft. Meade gage. As such, the ecological factors for determining the maximum allowable percent flow reduction of 10% for Block 3A (shown as the red reference line) were based on the inundation of floodplain habitats near Ft. Meade. A comparison of Figure 3 with Figure 1 indicates that flows occur less frequently Block 3A than in Block 2, as the gaged flows occurred on 27 percent of the days in Block 3A during the twenty-year period shown below.

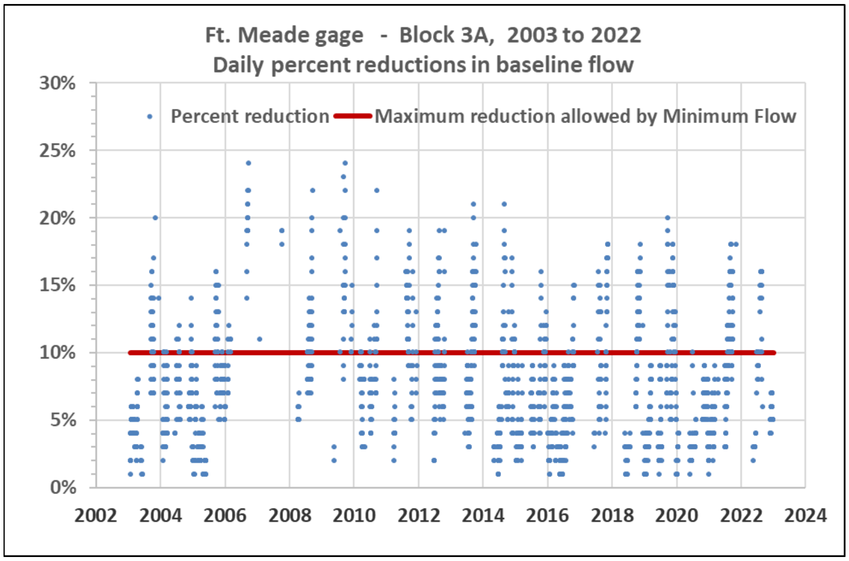


Figure 3. Time series of daily percent flow reductions at Ft. Meade gage for Block 3A for 2003 to 2022. Percent reductions are calculated from the gaged flow as a percentage of the same-day baseline flow.

Compared to Block 2, there was a much higher frequency of the gaged flows being within the maximum flow reduction limit for Block 3A allowed by the proposed minimum flows. The gaged flows met the minimum flow limit 77 percent of the days in Block 3A during this twenty-year period. This is was not unexpected, for as shown in my document SF-4, the daily percent flow reductions at Ft. Meade decline at increasing flow rates and largely meet the minimum flows at gaged flows above about 200 to 250 cfs. This fits with what is generally known about the Peace River at Ft. Meade, in that the low and medium flows are the most impacted near that location due to groundwater drawdowns and previous physical alterations to the river's watershed, especially extensive phosphate mining near the river channel.

A figure is not shown for Block 3B, which corresponds to flows above 529 cfs at Ft. Meade, as the gaged flows were within the minimum flow limits for all days during the period of analysis. During this twenty - year period, gaged flows were in Block 3B fourteen percent of the time, as this corresponds to high flows at the Ft. Meade gage.

Summary

Collectively, these results for the Ft. Meade gage clearly show that the gaged flows frequently do not meet the proposed minimum flows at that location, which is one of the three index gages that would be used to implement the proposed minimum flows for the Upper Peace River. I did not have to examine flows at the

Bartow gage, but they probably behave similarly. Also, as discussed in my other documents and in verbal communications to the scientific peer review panel, if the minimum flows are not being met at Ft. Meade that would preempt any surface water withdrawals at upstream locations, including near Bartow, as any such withdrawals would have to comply with minimum flows for all downstream index gages. However, my document SF-6 demonstrates that the minimum flows are being met at the Zolfo Spring gage, so new withdrawals near that location would be possible. Such withdrawals would also have much greater water supply yields as the flows are much greater at Zolfo Springs compared to Ft. Meade.

Conceivably, the District could possibly claim the minimum flows are being met for much of the time in Block 3A at the Ft. Meade gage, or better yet, raise the threshold for Block 3A to begin somewhere in the range of 200 to 250 cfs. However, the key thing at this time is the draft District report should be revised to conclude that the proposed minimum flows are not being much of the time at the Ft. Meade gage, as the overall conclusion in the draft report that the minimum flows for the Upper Peace River are being met is not supported by the data for the upper river at the Ft. Meade gage.

Feb 16, 2026

Technical memorandum (Document SF-12 on the minimum flows Webboard)

To: The Southwest Florida Water Management
From: Sid Flannery, Retired, formerly Chief Environmental Scientist, SWFWMD

Subject: Minimum flows for the Upper Peace River – Review of findings and suggested applications for practical and effective water management

Summary

This technical memorandum concerns the recent draft District minimum flows report for the Upper Peace River that is now being reviewed by the scientific review panel associated with that report. I have followed the review process, made public comments at the review panel meetings, and submitted documents to the minimum flows Webboard for the panel's review. This technical memorandum pulls together in one place a number of the key points and concepts I have presented to the scientific review panel.

The central conclusion of my analysis is the Upper Peace River at the Ft. Meade gage is not meeting the proposed minimum flows over much of the flow regime of the river at that location. This differs from the District report, which concludes that the Upper Peace River is currently meeting the minimum flows proposed for all of the three USGS index gages on the river which are located at Bartow, Ft. Meade, and Zolfo Springs.

My analyses found that the river at Ft. Meade is meeting the proposed minimum flows at fairly high flows rates at that gage, but they are not being met a large majority of the time at low and medium flow rates, so any new surface water withdrawals from the Peace River near Ft. Meade would not be possible over much of the flow regime in that reach of the river. For much of the time this would also preempt any surface water withdrawals linked to the Bartow gage, as any upstream surface water withdrawals would have to comply with the minimum flow limits at the downstream gages.

My analysis did find, however, that the minimum flows are being met at the Zolfo Springs gage, as the flows in the river improve and increase substantially downstream toward Zolfo Springs. As such, the findings in this memorandum should not result in any sort of water shortage issue as significant water supply yields from the Upper Peace River could be obtained near Zolfo Springs or other points farther downstream. The cost of any pipeline extended to an intake site near Zolfo Springs or another point downstream would be very cost efficient for providing significant water supplies for the region.

Any concerns about the possible need for additional recovery strategies for the Upper Peace River near Ft. Meade should not cause the District to incorrectly conclude that the minimum flows for the Upper Peace River are being met, for they clearly are not most of the time at the Ft. Meade gage. However, the Lake Hancock Project has improved the low flows in the Upper Peace River and this memorandum concludes with a discussion of economic and water management considerations related to the need, or not, for additional recovery strategies for the Upper Peace River.

Organization of this memorandum

The following section of this memo reviews the material presented in the draft District report related to the question of are the minimum flows for the Upper Peace River being met. The section after that summarizes flow duration characteristics of the Upper Peace River over different time periods. The important section that follows that compares the gaged and the baseline flows at the Ft. Meade gage, and concludes the proposed minimum flows are not being met at Ft. Meade over much of the flow regime of the river at that location. However, the minimum flows are being met at Zolfo Springs, and much greater water supply yields could be obtained there or at other points farther downstream.

This memorandum then concludes with a discussion of technical, practical, and economic considerations for the establishment and implementation of minimum flows for the Upper Peace River, including obtaining new surface water supplies from the river and the need, or not, for any additional recovery projects for the upstream reaches of the Upper Peace River.

Additional information for these topics can be found in documents that I have uploaded to the minimum flows Webboard, with references in this memorandum to direct readers to those other documents as needed.

Results presented in the draft District report about whether the minimum flows are being met

In my review of the District report, I initially focused on the findings for the USGS gage at Ft. Meade, which along with the gages at Barrow and Zolfo Springs, is one of the three index gages that are used to establish the minimum flows for the Upper Peace River. It is well known that this is one of the most highly impacted sections of the upper river, for as the District report describes, the Peace River is often a losing stream between Bartow and Ft. Meade as there are flow losses to the many sinks and fissures that have formed in the river channel and floodplain between those two locations.

Also, as described on page 1, if the minimum flows are not being met at Ft. Meade, it would preempt any new surface withdrawals associated with the Bartow gage, as any withdrawals would have to comply with the minimum flows at all downstream gages. As will be briefly described later in this memorandum, I also examined the results for the Zolfo Springs gage and the proposed minimum are consistently being met at that location, so that is not a limiting factor.

It is a bit ironic, for much of the District report is very well written with regard to the physical and ecological characteristic of the upper river, review of previous studies, flow trends in the river, and the habitat-based relationships that were analyzed to determine the minimum flows. However, the analyses that are presented in the report to determine if the minimum flows are being met were very limited.

To facilitate the question are the minimum flows being met, the percent withdrawal limits in the minimum flows proposed at the Ft. Meade gage are listed in Table 1 on the following page. A flow rate of 21 cfs serves as a low flow cutoff, as no surface water withdrawals would be allowed when flows at the Ft. Meade gage are at that flow rate or lower. Low flow thresholds such as that are routinely established in minimum flows and used to regulate surface water withdrawals from rivers.

Table 1. Flow ranges and maximum allowable percentage withdrawal rates for the four flow blocks at the Ft. Meade gage.

	Flow range	Percentage withdrawal limit
Block 1	< 21 cfs	0%
Block 2	>21 cfs and <120 cfs	12%*
Block 3A	> 121 cfs and < 529 cs	10%
Block 3B	> 529 cfs	7%

*** A full 12% cannot be taken until flows reach a rate of 24 cfs.**

As will be described, my analyses indicate the proposed minimum flows at the Ft. Meade gage are not being met over much of the flow regime of the river at that location. This is not, however, due to some over-restrictive aspect of the percent-of-flow method that was used to determine the minimum flows, as this method has been used in many minimum flows reports for freshwater streams with very favorable scientific review. Also, as will be described later in this memo, the proposed minimum flows associated with the Zolfo Springs gage have similar percentage withdrawal limits, and those minimum flows are consistently being met due to improved flows in the river at that location.

The approach the District took to determine the minimum flows for the Upper Peace River involved calculating a daily baseline flow regime for the three index gages on the river based on output from the Peace River Integrated Model 2 (PRIM2), along with some mathematical approximations to reflect the effects of groundwater use rates in years beyond the sixteen-year period for which the model was calibrated (2003 to 2018).

With this approach, a daily baseline flow regime was calculated for each of the three index gages for years 1975 to 2022. The draft District report presents hydrographs of mean and median daily values over the calendar year for both baseline and the measured gaged flows at each of the three gages. The District rightfully says that mean daily values for each year are highly influenced by periodic high flow events. I agree, and believe a comparison of median daily values can be more informative for evaluating flow conditions that frequently occur in the river.

Text continues on the following page

A hydrograph of median daily values for baseline and gaged flows over a calendar year in shown in Figure 1, which is reprinted from the draft District report and also my document SF-1 which is available on the minimum flows Webboard. From visual inspection. it appears that for much of the year the median daily values for the gaged flows are less that the baseline values by percentages that would exceed the limits allowed by the proposed minimum flows for the corresponding flow blocks at Ft. Meade.

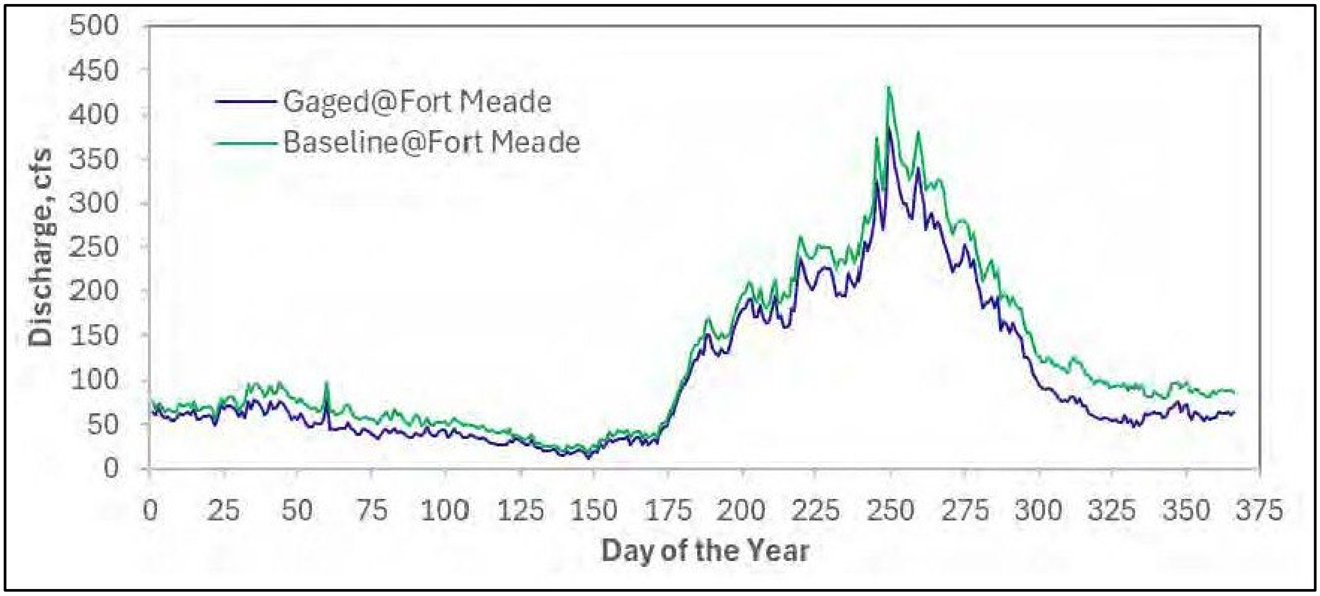


Figure 1. Median daily flows for the baseline flows and the gaged flows for the Peace River at the Ft. Meade gage calculated for the years 1975-2022. Reprinted from Figure 5-9 in the draft District report and document SF-1.

In late January, I requested the daily values for both baseline and gaged flows from the District. From these data I calculated daily values for baseline and gaged flows for each day of the year which matched the Figure in the District report shown above. A comparison of these values found that the gaged flows were less than the median values by percentages that were more than those allowed by the proposed minimum flows for 311 days, equal to 82 percent of the days during the year.

Text continued on the following page

The draft report also shows a cumulative distribution function graph, sometime called a flow duration curve, for baseline and gaged flows at the Ft. Meade gage, which is reprinted as Figure 2 below. Due the wide range of flow values that are shown, the Y axis of the graph is on a semi-log scale, which can make visual differentiation of differences between the two flow regimes difficult at some rates of flow. In document SF-7, I suggested the District redo this graphic with more tic marks and a finer scale on the Y axis and also list the values for various percent exceedance values for both baseline and gaged flows in a table.

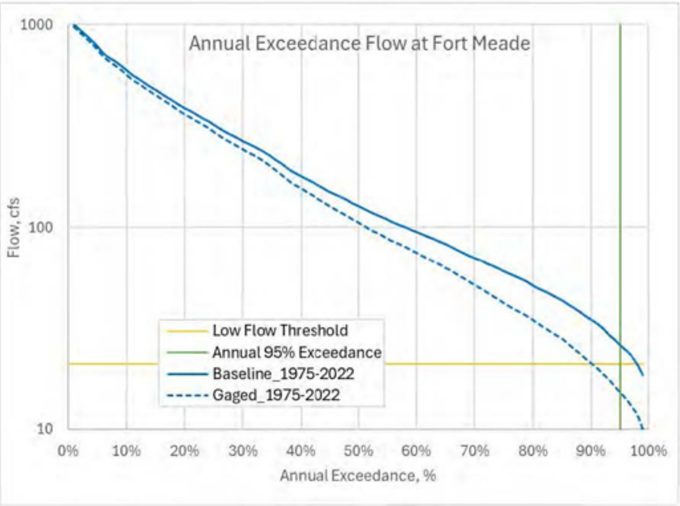


Figure 6-6. Annual exceedance flow for the USGS Peace River gage at Fort Meade for the periods 1975-2022, comparing baseline and gaged flows in relation to the low flow threshold.

Figure 2 – Reprinted from the draft District report and Document SF-1, with the legend contained in the Figure.

As part of my analysis of the gaged and baseline flow records, I calculated various percentile values for the period from 1975 to 2022 and two other periods. Rather than express the flows statistics as percent exceedance values as shown in Figure 2, I calculated the values as percentiles ranked from low to high flows. For example, a tenth percentile flow (P10) flow is equal to the 90 percent exceedance flow.

Mean flows and values for various percentiles are listed in Table 2 for both baseline and gaged flows for the years 1975 to 2022, which covers the entire period for which baseline flows were calculated. The mean value for gaged flows for this period (209 cfs) was 9% less than the mean value for baseline flows (230 cfs), but as previously described, mean flows are strongly influenced by periodic high flow events.

Table 2. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 1975 - 2022 (48 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	230	14	23	45	102	255	615	945
Gaged flow	209	3	7	26	78	230	591	923
Percent reduction	9%	79%	70%	42%	24%	10%	4%	2%

What is striking are the large reductions in the percentile values at low and medium flow rates. For example, the median (P50) value for gaged flows (78 cfs) represents a 24% reduction from the median baseline flow (102 cfs), keeping in mind that the proposed minimum flows only allow a 12% reduction at those flow rates. The percent reductions are much greater at low percentiles, ranging from 79% for the P5 values to 42% for the P25 values, which makes sense as it is well documented that the low flows at Ft. Meade have been impacted by groundwater drawdowns, leakage through karst features that have formed in in the river channel, and physical alterations to areas of land adjacent to the river resulting from phosphate mining.

The results in Table 2 indicate the high flows at Ft. Meade have not been as affected, which will be demonstrated later in this memo where plots of percent reductions in daily baseline flows are plotted versus the rate of flow. Also, the percent reductions listed in Table 2 include the earlier decades in the 1975 to 2022 period, when groundwater withdrawals were greater and groundwater levels in the Floridan Aquifer were lower. Flow duration statistics for two more recent periods will be discussed in the next section of this memorandum, along with a discussion of climatic effects on flows in the Upper Peace River.

Possibly the most perplexing conclusion in the District report on the question of whether the minimum flows are being met is in Chapter 7, which is titled Minimum Flows, Status, Implementation, and Conclusions. This chapter is two pages long and contains a three-sentence paragraph on page 233 that begins with the two sentences reprinted below.

> “Table 5-6 presents estimated monthly adjustment flows due to withdrawal-related effects over a 16-year assessment period. Collectively, these findings indicate the recommended minimum flows for the Upper Peace River are currently being met.”

Table 5-6 that referred to this paragraph is reprinted on the following page.

Text continues on the following page

Table 3. Reprinted from the draft District report and document SF-1.

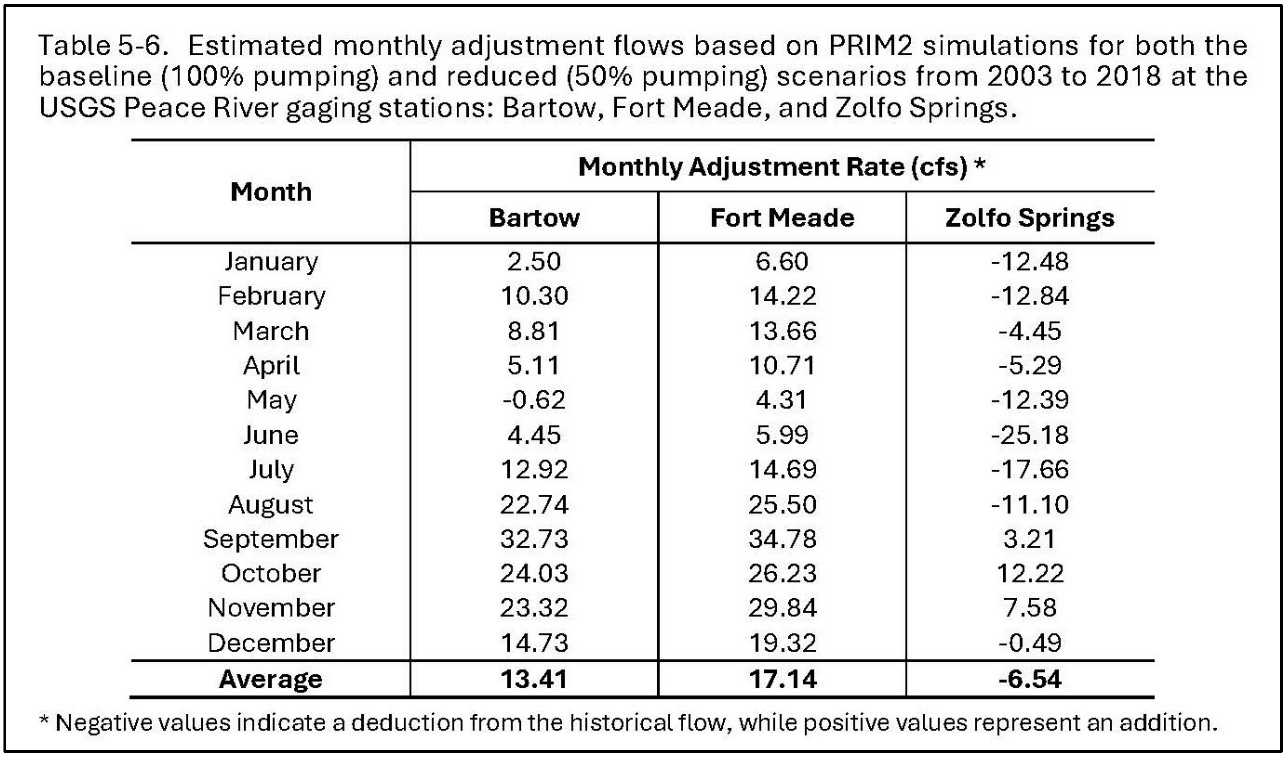


Table 5-6. Estimated monthly adjustment flows based on PRIM2 simulations for both the baseline (100% pumping) and reduced (50% pumping) scenarios from 2003 to 2018 at the USGS Peace River gaging stations: Bartow, Fort Meade, and Zolfo Springs.

Month	**Monthly Adjustment Rate (cfs) ***		
	Bartow	**Fort Meade**	**Zolfo Springs**
January	2.50	6.60	-12.48
February	10.30	14.22	-12.84
March	8.81	13.66	-4.45
April	5.11	10.71	-5.29
May	-0.62	4.31	-12.39
June	4.45	5.99	-25.18
July	12.92	14.69	-17.66
August	22.74	25.50	-11.10
September	32.73	34.78	3.21
October	24.03	26.23	12.22
November	23.32	29.84	7.58
December	14.73	19.32	-0.49
Average	**13.41**	**17.14**	**-6.54**

* Negative values indicate a deduction from the historical flow, while positive values represent an addition.

First, the heading of the table is unclear and needs to be revised. However, the text on page 179 states these are the monthly adjustment rates for a zero-pumping condition (baseline flows) for the modeling period from 2003 to 2018 for which the PRIM2 model was calibrated. Positive values mean addition to the gaged flow to get to baseline flows, while negative values mean that a subtraction from the gaged flows to get to baseline flows.

In contrast to the two sentences from the draft District report reprinted on the previous page, my interpretation of this table indicates that the minimum flows at the Ft. Meade gage are not being met for much of the year. For example, the amount of flow reduction allowed in Block 2 in the proposed minimum flow rule for the Ft. Meade gage is 12% at flows between 22 and 121 cfs. The median gaged flow at Ft. Meade for this same 16-year period represented in Table 3 was 70 cfs or midway in this range. How can the yearly average flow adjustment of 17.14 cfs for Ft. Meade at the bottom of Table 5-6, which equals 24% of the median gaged flow for the river at the Ft. Meade gage during that period, not result in flow reductions greater than the minimum flows for much of the year.

Similarly, the median gaged flow for March at Ft. Meade during that period was 30 cfs. How can a flow adjustment of 13.66 cfs for March not greatly exceed the allowable flow reductions during that month for much of the time? The District's reference on page 233 to Table 5-6 needs to be revised or clarified in the context of how the percent- of-flow method is typically applied, for it is currently used to regulated major water supply withdrawals from the Alafia, Little Manatee, and the Lower Peace River.

While at the District I was directly involved in the scientific evaluation and regulatory application of those permitted surface water withdrawals, and know well that the hydrologic analyses, water supply simulations, regulatory limits, and the assessment of the withdrawals on the rivers' ecology all involved assessing changes in flows on a daily basis as a function of flow. Changes in flows and surface water withdrawals were not assessed on an average monthly or average yearly basis to assess compliance.

Application to groundwater withdrawals using the percent-of-flow method are assessed over longer time periods. However, minimum flows reports are supposed to be clear in how surface water withdrawals from rivers will be evaluated and regulated. The information in Table 5-6, as referred to on page 233 in in Chapter Seven of the report, does not support the statement that the Upper Peace River is meeting the minimum flows at the Ft. Meade gage.

This is similar to my conclusions for Figures 1 and 2 presented in this memorandum, in that I don't think the limited results presented in the draft report support the District's general conclusion that the minimum flows for the Upper Peace River are being met. Using the standard application of the percent-of-flow method for regulating surface water withdrawals, they certainly don't seem to be met over much of the flow regime at the Ft. Meade gage.

I did not have time to examine the relationship of gaged and baseline flows at the Bartow gage, but based on what is known about that reach of the river and combined data and results for Bartow gage presented in the draft District report, it I likely the flows behave similarly to Ft. Meade. Regardless, for as previously described, if the minimum flows are not being met at the Ft. Meade gage, that would preempt any surface water withdrawals linked to the Bartow gage.

My analyses of whether the minimum flows are being met at the Ft. Meade gage

1. Flow duration statistics during different periods of analysis

As mentioned on page 4, I requested and received from the District their records for the calculated baseline flows and gaged flows measured by the USGS at the three index gages that were used to develop the proposed minimum flows for the Upper Peace River. Before I present some of the results that I generated, I want to discuss an important topic that I assessed and has also been emphasized in comments by the scientific review panel in their public meetings. That is the flow duration characteristics for the various periods over which the minimum flows were assessed in the District report.

The panel has mentioned that the period for which the Lake Hancock Project has been operable (starting in 2016) has generally been wet, which has helped the river meet the existing low minimum flows for the Upper Peace River. I agree and the flow duration characteristics for the period from 2016 to 2022, for which baseline flow are available, is discussed on the following pages. Another key period that is discussed is the sixteen-year period from 2003 to 2018 over which the PRIM2 model was calibrated. Flow duration statistics entire period for which baseline flows were calibrated were listed in Table 2 on page 5 and are also referenced in the following discussion.

The first period for consideration is the period from 2003 to 2018. Again, this is the period over which the PRIM2 was calibrated and it probably represents the most accurate predictions for the baseline flows. Mean and percentile values for flows at the Ft. Meade gage for the period from 2003 to 2018 are listed in Table 4, which is reprinted from document SF-4. In both Table 2 and Table 4 below, the values for baseline flows are very helpful for the baseline flows account for changes in groundwater withdrawals, thus the values for baseline flows should best reflect climatic conditions over these periods.

Table 4. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 2003 - 2018 (16 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	237	11	18	39	87	267	696	1008
Gaged flow	220	3	6	21	70	246	675	986
Percent reduction	7%	73%	67%	46%	20%	8%	3%	2%

It is notable that the mean baseline value for 2003 to 2018 (237 cfs) is very close to the mean value of 230 cfs for the 48-year period from 1975 to 2022, which probably best represents the long-term climatic conditions in the upper river basin. The high flow statistics for the river represented by the P75, P90, and P95 values are also similar between the two periods, and as previously discussed, high flows in the river have a very large effect on the means.

The values for the median value and the lower percentiles for baseline flows are slightly less for this period than for the long-term 1975-2022 period. For example, percentile values for the long-term period compared to the 2003 to 2018 period are as follows, with the long-term period listed first: P5 = 14 cfs vs. 11 cfs; P10 23 cfs vs. 18 cfs; P25 45 cfs vs. 39 cf; and P50 102 cfs vs, 87 cfs. Although the differences in these quantities are fairly small, they are meaningful because the Upper Peace River at Ft. Meade frequently has such very low flows.

What is notable about the 2003-2018 period is that it included one of the most prolonged dry periods in the last few decades, that being a series of consecutive years of below average rainfall from 2006 to 2013. Figure 2-37 in the draft District report shows that rainfall deficits were particularly large in 2006 and 2007, with the 5-year moving average rainfall in 2010 being the lowest in 108 years of record shown in that Figure. Although the period contained some wet years including 2004, 2025 and consecutive years with above average rainfall from 2015 to 2018, the 2003 to 2018 period is very helpful for assessing the minimum flows it shows the effects of dry years on flows in the river.

Before leaving Table 4, it is notable that the gaged flows for the 2003 to 2018 period were much less than the baseline flows for the median and lower flow percentiles. The median gaged flow represented a 20% reduction from the baseline value in the flow range for which the minimum flows only allow a 12% reduction at Ft, Meade. The percent reductions in the P5 to the P25 flows are much greater, ranging between 46% and 73%, with the greatest reductions at the lowest percentile values.

A very different situation existed for the period from 2016 to 2022, which was the years for which baseline flows were calculated and the Lake Hanock Project was also operable. Table 5 lists the mean and percentile values for the Ft. Meade gage during this recent seven-year period.

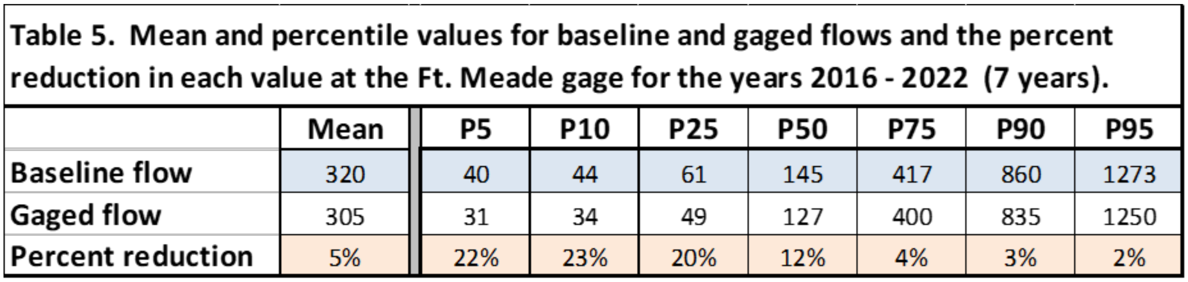


Table 5. Mean and percentile values for baseline and gaged flows and the percent reduction in each value at the Ft. Meade gage for the years 2016 - 2022 (7 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	320	40	44	61	145	417	860	1273
Gaged flow	305	31	34	49	127	400	835	1250
Percent reduction	5%	22%	23%	20%	12%	4%	3%	2%

This was a fairly wet period, as there were five years with above average rainfall in this seven-year period (see Figure 2-37 in the District report). As a result, the mean value for baseline flows during this period of 320 cfs was considerably greater than the mean baseline values of 230 and 237 cfs for the 1975-2022 and the 2003-2018 periods, respectively. In document SF-6, I calculated average gaged flows over moving seven-year periods from 1981 to 2002 and the mean value of 305 cfs for 2016 to 2022 was the second highest values in the 42 years for which seven-year moving average values could be calculated.

The values for all the baseline percentile values, both low and high, were also much greater than for the other two periods, again emphasizing the baseline values take out the effects of groundwater withdrawals so they should best represent changes in climatic conditions.

What is also notable in Table 5 is that the percent flow reductions from baseline to gaged flows are much smaller than for the other two periods previously discussed for Tables 4 and 5. This is especially true for the low percentile values (P5 to P25) as the percent reductions were much lower with values between 20 and 22 percent. However, the proposed minimum flows only allow a 12% withdrawal in Block 2, which extends between daily flow rates of 22 and 120 cfs, so these reductions still would be in excess of that allowed by the proposed minimum flows rule at the Ft. Meade gage.

Still, this improvement in the low percentile values is promising, and to some extent likely reflects the operation of the Lake Hancock Project during this period. However, there appears to be a major climatic factor for the high P5 and P10 values in Table 5, as this was a fairly wet seven-year period. There is serial effect to flows in that wet years and high flows tend to bring up aquifer levels, which may slow the rate of groundwater loss from the river to the underlying aquifer during dry periods.

It is also important to note in the dry spring of 2017, flows went to as low as 2 cfs at the Ft. Meade gage and 36 continuous days of zero flow were recorded at the USGS gage at Clear Springs, located about 10 miles upstream of Ft. Meade. It is important to recognize that dry years and series of consecutive dry years periodically occur in the Peace River basin, such as during 2006 to 2012 which are reflected in the results in Table 4.

In that regard, I offer a cautionary note, in that the encouraging results from the more recent years seem to have been influenced by a strong climatic effect in addition to the release of water from Lake Hancock.

In their comments at their public meetings, the scientific review panel seems to recognize this climatic effect as well. In that regard, it will be important to evaluate the effectiveness of the Lake Hanock Project in dry periods and years, such as occurred in the spring of 2017.

2. Time-series of percent reductions in baseline flows at the Ft. Meade gage

Three other simple but informative analytical techniques were performed to examine how well the gaged flows at the Ft. Meade are meeting the proposed minimum flows for that gage. These are time-series plots of percent reductions in daily baseline flows, plots of percent reductions in baseline flows vs. gaged flow rates, and statistical summaries of the percent of time in each of the flow blocks the gaged flows met the proposed minimum flows at the Ft. Meade gage. These results were generated for two of the periods that have been previously described; from 2003 to 2018 and from 2016 to 2022.

These two time periods are grouped together in time-series plots of the daily values for percent reductions in baseline flows in this section, with the data grouped by the flow blocks used to implement the minimum flows. These plots were also presented with additional discussion in document SF-11.

The graphic for Block 2 is presented first in Figure 3 below, as this is a critical block for the river's ecology as it corresponds to habitats and biological communities within the river channel, as does Block 1. However, I consider the flow reductions in Block 2 to be more problematic. The Lake Hancock Project primarily benefits flows in Block 1, but Block 2 is equally important to the ecology of the river.

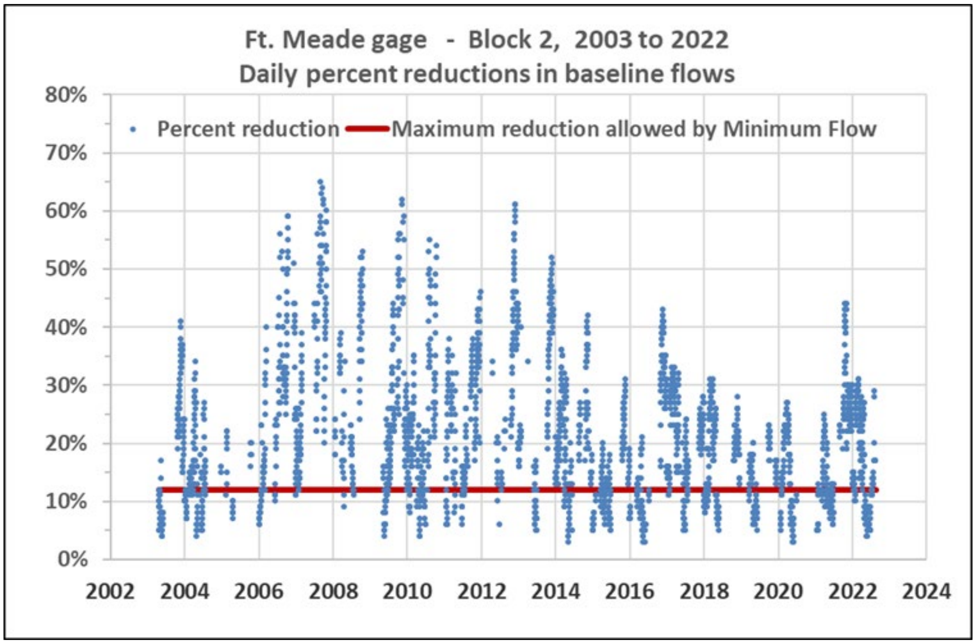


Figure 3. Time series of daily percent flow reductions at Ft. Meade for Block 2 for 2003 to 2022. Percent reductions are calculated from the gaged flow as a percentage of the same-day baseline flow.

For the twenty-year time period shown in Figure 3, gaged flows were in Block 2 thirty-nine percent of the time. As shown in Figure 3, percent flow reductions can be very high in Block 2, as the maximum percent allowable flow reduction in daily flows for Block 2 is twelve percent, which is shown by the red reference line in Figure 3. If a daily gaged flow was greater than the corresponding baseline flow it would show up as negative value, but there were no days in this 20-year period when a gaged flow at Ft. Meade was higher than baseline flow in any of the blocks.

Daily flow reductions in excess of 50% occurred in Block 2 in a number of years. As previously discussed, the period after 2016 was generally wet, although a dry spring occurred in 2017. It is notable that flow reductions in excess of 30% occurred late in 2016 and the spring of 2017, but also briefly in 2018 and at the end of 2021. Percent flow reductions in excess of 20% were common in the first part of 2022.

It is clear that the minimum flows are frequently not being met during Block 2 at the Ft. Meade gage. The minimum flows in Block 2 were met (percent reductions at or less than the maximum allowable limit) only 24% of the time during this 20-year period. As will be discussed in another section, the minimum flows were only met 30% of the time in Block 2 during the wet period from 2016 to 2022 when the Lake Hancock Project was in effect. The results for Block 2 at Ft. Meade alone support my disagreement with the general conclusion in the draft District report that the minimum flows for the Upper Peace River are being met.

The time-series plot Block 1 for this same twenty-year period is shown in Figure 4. As listed in Table 1, Block 1 represents a low flow cutoff as no surface water withdrawals are allowed when flows are at or below 21 cfs at the Ft. Meade gage, thus the red reference line at 0% in Figure 2. The data shown in Figure 4 end in 2017, for there were no days after that year when the gaged flows were at or below 21 cfs. This was due in part to the operation of the Lake Hanock Project, but as previously described, this was also a generally wet period which also contributed to the river at the Ft. Meade gage largely staying above the ≤ 21 cfs threshold for Block 1.

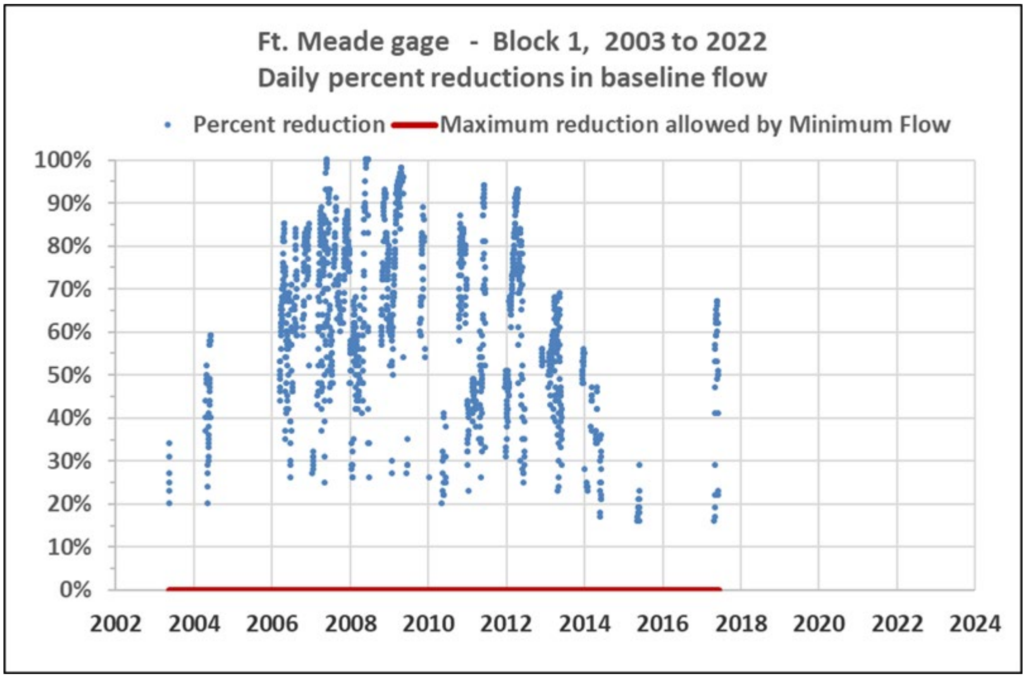


Figure 4. Time series of daily percent flow reductions at Ft. Meade for Block 1 for 2003 to 2022. Percent reductions are calculated from the gaged flow as a percentage of the same-day baseline flow.

As also previously discussed, flows went to as low as 2 cfs at the Ft. Meade gage in the dry spring of 2017, which is shown by high percent reduction values during 2017 in Figure 4. As described in my documents SF-4 and SF-6, a series of consecutive years with low or slightly below average rainfall occurred from 2006 to 2012 when percent reductions in baseline flows during Block 1 were frequently very high.

It is good that the Lake Hancock Project is helping increase the very low flows in the Upper Peace River. However, the occurrence of high percentage flow reductions in Block 1, particularly in the recent dry spring of 2017, and the fact that series of dry years periodically occur in the upper river basin, support my conclusion that the District's statement that the minimum flows for the Upper Peace River are being met is not correct, at least for Blocks 1 and 2 at the Ft. Meade gage.

The results for Block 3A for this same twenty-year period are shown in Figure 5. Block 3A corresponds to fairly high flows between 122 cfs and 529 cfs at the Ft. Meade gage. As such, the ecological factors for determining the maximum allowable percent flow reduction of 10% for Block 3A (shown as the red reference line) were based on the inundation of floodplain habitats near Ft. Meade. A comparison of Figure 3 with Figure 5 indicates that flows occur less frequently Block 3A than in Block 2, as the gaged flows occurred on 27 percent of the days in Block 3A during the twenty-year period shown below.

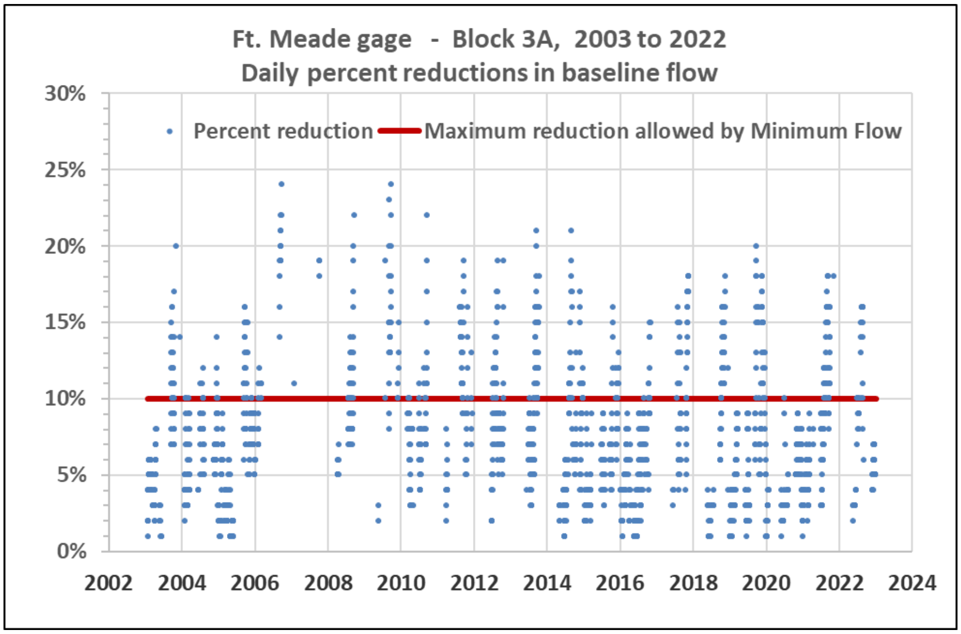


Figure 5. Time series of daily percent flow reductions at Ft. Meade gage for Block 3A for 2003 to 2022. Percent reductions are calculated from the gaged flow as a percentage of the same-day baseline flow.

Compared to Block 2, there was a much higher frequency of the gaged flows being within the maximum flow reduction limit for Block 3A allowed by the proposed minimum flows. The gaged flows met the minimum flow limit 77 percent of the days in Block 3A during this twenty-year period. This is was not unexpected, for as shown in my document SF-4, the daily percent flow reductions at Ft. Meade decline at increasing flow rates and largely meet the minimum flows at gaged flows above about 200 to 250 cfs.

This fits with what is generally known about the Peace River at Ft. Meade, in that the low and medium flows are the most impacted near that location due to groundwater drawdowns and previous physical alterations to the river's watershed, especially extensive phosphate mining near the river channel.

A figure is not shown for Block 3B, which corresponds to flows above 529 cfs at Ft. Meade, as the gaged flows were within the minimum flow limits for all days during the period of analysis. During this twenty - year period, gaged flows were in Block 3B fourteen percent of the time, as this corresponds to high flows at the Ft. Meade gage.

3. Percent reductions in baseline flows as a function of the rate of flow

The time series plots previously described indicate that percent reduction in baseline flows lessen at higher rates of flow. To examine this more directly, plots of percent reductions in baseline flow at the Ft. Meade gage that were included in my document SF-4 are reprinted in this section of this memorandum.

Daily percentages that gaged flows are reduced from baseline flows are plotted vs. the same-day gaged flow rates in Figure 6 for the sixteen-year period from 2003 to 2018. Red reference lines show the maximum percent reductions allowed by the proposed minimum flow rule for Blocks 1, 2 and 3A at Ft. Meade, with the data not extending into Block 3B which starts at a flow rage of 529 cfs, which is not shown in order to give better resolution on the X axis.

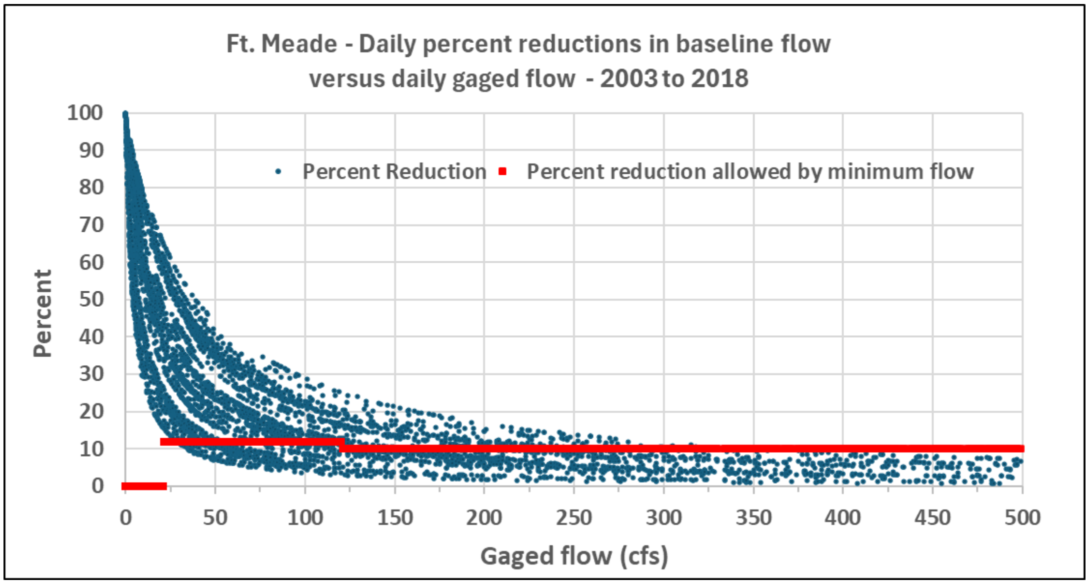


Figure 6. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow at Ft. Meade for the years 2003 – 2018.

There is a clearly a strong nonlinear relationship in the greatest flow reductions occur at low flows and substantial reductions occur over range of medium flows. As listed in Table 4, the median gaged flow for this period was 70 cfs and flows were less than 246 cfs seventy-five percent of the time. This nonlinear relationship with flow fits with what as it has been well documented in several studies, in that the low flows in the upper river have been highly impacted near the Ft. Meade gage.

However, there is clear pattern of the percent reductions being within the minimum flow percentages at higher flow rates.   Flows above 500 cfs occurred during the 2003 to 2018 period covered by Figure 6, but even though the allowable percentage withdrawal rates goes down to seven percent at flow rates above 529 cfs, the river continued to comply with the minimum flow limits above that flow.

A similar graph for the seven-year period from 2016 to 2022 at Ft. Meade is shown in Figure 7. It is obvious from this graph that this period included much less that data than from sixteen-year period from 2003 to 2016. Also, as previously discussed, the gaged flows (and corresponding baseline flows) were generally higher during this period, so there is not as much data at low and low-medium flows.

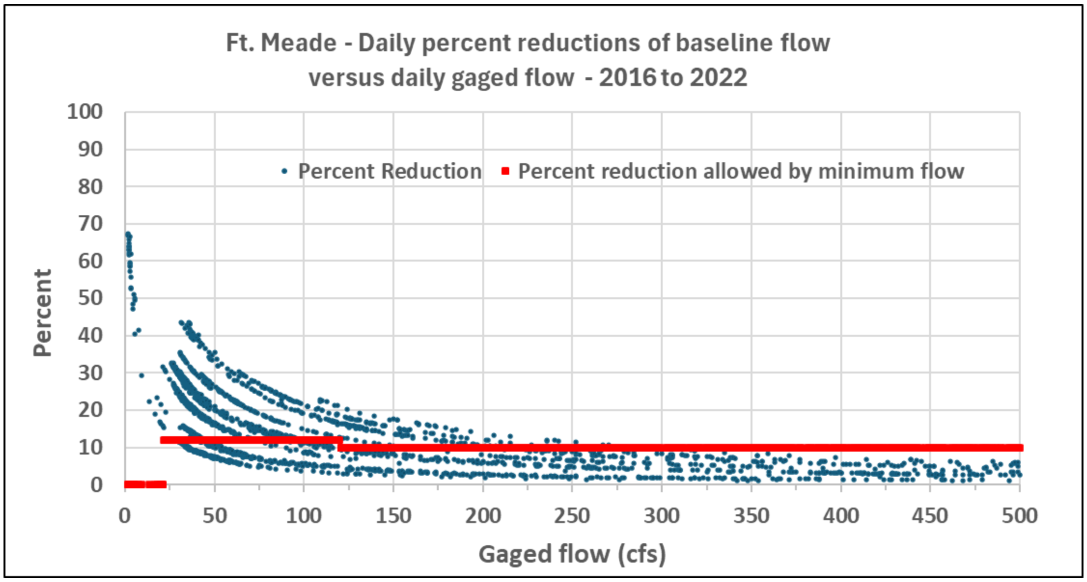


Figure 7. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow at Ft. Meade for the years 2016 to 2022.

Still, the same patterns emerge as percentage reductions in baseline flows are greatest at low flows and extend to medium flows. Seventy-two percent of the days below the long-term median baseline flow of 102 cfs listed in Table 2 did not meet the minimum flows, while 63% of the days below the long-term 75th percentile baseline flow of 255 cfs did not meet the minimum flows during this period.

As previously described, this was generally a wet period and this may have helped keep groundwater levels somewhat higher near the river which benefited dry season flows. The Lake Hancock project also seemed to benefit the low flows in the river, as the reductions in gaged flows in Block 1 ($\leq$ 21 cfs) maxed out at percentages between 60 and 70 percent, whereas the 2003 to 2018 periods had many days with flow reductions between 70 and 100 percent at very low flows. Also, it should be noted that when the baseline flow is very small (less than 10 or so cfs), relatively small reductions in flow can result in large percentage changes.

As previously discussed, there was a very dry spring in 2017, which is when most of the flows in Block 1 occurred within this seven-year period. The data indicate the Lake Hancock project is benefitting the low flows of the upper river, but the effectiveness of the project should be revisited in drier years or a series of years that have more prolonged dry conditions than what occurred during the 2016 to 2022 period.

Finally, Figures 6 and 7 indicate that flow reductions that comply with the maximum allowable flow reductions in the proposed minimum flow rule occur at flow rates above about 200 to 250 cfs, which are within Block 3A at the Ft. Meade gage, and though not shown in this memo, the minimum flows are consistently met in Block 3B, which starts at a flow rate of 529 cfs at the Ft. Meade gage.

These results indicate that surface water withdrawals could be obtained at Ft. Meade during high flows, but the frequency that this could occur would be fairly small and likely impractical as much greater withdrawals could be obtained at Zolfo Springs over a much larger percentage of the time, including all of Block 2 at that location.

4. Percentages of time within each block that minimum flows are met at the Ft. Meade gage

Another way to evaluate the effectiveness of the minimum flows is to examine the number of days within each of the flow blocks that met the percentage flow reductions allowed by the proposed minimum flows. The values for the period from 2003 to 2018 are listed in Table 6, calculated for days when the gaged flows were within the various flow blocks at the Ft. Meade gage. It is notable that during this period, which included some low flow years, the gaged flows in river at Ft. Meade were in the low flow Block 1 twenty-five percent of the time, which is quite a lot.

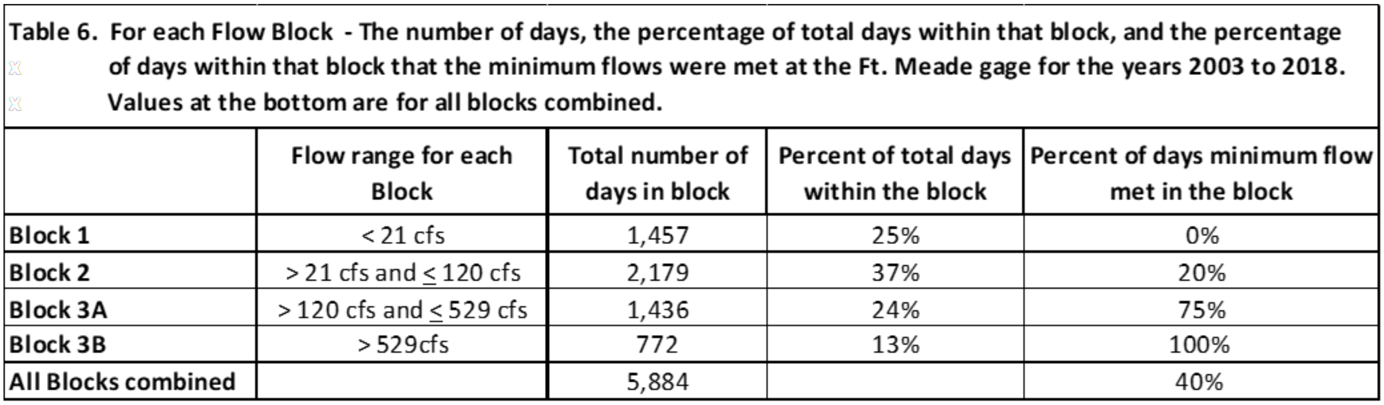


Table 6. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of days within that block that the minimum flows were met at the Ft. Meade gage for the years 2003 to 2018. Values at the bottom are for all blocks combined.

	Flow range for each Block	Total number of days in block	Percent of total days within the block	Percent of days minimum flow met in the block
Block 1	< 21 cfs	1,457	25%	0%
Block 2	> 21 cfs and ≤ 120 cfs	2,179	37%	20%
Block 3A	> 120 cfs and ≤ 529 cfs	1,436	24%	75%
Block 3B	> 529cfs	772	13%	100%
All Blocks combined		5,884		40%

Block 2 is very important for the ecology of the river, as it based on habitats and communities that are in the river channel, which are closely related to the water levels and current velocities of the river. During this 16-year period, only 20% of the flows at Ft. Meade would have met the minimum flows in Block 2.

A total of 37% of the days in this period were in Blocks 3A and 3B, which correspond to flows that inundate the floodplain of the river. The percentages that the minimum flows were met were much higher for these blocks, at 70% for Block 3A and 100% for Block 3B. This is keeping with the data shown in Figures 6 and 7 that the percent reductions in baseline flows are much less at high flows in the river. Finally, for all the blocks combined, basically all days in this sixteen-year period, the minimum flows were only achieved 40 percent of the time.

As it was during a generally wetter period, the results for the period from 2016 to 2022 at Ft. Meade are much different (Table 7). The first very striking point is the smaller percentage of days in Block 1, which was partly due to climate, and possibly due operation of the Lake Hancock Project. However, the baseline flows only had 33 days in Block 1. As previously discussed, generally weather helps groundwater levels in the region, and most of the days in Block 1 in this period occurred in the spring of 2017, which was the driest stretch of time during this seven-year period.

Table 7. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of days within that block that the minimum flows were met at the Ft. Meade gage for the years 2016 to 2022. Values at the bottom are for all blocks combined.

	Flow range for each Block	Number of days in the Block	Percent of total days within the Block	Percent of days minimum flow met withinin the Block
Block 1	< 21 cfs	37	1%	0%
Block 2	> 21 cfs and ≤ 120 cfs	1,197	47%	30%
Block 3A	> 120 cfs and ≤ 529 cfs	840	33%	81%
Block 3B	> 529cfs	483	19%	100%
All Blocks combined		2,557		59%

Nearly half for the total number of days in this period occurred in Block 2, again demonstrating the importance of this flow block to the ecology of the river. The minimum flows were met only 30% of the time in Block 2, which clearly means the minimum flows oriented to the health of the river channel near Ft. Meade were not adequately met. As with the 2003 to 2018 period, the percentages of days that met the minimum flows were much higher for Blocks 3A and 3B, with 100 percent compliance in Block 3B. The minimum flows were met for 59% of all the days in this recent seven-year period, which is a surprisingly low number, given that it was a relatively wet period.

Collectively, the findings presented in this memorandum strongly suggest that it would be incorrect for the District to conclude in the minimum flows report that the minimum flows at the Ft. Meade gage are being met. The minimum flows are not being met a large majority of the time over much of the flow regime of the river at this location. The minimum flows are being met at high flows at Ft. Meade, above flow rates of approximately 200 to 250 cfs. However, this would make the frequency of time that new surface water supplies would be available at Ft. Meade to be fairly low.

As previously discussed, this also has application to the river near the Bartow gage, as withdrawals from that reach of the river would have to also comply with the minimum flow limits at Ft. Meade. I did not have time to analyze the data at Bartow, but due to the existing flow reduction conditions at Ft. Meade, it is expected that any surface water for possible withdrawal at Bartow would possibly be available only infrequently during periods of high flow.

5. Percent of time that the minimum flows are being met at the Zolfo Springs gage

Compared to Ft. Meade, a very different situation exists at the Zolfo Springs gage, which is located about 23 river miles downstream of Ft. Meade. The results presented in the draft minimum flows report indicate that the minimum flows are being met at the Zolfo Springs gage nearly all the time, as there are significant increases in flow and improvements in the flow regime of the Upper Peace River between Ft. Meade and Zolfo Springs.

This conclusion should be viewed with some degree of caution as it closely related to modeling simulations, which inherently involve some degree of error. For example, as discussed in my document SF-1 and has also been raised in discussions by the scientific review panel, the approach taken with the PRIM2 model might underestimate the baseline flows for it assumes the gains in river flow as a function of groundwater levels respond linearly, and in the approach that was taken, the gain in flows observed between the existing groundwater withdrawals and a 50 percent cutback in withdrawals was simply doubled to estimate the gain in flows that would result from a complete cutback in groundwater withdrawals. The scientific review panel has commented on this at the public meetings.

Also, it is stated in the draft minimum flows report, part of the gain in flow between Ft. Meade and Zolfo Springs is due in to excess flows resulting from agricultural operations upstream of the Zolfo Springs gage. In that regard, it is important to note that the District has strongly emphasized increased water use efficiency for agricultural operations, and in some basins such as the Little Manatee River, it has been clearly demonstrated that excess flows from agricultural operations have markedly declined in recent years in part due to increased water use efficiency for various agricultural practices.

Combined, these modeling assumptions and uncertainties and possibly future increases in agricultural water use efficiency should be the cause for some caution and close monitoring of flows in the Upper Peace River. However, at this time the results presented in the draft minimum flows report indicate that the minimum flow requirements for the Upper Peace River are being met at the Zolfo Springs gage.

The material presented in this memorandum to support this finding is presented is a more concise and limited manner compared to the information that was presented for Ft. Meade, as the situation is completely different at Zolfo Springs. As it represents a longer and drier and thus more conservative period for analysis, the results presented in this memorandum for the Zolfo Springs gage are limited to the sixteen-year period from 2003 to 2018, over which the PRIM2 model was calibrated and it also includes three years that the Lake Hancock Project was operable.

My assessment of minimum flows conditions at the Zolfo Springs gage were presented in document SF-6, which was uploaded to the minimum flows Webboard. Some findings from that document are presented in this memorandum Table 8 lists the mean flow and selected percentile values for baseline and gaged flow values for the period from 2003 to 2018.

The first key point to Table 8 is how much greater the flow quantities are at Zolfo Springs compared to the values presented for the same time period at Ft. Meade in Table 4. For example, the mean gaged

Table 8. Mean and percentile values for baseline and gaged flows and the percent increase in each value as gaged relative to baseline at the Zolfo Springs gage for the years 2003 - 2016 (16 years).

	Mean	P5	P10	P25	P50	P75	P90	P95
Baseline flow	545	24	35	89	234	636	1500	2075
Gaged flow	540	29	43	93	241	639	1510	2080
Percent Change	-1%	+21%	+23%	+4%	+3%	0%	+1%	0%

flow at Zolfo Springs was 540 cfs compared to a mean value of 220 cfs at Ft. Meade. Similarly, the median (P50) gaged flow at Zolfo Springs was 234 cfs compared to a median value of 70 cfs at Ft. Meade.

The other key point is that percentile values for gaged flows are either nearly the same or higher than the corresponding percentile value for baseline flows, denoted by positive percent changes in Table 8. The percent increases are greatest for the low percentile values, at +21% for the P5 values and +23% for the P10 values. This is completely opposite from the Ft. Meade gage, where large percent reductions were observed for the low percentile values. These results, which again are related to modeled baseline values, indicate the flow losses at Ft. Meade are made up for by increased low flows at the Zolfo Springs gage.

This change in low flows is also apparent in Figure 8, where daily percent changes from baseline to gaged flows are plotted vs. the same-day rate of gaged flow for the period 2003 to 2018. Negative values indicate the daily gaged flow is greater than the baseline flow, with the maximum allowable percent flow reduction denoted by the red reference lines.

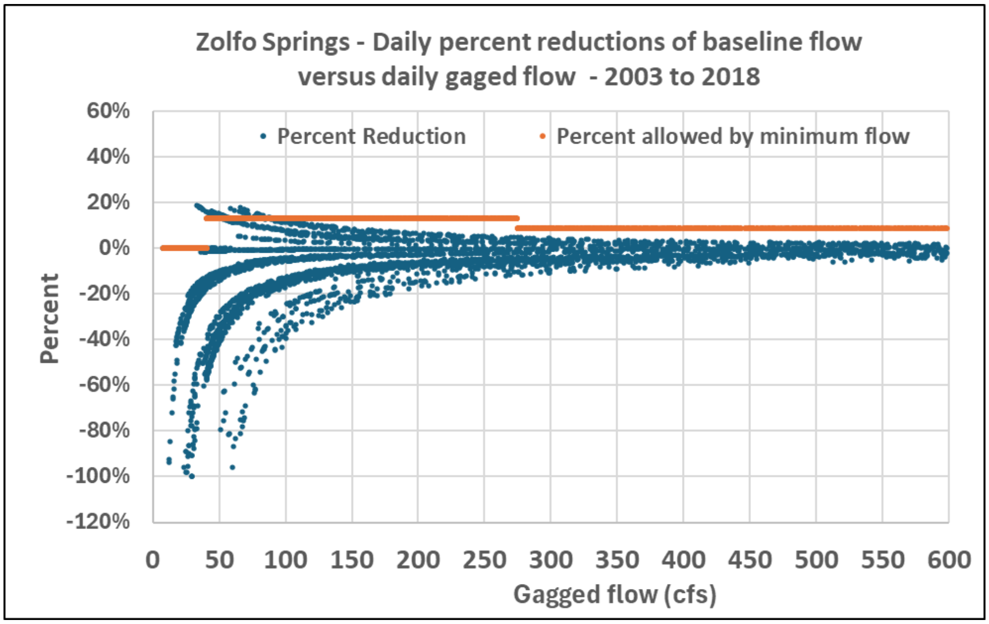


Figure 8. Daily values for the percentage that gaged flows are reduced from baseline flows vs. the same-day gaged flow at Zolfo Springs for 2003 to 2018. Negative values represent an increase in flow.

It is clear that the daily percent reductions in baseline flows meet the minimum flow requirements for nearly all the days at Zolfo Springs, with the exception of a small amount of days with gaged flow rates of about 30 to 80 cfs. The large negative values at lower gaged flow rates reflect the values listed in Table 8, in that the gaged flows were substantially greater than the baseline values, which similarly indicates the loss in low flows at FT. Meade are more than made up for at Zolfo Springs, again based on an analysis that is partly based on modeled values which simulated the effects of excess flows from agricultural operations upstream of Zoflo Springs. Another factor that could be involved are fairly high gaged runoff rates from Payne Creek, which flows into the Peace River upstream of the Zolfo Springs gage (see Table 2-10 in the draft District report and page 8 in document SF-3).

The percent of time that the gaged flows at the Zolfo Spring gage were in various flow blocks and the percent of time the gaged flows were within the minimum flow limits within each block were calculated for the Zolfo Springs gage, with the results for the period from 2003 to 2018 in Table 9.

Table 9. For each Flow Block - The number of days, the percentage of total days within that block, and the percentage of of days within that block that the minimum flows were met at the Zolfo Springs gage for the years 2003 to 2018. Values at the bottom are for all blocks combined.

	Flow range for each Block	Total number of days in block	Percent of total days within the block	Percent of days minimum flow met in the block
Block 1	< 40 cfs	507	9%	98%
Block 2	> 40 cfs and ≤ 274 cfs	2,622	45%	97%
Block 3A	> 274 cfs and ≤ 1,047 cfs	1,779	30%	100%
Block 3B	> 1,047 cfs	936	16%	100%
All Blocks combined		5,844		99%

It is interesting that the amount of time the flows were in Block 2 was 45%, compared to 37% at the Ft. Meade gage for this same period (Table 6). Most notably, however, is the gaged flows at Zolfo Springs were in Block 1 only 9% percent of the time compared to 25% of the time at Ft. Meade, reflecting the substantial increase in flow flows at the Zolfo Springs gage. The gaged flows were in Blocks 3A and 3B a total of 46% of the time, reflecting how important these blocks are to the river ecosystem.

As also reflecting the previous information shown for the Zolfo Springs gage, the gaged flows were within the minimum flow limits at the Zolfo Springs gage nearly all the time, with percent compliance values ranging from 97% to 100%. Collectively, these results show how much improved that flow regime is at Zolfo Springs compared to Ft. Meade, and how much more of a reliable and productive water supply source it potentially represents.

Synthesis of findings and management applications

Some conclusions and recommendations regarding the application of the minimum flows for the Upper Peace River are presented in this closing section. As been repeatedly pointed out in this memorandum, I do not think the current gaged flows are being met for a large majority of the time over much of the flow regime of the river at Ft. Meade.

This is supported not only by the modeling analyses, but just as importantly by what is physically known about the Upper Peace River near Ft Meade. where many karst sinks and fissures have formed, not only in the river channel but also in the river floodplain. The Lake Hancock Project has helped increase the very low flows in the river, but the river at Ft. Meade at times continues to be a losing stream and flow rates can fall to very low levels as in the spring of 2017. The flows at Ft. Meade do meet the minimum flow requirements at high flows, but the high frequency that the proposed minimum flows are not being met should make it straightforward for the District to conclude that the minimum flows at the Ft. Meade gage are not being met.

As also previously discussed, the times when the minimum flows are not being met at Ft. Meade would preempt any water supply withdrawals from the river linked to the Bartow gage.

The Upper Peace River is consistently meeting the minimum flows at Zolfo Springs, and the much greater flow there mean that significant water supplies could be obtained at that location. It should be noted, however, that even greater water supply yields could be obtained at other downstream locations, as flow from tributaries such as Charlie Creek increase the flow of the river. In 2018, I wrote a report abut a watershed based approach to water supply and environmental management in the Peace and Alafia River basins, which was uploaded to the minimum flows Webboard as document SF-3. The District report cites this study and reports statistics for gages downstream of Zolfo Springs in a manner similar to that presented in my report.

The adoption of minimum flows for the Upper Peace River at this time will not depend on considerations of any possible future withdrawals below Zolfo Springs, as that is a topic is for future reference. One factor that should be looked at soon, however, is if any withdrawals allowed by the minimum flows in the Upper Peace River would be constrained by the adopted minimum flows for the Middle and Lower Peace River. The minimum flows for the Lower Peace River are also based on a flow block approach, but the minimum flows for the Middle Peace River are based on a calendar based approach, which the District no longer uses to establish minimum flows.

I think it is unlikely that any withdrawal schedule that could be permitted based on adopted minimum flows for the Upper Peace River would be in conflict with the adopted minimum flows for the Middle Peace River, which are based on flows at the Arcadia gage, but the District could do such an analysis if it is needed in the future. Having said that, it might be a good idea for the District to put the re-evaluation of the minimum flows for the Middle Peace River on the priority schedule for a future year, so that all the minimum flows on the Peace River are based on the same approach. I would think the District might not have to collect any new data, but rather could analyze for the middle river with a flow-base approach, but that is not a critical factor at this time.

An issue that is critical at this time is whether additional recovery steps are need for the Upper Peace River. On page 233, the District states that the reservation of water in Lake Hancock to add water to the river when flows fall to the low-flow thresholds at either the Bartow, Ft. Meade, of Zolfo Springs gages, alleviates the need for an additional recovery or prevention strategy for the Upper Peace River is not required at this time.

I can agree with that, but as described in my review of the draft minimum flows report (document SF-7 on the minimum flows Webboard), more information needs to be presented in the report about the quantities of water that are released to the lower river from Lake Hancock, either at Structure P-11 or through the treatment wetland that is connected to the lake. Hydrographs and tabular summaries of the data should be presented, including a water level hydrograph for Lake Hancock and records for pumpage into and estimated discharge from the treatment wetland associated with the lake.

On a broader note, the District should be commended on investing so much cost, time, and effort on estimating a baseline flow regime for the Upper Peace River and basing the proposed minimum flows on analyses that examined taking various percentages of water from the baseline flow regime. That was the right approach. Although flows in the river at Ft. Meade are not currently at baseline levels over most of the flow regime, when flows are at rates within Blocks 2, 3A, and 3B, it was appropriate that the minimum flows analyses to examine changes in instream and floodplain habitats used the baseline flows.

I don't think that the technically valid conclusion that the minimum flows are not being met at the Ft. Meade gage necessarily means the District has to pursue additional recovery strategies for the Upper Peace River other than the Lake Hancock Project. The District could consider other measures, but it should not be required. Florida Statutes allow for technical and economic factors to be considered for determining that flows for a water body do not have to be recovered to historical conditions. If feasible, some additional recovery of flows in the Upper Peace River could be desirable, but the Florida Department of Environmental Protection and the District Governing Board can consider all factors for determining if additional recovery steps are needed.

The percent-of-flow method has been a very robust, scientifically endorsed, and successfully implemented method for establishing minimum flow rules that make water supplies available while protecting the environment. Any unclear or false assumptions about the requirements for additional recovery projects should not interfere with objective, technically valid analyses using the percent-of-flow method for establishing minimum flows for the Upper Peace River.

From:	Sempsrott, Michelle <Michelle.Sempsrott@MyFWC.com>
Sent:	Tuesday, March 10, 2026 1:04 PM
To:	Lei Yang
Cc:	Conservation Planning Services; DiGruttolo, Laura; Gruver, Pamela; Baysinger, Samantha; Cucinella, Josh
Subject:	FWC's Comments for Independent Scientific Peer Review – Proposed Minimum Flows for the Upper Peace River

Hello Mrs. Yang,

Thank you for the opportunity to review the draft *A Reevaluation of Minimum Flows for the Upper Peace River from Bartow to Zolfo Springs, Florida* (November 2025), which was received on December 16, 2025.

FWC staff reviewed the document as technical assistance in accordance with Chapter 379, Florida Statutes. At this time, we have no comments or objections related to fish and wildlife resources, listed species, or their habitats associated with this project.

However, we recommend the following minor edits for consideration:

- In the third paragraph of Section 1.5.6, replace the citation "Instream Flow Council (2002)" with "Annear et al. 2004," which is the revised edition and is already included in the Literature Cited.
- In Section 2.4.6, consider adding a graphic showing retention and releases from the Lake Hancock P-11 structure over time.
- In Tables 2-17 and 2-18, update the common and scientific names of Brook Silverside to Green Silverside (*Labidesthes vanhyningi*) consistent with Robins et al. 2018 and the updated American Fisheries Society Names of Fishes.
    - Robins, R. H., L. M. Page, J. D. Williams, Z. S. Randall, and G. E. Sheehy. 2018. *Fishes in the Fresh Waters of Florida: An Identification Guide and Atlas*. University of Florida Press, Gainesville, FL. 467 pp.
- In Table 2-18, The genus of Coastal Shiner should be corrected to *Notropis*.

Additionally, if available, FWC staff would be interested in coordinating a site visit to the P-11 structure on Lake Hancock to better understand how the structure functions to maintain the required minimum flow for the Upper Peace River and, if possible, to visit karst features within the upper river. Please contact Michelle Sempsrott at (407) 572-9122 or by email at Michelle.Sempsrott@MyFWC.com to coordinate.

We appreciate the opportunity to review this draft and look forward to continued coordination. If further assistance is needed, please contact our office by email at ConservationPlanningServices@MyFWC.com.

Michelle Sempsrott
Land Use Planning Biologist
Office of Conservation Planning Services
Florida Fish and Wildlife Conservation Commission
Central Florida
(407) 572-9122

From: Lei Yang <Lei.Yang@swfwmd.state.fl.us>
Sent: Tuesday, December 16, 2025 11:26 AM
To: james.albright@dep.state.fl.us; jennifer.g.adams@dep.state.fl.us; Sempsrott, Michelle <Michelle.Sempsrott@MyFWC.com>; Nagid, Eric <eric.nagid@MyFWC.com>; Hamm, Ryan <Ryan.Hamm@MyFWC.com>; Angela.Chelette@FDACS.gov; Rebecca.Elliot@FDACS.gov; Escribano, Yesenia <Yesenia.Escribano@fdacs.gov>; JessicaLea.Stempien@freshfromflorida.com; jhecker@chnep.org; Andrew Sutherland <asutherl@sjrwmd.com>; nmouzon@sjrwmd.state.fl.us; sean.king@srwmd; Sean Scully <ssculley@sfwmd.gov>; Beerens, James <jabeeren@sfwmd.gov>; Paul Thurman <Paul.Thurman@nwfwater.com>; kathleen.coates@nwfwmd.state.fl.us
Cc: Jennette Seachrist <Jennette.Seachrist@swfwmd.state.fl.us>; Randy Smith <Randy.Smith@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Yonas Ghile <Yonas.Ghile@swfwmd.state.fl.us>; Hua Zhang <Hua.Zhang@swfwmd.state.fl.us>; Amanda Simat <Amanda.Simat@swfwmd.state.fl.us>; Bruno Kapacinskas <Bruno.Kapacinskas@swfwmd.state.fl.us>; Cara S. Martin <Cara.Martin@swfwmd.state.fl.us>; Melissa Gulvin <Melissa.Gulvin@swfwmd.state.fl.us>; Tom Hyle <Tom.Hyle@swfwmd.state.fl.us>; Adrienne E. Vining <Adrienne.Vining@swfwmd.state.fl.us>; Mike R. Bray <Mike.Bray@swfwmd.state.fl.us>; Virginia Singer <Virginia.Singer@swfwmd.state.fl.us>
Subject: Independent Scientific Peer Review – Proposed Minimum Flows for the Upper Peace River

[EXTERNAL SENDER] Use Caution opening links or attachments

Good morning,

Southwest Florida Water Management District staff have developed proposed minimum flows for the Upper Peace River. As you may know, a minimum flow sets a limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.

Draft reports outlining the proposed minimum flows were presented to the District Governing Board this morning (December 16). An informational web page, including the draft reports, supporting appendices, meeting schedules, and agendas, is available at: https://www.swfwmd.state.fl.us/projects/mfls/minimum-flows-the-upper-peace-river.

The draft report and appendices will undergo an independent scientific peer review over the coming months. The review panel will convene via publicly noticed teleconferences (Microsoft Teams) and communicate through a dedicated web board. The first meeting is scheduled for **January 16, from 10:00 AM to 12:00 PM**, with additional meetings scheduled as follows:

- January 23 at 10:00 AM
- January 30 at 10:00 AM
- February 6 at 10:00 AM
- March 20 at 10:00 AM
- March 27 at 10:00 AM

Meeting details will be available on the District website (https://www.swfwmd.state.fl.us/projects/mfls/mfls-public-meetings).

The peer review panel's web board, also open for stakeholder comments, will be accessible starting **January 16** at https://swfwmd.discussion.community/. It will remain active for communications through **May 12**, and viewable through at least **December 31, 2026**.

If you or your agency would like to provide feedback on the proposed minimum flows, written comments may be sent directly to me. To allow adequate time for District staff to review and consider, we kindly request that comments be submitted by **March 20, 2026.**

Following the peer review process, the District will host a public workshop to share information and gather additional stakeholder input. Details about this workshop will be announced in the coming months.

All findings from the independent scientific peer review and public comments will be summarized and presented to the District Governing Board to support their consideration of the proposed minimum flows for the Upper Peace River in **Spring 2026**.

Pease feel free to reach out with any questions or to schedule a meeting with District staff to discuss the proposed minimum flows.

Best regards,

Lei Yang, PhD, PE
Chief Professional Engineer
Environmental Flows and Levels Section
Natural Systems and Restoration Bureau
Southwest Florida Water Management District
2379 Broad Street • Brooksville • FL 34604-6899
☎ 352-269-5947 • ✉ Lei.Yang@swfwmd.state.fl.us

SF-13 – Verbal comments presented by Sid Flannery at the March 20, 2026 meeting of the scientific review panel for the draft minimum flows report for the Upper Peace River

I have read the latest draft of the District's minimum flows report and reviewed the changes they have made in response to the review panel's comments and some of my own. At this time, I strongly believe the report needs further revision to be technically sound. Since January, I have performed my own analyses which are contained in documents that have posted to minimum flows Webboard and I will be referring to some of those documents today.

A key factor that I and the panel have commented on is what is considered compliance with the minimum flows. Keep in mind the low flow thresholds at the three gages are only one component of the minimum flows. As the District report says on page 236, the District anticipates using the Lake Hanock project when these low flow thresholds are not being met – which is purely a low flow phenomenon.

However, the District also applied the percent-of-flow method to evaluate changes to the entire flow regime of the river, which has been the District' procedure from many years. However, in doing so for the Upper Peace, they pursued some new, flawed approaches that jeopardize the utility of the percent-of-flow method.

In response to comments about how compliance with the minimum flows would be assessed, the District made additions and revisions to Chapter 7, but it still has some serious problems. For example, Table 7-1 on page 237 in the revised report compares mean values within blocks for different flow scenarios. A critical flaw in Table 7- 1 is that it does not show any mean values for the actual gaged flows of the river. To assess minimum flows compliance, the revised report compares differences in mean values between the modeled baseline flows and the modeled existing flows within each block.

Well guess what, the values that best represent the existing flows in the river are the actual gaged flows measured by the USGS, yet the District's assessment of minimum flow compliance did not use the gaged data. When the methods were clarified in the revised report, this really took me by surprise. In all of my analyses, I compared the modeled daily baseline flows to the actual gaged flows to assess if the river was meeting the proposed minimum flows. In my opinion, it is a serious mistake to not incorporate the actual gaged flows in the assessment of minimum flow compliance.

Secondly, the use of mean values within each block to assess minimum flows compliance is flawed. As the District states on page 74 in their revised report - "trends or observations based on mean annual flows tend to be biased toward high flows and may not accurately capture changes in flow and medium flow conditions." I would add this holds true even within blocks.

Plots of percent reductions in baseline flows represented by the gaged flows presented in my documents SF-4 and SF-12 show there is a very strong relationship between the rate of baseline flow and the amount of flow reduction at Ft. Meade, with the greatest amounts of flow reductions at low flows, which should not be surprising given what we know about the Upper Peace River.

As an example of problems with the Districts approach, Block 3A at the Ft. Meade gage applies to flows between 121 to 529 cfs. As I have stated in these meetings and shown graphically in my documents, gaged flows at Ft. Meade largely comply with the proposed minimum flows at flow rates above about 200 to 250 cfs, however, there are much greater percent reductions at low flows. Therefore, when calculating difference in mean flows in Block 3A, a small number of days with baseline flows of 400 to 500 cfs, where the percent flow reductions are small, can overwhelm the effects of many days at flows of 121 to 150 cfs, where the percent flow reductions are much greater, and the same effect holds for block 2.

As such, the District's approach of comparing mean values between baseline and existing flows within each block is fundamentally flawed, and hides some of the most important relationships in the data. A much better way to do this, as I did in documents SF-4, SF-6, and SF-12, is to examine at what rates of flow does the river begin to meet the minimum flows, as sufficient rainfall can overcome some of the physical impacts the upper river has experienced.

The District's flawed approach really becomes problematic in the text on pages 238 and 239, where it describes how surface water withdrawals from the Upper Peace River will be regulated. For the middle segment, which is based on the Ft. Meade gage, the text indicates that 12% of surface flow can be taken in block 2, despite the data clearly showing the existing flow reductions are well above 12% over most of the flow range in that block. Again, the District's conclusion of minimum flow compliance in Block 2 was based on the flawed comparison of mean modeled values within blocks, that did not even analyze the actual gaged flows of the river. I believe this a bad approach will result in ecological damage to the Upper Peace River.

The approach I have proposed is well described in documents SF-4 and SF-12, with supporting information in documents SF-6 and SF-7. I want to strongly emphasize this approach provides a technically sound method that will not result in water shortage issues, for although the minimum flows are not being met over much of the flow regime at Ft. Meade, my analyses show they are almost always met at Zolfo Springs where the water supply yields are much greater. I think this analysis and conclusions fit much better with what we know about the physical and hydrologic characteristics or the Upper Peace River, rather than the District's false conclusion that the river is meeting the minimum flows at all thee gages based on comparisons of mean modeled values.

I want to emphasize the Upper Peace River represents a critical juncture in the minimum flow program. The District did some analytical approaches for the Upper Peace that have never done before, which are technically flawed. The percent-of-flow method been based on many years of careful thought, analysis, and real-world application, and this report needs to be revised to properly apply that approach to protect the resources of the Upper Peace River and the technical integrity of the minimum flows program.

I think the District took their analytical approach so they can be off the hook for any further recovery strategies for the Upper Peace River beyond the Lake Hancock project. As document SF-12 describes, I think the District Governing Boad can consider technical and economic factors to determine if any further recovery strategies are feasible for the Upper Peace River, and maybe they aren't. I think this approach is much better than misinterpreting the data and jeopardizing the effectiveness of the percent-of-flow method for protecting the natural resources of the river.

I hope the District and the scientific review process will allow for the time to fix this report, because it is very important. Today I have referred to four key documents that I have prepared that I hope you will read it you already have not, for it won't take long. As finding these documents in the public comments section of the Webboard can be tedious, I suggest you could request them from the District project manager, along with the written transcript of my verbal comments today which have also been provided to the District project manager and posted on the minimum flows Webboard.

From: Angel Martin
To: Kristina Deak
Subject: Upper Peace River MFL Peer Review Panel--Meeting 4--March 20, 2026
Date: Friday, March 20, 2026 5:08:31 PM

Concerning Meeting 4 of the subject Upper Peace River MFL Review Panel, below are comments/suggestions.

1. Suggest additional discussion concerning water-quality trends and patterns in the Upper Peace River. Additional discussion is needed concerning areas where appreciable color changes in water are noted.
2. Please provide a reference for the discussion concerning that the original calibrated heads from modeling results should be used as the beginning conditions when performing model simulations with reduced pumpage.
3. Additional discussion is needed concerning the length of the stabilization period. Is this period on the scale of months or years? Are there are periods when the system is not considered stabilized? What criteria are considered in determining when the hydrologic system is considered stable?
4. The extended discussion during the meeting concerning what was referred to as compliance left me a little confused. It must be made clear in the report specifically how the MFLs were established and associated approaches/methodologies applied so that future analyses completed as part of a permit application can be used to compare directly with the approaches/methodologies used in determination of the MFLs.

Please contact me if you need any additional information or clarification. Thank you for the opportunity to participate in the subject MFL process.

Angel Martin
813-767-6944

From: Angel Martin
To: Kristina Deak
Subject: Upper Peace River MFL Peer Review Panel--Meeting 5
Date: Friday, March 27, 2026 1:16:33 PM

Below are my comments/suggestions concerning the subject meeting.

1. Suggest a thorough discussion of the limitations of applying the groundwater-flow model in the MFL process. Should refer that the model is regional in nature and being applied to a specific portion of the Upper Peace River Basin.
2. Illustrations were shown showing groundwater withdrawals on an average yearly basis. Should be made clear if these amounts are for the entire basin or some portion of the basin.
3. Possible sensitivity analysis of the model concerning the initial hydrologic conditions was discussed. Other model parameters should be considered in possible future sensitivity analyses.
4. When the model is updated, besides the updated pumpage data, other hydrologic data, such as results from aquifer performance tests, need to be investigated and included in the updated model. Also, state that updating the model doesn't necessarily indicate that the MFL must be reinvestigated.
5. Martin indicated that the upper Floridan aquifer draws down and recovers (groundwater levels) relatively rapidly. In 2010, large amounts of groundwater withdrawals for frost/freeze protection caused up to 60 feet of drawdown in the upper Florida aquifer and the aquifer recovered quickly. These conditions were simulated with the District Wide Regulation Model (DWRM).

Please contact me if you need any additional information or clarification. Thank you for the opportunity to participate in the MFL process.

____

Angel Martin
813-767-6944

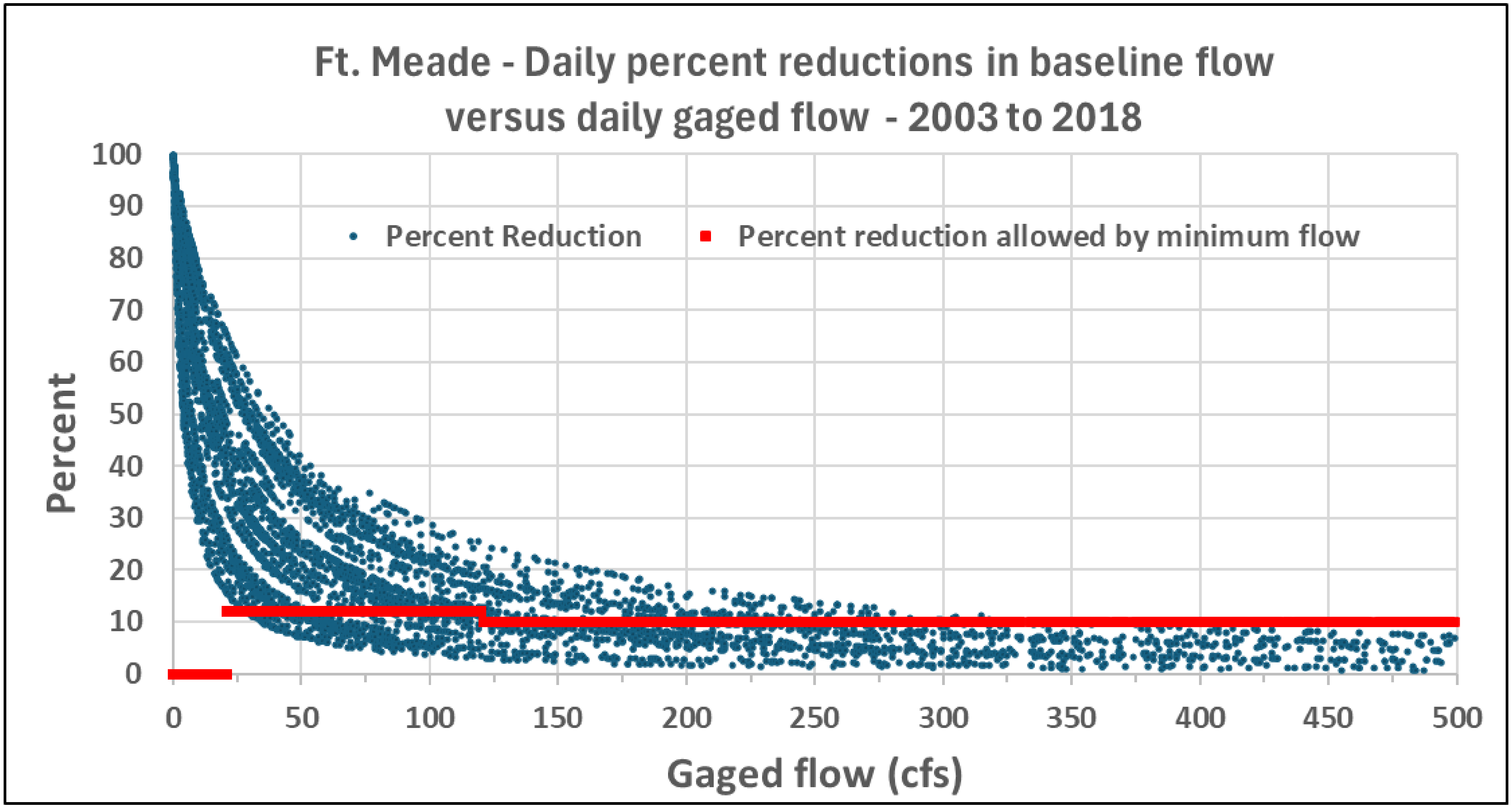

Ft. Meade - Daily percent reductions in baseline flow
versus daily gaged flow - 2003 to 2018
Percent Reduction
Percent reduction allowed by minimum flow
Percent
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
450
500
Gaged flow (cfs)

Table 1. Final net flow reductions (withdrawals) allowed at the Ft. Meade gage by the proposed minimum flows for three gaged flow rates within each month and the values used to make those determinations inlcuding the adjustment rates used to calculate the baseline flows for each month

Month	Block	Gaged flow (cfs)	Baseline Adjustment (cfs)	Baseline flow (cfs)	Allowabe MFL Percent Reduction (%)	Allowable MFL Flow Reduction (cfs)	Final net flow reduction or withdrawal (cfs)
January	2	100	6.6	106.6	12%	12.8	6.2
January	3A	150	6.6	156.6	10%	15.7	9.1
January	3A	300	6.6	306.6	10%	30.7	24.1
February	2	100	14.2	114.2	12%	13.7	0
February	3A	150	14.2	164.2	10%	16.4	2.2
February	3A	300	14.2	314.2	10%	31.4	17.2
March	2	100	13.7	113.7	12%	13.6	0
March	3A	150	13.7	163.7	10%	16.4	2.7
March	3A	300	13.7	313.7	10%	31.4	17.7
April	2	100	10.7	110.7	12%	13.3	2.6
April	3A	150	10.7	160.7	10%	16.1	5.4
April	3A	300	10.7	310.7	10%	31.1	20.4
May	2	100	4.3	104.3	12%	12.5	8.2
May	3A	150	4.3	154.3	10%	15.4	11.1
May	3A	300	4.3	304.3	10%	30.4	26.1
June	2	100	6.0	106.0	12%	12.7	6.7
June	3A	150	6.0	156.0	10%	15.6	9.6
June	3A	300	6.0	306.0	10%	30.6	24.6
July	2	100	14.7	114.7	12%	13.8	0
July	3A	150	14.7	164.7	10%	16.5	1.8
July	3A	300	14.7	314.7	10%	31.5	16.8
August	2	100	25.5	125.5	12%	15.1	0
August	3A	150	25.5	175.5	10%	17.6	0
August	3A	300	25.5	325.5	10%	32.6	7.1
September	2	100	34.8	134.8	12%	16.2	0
September	3A	150	34.8	184.8	10%	18.5	0
September	3A	300	34.8	334.8	10%	33.5	0
October	2	100	26.2	126.2	12%	15.1	0
October	3A	150	26.2	176.2	10%	17.6	0
October	3A	300	26.2	326.2	10%	32.6	6.4
November	2	100	29.8	129.8	12%	15.6	0
November	3A	150	29.8	179.8	10%	18.0	0
November	3A	300	29.8	329.8	10%	33.0	3.2
December	2	100	19.3	119.3	12%	14.3	0
December	3A	150	19.3	169.3	10%	16.9	0
December	3A	300	19.3	319.3	10%	31.9	12.6

SF- 16 Comments presented by Sid Flannery at the March 27, 2026 meeting of the scientific review panel for the draft Upper Peace River minimum flows report

I believe there are some important, fairly straightforward analyses that still need to be performed to determine if the Upper Peace River is currently meeting the proposed minimum flows, and secondly, evaluate how surface water withdrawals from the river can be better managed.

I want to refer to a graph that was uploaded to the minimum flows webboard this morning labeled document SF-14. It was taken from one of the documents I have previously prepared, but hopefully you can look it again sometime. It shows percent reductions in daily baseline flows comprised by gaged flows at the Ft. Meade gage, with a most days exceeding the maximum flow reductions allowed by the proposed minimum flows, but the situation improves at higher flow rates and largely meets the minimum flows at flow rates above 200 to 250 cfs.

What I want to emphasize today is the baseline flows used to generate this graph were not taken directly from the Peace River Integrated model, but instead were calculated using the method described in minimum flows report, where monthly adjustment factors are applied to daily gaged flows to calculate baseline flows. Had the proposed minimum flows been in effect during this time period, this graph represents how often the daily gaged flows would have met the minimum flows, which was not very much over most of the flow regime of the river at Ft. Meade.

The time period for the graph is the years 2003 to 2018. This is the appropriate period to use to assess compliance, for average values for this same period are presented in Table 7-1 in the District's report to conclude that the minimum flows for the Upper Peace River are being met at all three gages.

As I said last week, I think that basing compliance on average values within blocks is technically wrong and not in keeping with the proper application and power of the percent-of-flow method, as relatively small percent changes at high flows can mask what is happening at low and medium flows.

Secondly, the District's comparison of average values in Table 7-1 to assess compliance was based on modeled vs. modeled values. I understand the purpose for that, but the modeled baseline flows must also be compared to gaged flows, for the gaged flows truly represent the existing conditions and can differ significantly from the modeled values. Gaged flows also have to be assessed to evaluate minimum flow compliance.

Getting back to the figure that was uploaded to the webboard today, the strong pattern shown in that graph is partly due to how baseline flows are calculated using the method in draft report. With some slight modifications between years, a single adjustment value is applied within a month regardless of the rate of flow. This affects pattern shown in the graph. For example, the 10.7 cfs adjustment factor for November to calculate baseline flows is a pretty big percentage of flow at a rate of 30 cfs, but a much smaller percentage at a flow rate of 200 cfs. But that graph does reflect how the minimum flows are to be assessed according to the method in the report.

I believe it would be worth examining the development of baseline adjustment factors based on the rate of flow, possibly with a seasonal factor, as it could have very valuable management applications that better reflect the hydrologic and ecological characteristics of the river.

I have requested from the District, values for baseline and existing flows predicted by the integrated model for this same period to examine possible relationships between rates of modeled baseline flows and gaged flows, which I could pursue in pretty short order.

But with regard to the methods presented in the draft report, using those methods I calculated the amounts of water that could be withdrawn for supply at Ft. Meade for three rates of flow within each month. A table of those values was uploaded this morning to the minimum flows webboard as document SF-15.

Because each monthly adjustment factor does not change with the rate of flow, the results in that table show that the amount of water that can be withdrawn for supply has some odd seasonal characteristics. For example, at a flow of 150 cfs in the ecologically critical month of June, 9.6 cfs of water can be withdrawn from the river at Ft. Meade, while no water can be withdrawn at that rate of flow in each of the five months from August to December, which are ecologically less sensitive. In fact, water cannot be withdrawn from the river in September until flows reach a rate of 348 cfs. Again, it could be valuable to examine the adjustment rates based directly on the rate of flow to improve water supply availability and also better protect the ecology of Upper Peace River.

Finally, based on working almost 30 years in the minimum flows program at the District, I want to express that that Upper Peace River is one of the most important minimum flow determinations the District has ever pursued. In that regard, it is important for the District and the panel to take whatever time is necessary to extend this process to get this one right.

A transcript of these verbal comments was uploaded to the minimum flows webboard this morning as document SF-16.

Memorandum

Date: **4/8/2026**

Project No.: **204792**

To: **Eric DeHaven, Executive Director, Polk Regional Water Cooperative**

From: **Tony Janicki, PhD, Environmental Science Associates**
A. Dale Helms, PE, Carollo Engineers

Subject: **Review Comments on the Proposed Minimum Flows for the Upper Peace River from Bartow to Zolfo Springs, Florida**

1 Executive Summary

This technical analysis identifies ecological and methodological deficiencies in the Southwest Florida Water Management District's ("District") November 2025 draft report entitled *A Reevaluation of Minimum Flows for the Upper Peace River from Bartow to Zolfo Springs, Florida* (the "Draft Report"). The Draft Report proposes to replace the existing minimum flows adopted in 2006 with a four-block flow regime (**Table 1**) that includes new high-flow restrictions (Blocks 3A and 3B) designed to protect floodplain inundation. These new high-flow restrictions will substantially reduce the quantity of water available for consumptive use by the Polk Regional Water Cooperative ("Cooperative") from the Upper Peace River.

Table 1 Proposed Upper Peace River Minimum Flows and Allowable Flow Reductions

River Segment	Index Gage Name (Site ID)	Flow Block	Flow Range	Maximum Allowable Reduction [a]	Minimum Flow [a]
Upper	Bartow (02294650)	1	≤ 30 cfs	0%	100% [b]
		2	> 30 cfs and ≤ 71 cfs	12%	30 cfs or 88% [c]
		3A	> 71 cfs and ≤ 483 cfs	15%	85%
		3B	> 483 cfs	7%	93%
Middle	Fort Meade (02294898)	1	≤ 21 cfs	0%	100% [b]
		2	> 21 cfs and ≤ 120 cfs	12%	21 cfs or 88% [c]
		3A	> 120 cfs and ≤ 529 cfs	10%	90%
		3B	> 529 cfs	7%	93%
Lower	Zolfo Springs (02295637)	1	≤ 40 cfs	0%	100% [b]
		2	> 40 cfs and ≤ 274 cfs	13%	40 cfs or 87% [c]
		3A	> 274 cfs and ≤ 1,047 cfs	9%	91%
		3B	> 1,047 cfs	7%	93%

Notes:
[a] Based on previous day baseline flow.
[b] A 95% annual exceedance is proposed to account for uncertainties related to annual rainfall variations, provisional USGS data, sinkhole losses, Lake Hancock water storage capacity, and structure maintenance, etc.
[c] Whichever is greater.

The Cooperative's water supply operations will depend on withdrawing water from the Upper Peace River at a future intake station located near Bowling Green during high-flow periods and storing it in a reservoir for use throughout the year, including during low-flow periods when the Cooperative is unable to withdraw. The proposed Block 3A and 3B restrictions at the Zolfo Springs index gage would limit the Cooperative to withdrawing no more than 7-9% of the flow during these critical high-flow periods, reducing the Cooperative's potentially available long-term average available withdrawals from approximately 28 million gallons per day (mgd) to approximately 17-18 mgd—a reduction of approximately 36-39%.

The Florida Water Resource Implementation Rule (Rule 62-40.473, Florida Administrative Code) for establishment of Minimum Flows and Levels (MFLs), requires that "…consideration shall be given to natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic and wetlands ecology, including:

- Recreation in and on the water;
- Fish and wildlife habitats and the passage of fish;
- Estuarine resources;
- Transfer of detrital material;
- Maintenance of freshwater storage and supply;
- Aesthetic and scenic attributes;
- Filtration and absorption of nutrients and other pollutants;
- Sediment loads;
- Water quality; and
- Navigation."

The District's MFL approach for the Upper Peace River included establishment of a baseline flow condition that provided the basis for comparison to various potential MFL flow regimes. To account for seasonal variability of the effects of flow changes on critical river characteristics, flow-based blocks were defined. A HEC-RAS hydraulic model of the Upper Peace River was established to provide quantitative estimates of the relationships between streamflow and various metrics that represent the MFL water resource values (WRVs).

A number of potential concerns associated with the proposed revisions to the current Upper Peace River MFLs have been identified including:

- Choice of MFL floodplain metric—inundated floodplain area
- Non-linear ecological responses to changes in flows
- Percent-of-flow methodology
- Groundwater component of MFL determination

Identified technical deficiencies associated with these issues are discussed herein. The District should consider these comments and revise the Draft Report so that the proposed Upper Peace River MFLs are grounded in sound science and appropriately balance the statutory objectives of ecological protection and the provision of water for reasonable-beneficial use.

2 MFL Approaches to Address Ecological and Water Resource Values

The following generally describes the approaches used by the District for the evaluation of each potential WRV.

2.1 Recreation in and on the Water

Using the HEC-RAS model output, the Recreation WRV was evaluated by assessing water depths and analyzing potential changes in floodplain inundation. Water levels were reviewed to ensure protection of the floodplain and instream fish and invertebrate habitats.

2.2 Navigation

The navigation criterion is defined as the flow corresponding to a water depth of 0.5 ft (0.15 m), consistent with several previous minimum flow evaluations conducted for the Lower Santa Fe River (HSW, 2021), Charlie Creek (Deak et al., 2023), Horse Creek (Ghile et al., 2023), and Little Manatee River (Holzwart et al., 2023). Given the availability of existing boat launch facilities and docks along the river, the waterway is not expected to support commercial and large-scale recreational boating, aside from canoeing or kayaking.

2.3 Water Quality

The District analyzed 14 water quality parameters. These analyses included assessment of temporal trends in these parameters. Spatial variability was also examined in relation to variation in river flows. The potential impacts of river flows on both temporal and spatial variability were also examined. As part of the minimum flow evaluation, The inundation of floodplain areas can largely contribute to both temporal and spatial variability. The results from these analyses indicate that the recommended minimum flows for the Upper Peace River are not expected to negatively affect water quality or impair the water designated use of the water body.

2.4 Sediment Loads

Variation in sediment loads (the total quantity of sediment transported by a river, including both suspended particles and bedload) can significantly alter stream habitats for fishes and macroinvertebrates. Sediment loads are largely affected by river flow, channel morphology, and sediment size. The relative change between the baseline and minimum flow conditions provides a useful measure of the potential effects of the recommended minimum flows on sediment loads. The District concluded that the recommended minimum flows will not significantly reduce sediment loads in the Upper Peace River.

2.5 Filtration and Absorption of Nutrients and Other Pollutants

The relationships between the Filtration and Absorption of Nutrients and Other Pollutants WRV and river flow were assessed by the District. As was observed for several other WRVs, variation in river flows can significantly affect this environmental value. This environmental value is also linked to other WRVs, including Recreation in and on the Water, Fish and Wildlife and the Passage of Fish, Transfer of Detrital Material, Sediment Loads, and Water Quality. The District assessed this environmental value by evaluating system bathymetry, floodplain inundation, and instream habitats. This WRV is perhaps most closely linked to the inundation of floodplain areas.

2.6 Aesthetic and Scenic Attributes

The District concluded that the aesthetic and scenic attributes of the Upper Peace River are closely intertwined with other WRVs (i.e., Recreation In and on the Water, Fish and Wildlife and the Passage of Fish, Transfer of Detrital Material, Filtration and Absorption of Nutrients and Other Pollutants, Sediment Loads, Water Quality, and

Navigation). Therefore, minimum flows that are protective of these other WRVs will also protect the river' s aesthetic and scenic attributes.

2.7 Estuarine Resources

The District noted that the Upper Peace River flows through the middle and lower segments of the Peace River before ultimately emptying into Charlotte Habor estuary. The Upper Peace River is not directly connected to estuarine resources. Therefore, the District did not consider this WRV directly relevant for the development of minimum flows for the Upper Peace River.

2.8 Maintenance of Freshwater Storage and Supply

While the maintenance of freshwater storage and supply is protected through the implementation of the District's Water Use Permitting and Environmental Resource Permitting Programs, the established MFL will provide the regulatory basis for its water supply.

2.9 Transfer of Detrital Material Transfer

The District considered the Transfer of Detrital Material WRV (i.e., the movement of loose organic material, debris, and decomposing biota from floodplain overbanks into the main channel) for MFL development of recommended minimum flows for the Upper Peace River. Maintenance of the floodplain habitats in the Upper Peace River is essential to detrital transfer processes, including serving as sources or sinks, and conduits for organic matter production, export, and utilization. Of particular importance is the inundation of floodplain areas at the proposed Block 3A and 3B MFLs.

2.10 Fish and Wildlife Habitat and the Passage of Fish

To support the Fish and Wildlife Habitat and the Passage of Fish WRV, the District defined an MFL that protected the full range of flow conditions. The protection of fish passage is ensured by the low flow conditions that provide for an adequate water depth to allow passage. The District applied the System for Environmental Flows Analysis (SEFA) to define the flows necessary to sustain instream habitats for fish and wildlife. Woody habitat inundation analysis was performed to ensure adequate inundation of habitats for microbial colonization and subsequent probable use by other organisms. The higher MFL block flows and water levels were also evaluated to ensure the protection of critical floodplain habitats for fish and wildlife.

3 Ecological Issues Associated with Proposed Revisions to Current MFLs

A central assumption of the proposed MFLs is that the Block 3A and 3B flow restrictions are necessary to protect the area of Upper Peace River floodplains, and that maintaining a minimum floodplain inundation area is necessary to prevent "significant harm." This assumption rests on the choice of the most appropriate floodplain characteristic, which in this case is area of floodplain inundation. A number of MFLs previously established by the state's water management districts applied this approach. Is there any evidence that supports the assumption that ecological function varies with the area of floodplain that is inundated?

3.1 Choice of MFL Floodplain Metric: Inundated Floodplain Area

Recent research, for example a study authored by Cliff Neubauer and others of the St. Johns River Water Management District (Neubauer et al., 2008), has concluded that inundation frequency, duration, and timing are more ecologically important than total inundation area. Similar results were reported by Scott et al. (2019). The District should provide further justification to support the choice of inundated area as the best metric of floodplain health and productivity.

3.2 Non-Linear Ecological Responses

Floodplain ecosystems typically exhibit threshold effects and non-linear responses to flow changes, not the linear relationship assumed by the 85% area proposed threshold. D'Amario et al. (2019), published in *Scientific Reports*, found that nonlinear ecological responses occur in "half of all analyses, with some evidence of multiple breakpoints." Dodds et al. (2010) established the theoretical framework for understanding thresholds in freshwater systems, defining a threshold as a point where "the system responds rapidly to a relatively small change in a driver." The existence of ecological thresholds means that a 15% reduction in floodplain area may fall well within the range of ecological resilience, producing no detectable harm.

3.3 Percent-of-Flow Methodology

The District employs a percent-of-flow methodology to establish the Block 3A and 3B minimum flows. The District has a long history of applying this methodology particularly in both MFL development and water use permitting. However, a comprehensive meta-analysis published in *Water Supply* (Gebreegziabher et al., 2023) characterized percent-of-flow methods as "simplistic hydrological approaches with low data requirements that address only physical aspects and provide simplistic answers with little or no ecological relevance." Some of the environmental community has shifted toward "functional flows" approaches that identify specific ecological functions (fish migration, nutrient cycling, floodplain connectivity, sediment transport) and evaluate whether specific flow reductions actually compromise those functions. The California Environmental Flows Framework, for example, identifies five discrete components of the annual hydrograph that support key biophysical processes, rather than imposing fixed percentage reductions. Yarnell et al. (2020) provide a rigorous methodology for selecting ecologically relevant flow metrics tied to specific ecological outcomes, representing the current state of the science. If possible, the District should consider this criticism.

4 Groundwater Component of MFL Determination

4.1 Development of Groundwater Adjustment Rates

A central component of the District's proposed MFL methodology is the estimation of baseline flows—i.e., what river flows would have been without the influence of regional groundwater withdrawals. To derive these baseline flows, the District used the Peace River Integrated Model, Version 2 (PRIM2), a coupled groundwater/surface water model. The PRIM2 model was run for two scenarios covering the years 2003 to 2018: one using existing (100%) groundwater pumpage rates, and one using a 50% reduction in groundwater pumpage. The monthly differences in simulated streamflow between these two scenarios were then doubled to estimate the streamflow changes attributable to the full elimination of groundwater withdrawals. These estimated monthly streamflow differences—referred to as groundwater impact adjustment rates—were then added to actual historical gaged streamflows at each of the three index gages (Bartow, Fort Meade, and Zolfo Springs) to produce estimated baseline daily flows for MFL development.

Because the PRIM2 model was only run for the 16-year period from 2003 to 2018, the District needed to extend the adjustment factors to cover the full desired baseline period of 1975 to 2022. To accomplish this, yearly adjustment rates were determined by dividing the estimated total groundwater use in each of the baseline years by the average groundwater use for the 16-year PRIM2 modeling period. These yearly adjustments were then applied to the average monthly adjustment factors for the PRIM2 modeling period. The resulting final factors were applied to the daily gaged record of the river to estimate daily baseline flows for the 1975–2022 period (Draft Report, Section 5.4).

The resulting monthly adjustment rates, as reported in Table 5-6 of the Draft Report, vary significantly by month and by gage location. At Bartow, adjustments range from –0.62 cfs (May) to +32.73 cfs (September), with an annual average of +13.41 cfs. At Fort Meade, adjustments range from +4.31 cfs (May) to +34.78 cfs (September), with an annual average of +17.14 cfs. At Zolfo Springs, adjustments are predominantly negative, ranging from –25.18 cfs (June) to +12.22 cfs (October), with an annual average of –6.54 cfs. These adjustment factors are central to the District's determination of both baseline flows and MFL compliance status.

4.2 Application of Monthly Adjustment Rates to Determine Available Water

The District's proposed method for implementing the MFLs for compliance purposes uses the monthly groundwater adjustment rates to convert daily gaged flows into estimated daily baseline flows. Specifically, on any given day, the monthly adjustment rate for that calendar month is added to (or subtracted from) the observed gaged flow at each index gage to compute the estimated baseline flow. The proposed percent-of-flow diversion limits (by block) are then applied to these adjusted baseline flows to determine the allowable daily diversions. This methodology is described in the District's March 27, 2026 presentation (Ghile, 2026) and would also serve as the basis for determining permissible limits for new surface water withdrawals from the Upper Peace system upstream of Zolfo Springs.

4.3 Impracticality of Monthly Adjustment Rates

Applying the groundwater impact adjustment rates on a monthly basis creates operationally problematic and scientifically questionable transitions at calendar month boundaries. Because each adjustment rate changes discretely at the turn of each month, the estimated baseline flow—and therefore the allowable diversion—can change abruptly from one day to the next even though the actual river flow may not change appreciably. For example, if the river is experiencing nearly the same gaged flow on the 31st of one month as on the 1st of the following month, the monthly adjustment factor applied to that flow will differ solely because of the calendar date. This could result in a situation where a water user is permitted to withdraw water from the river on the 31st but is no longer permitted to withdraw on the 1st, despite the streamflow being essentially identical on both days. From an operational standpoint, particularly for a surface water supply project that depends on consistent withdrawal opportunities during high-flow periods, this approach is impractical and perhaps unnecessarily restrictive. The Cooperative's proposed withdrawal from the Upper Peace River near Bowling Green would require consistent and predictable operational rules, and tying withdrawal eligibility to a monthly adjustment rate that shifts arbitrarily at calendar boundaries undermines that objective.

4.4 Ecological Unsoundness of Monthly Adjustment Rates

Beyond the operational difficulties, the use of monthly groundwater adjustment rates for MFL compliance is ecologically unsound. Groundwater interactions with the Upper Peace River do not change discretely at the boundary of each calendar month. Groundwater discharge to, and recharge from, a river is a continuous process governed by the hydraulic gradient between the aquifer and the stream, which responds to regional pumping patterns, seasonal rainfall, and aquifer storage on timescales that do not align with the calendar. As Flannery (2026) has observed, the Upper Peace River is a highly complex system for modeling groundwater interactions with streamflow, in large part because of extensive physical alterations to its watershed—particularly widespread phosphate mining, which currently accounts for approximately 25% of the upper river basin. Mined lands in close proximity to the river, including large areas of clay settling ponds, have very little recharge to the Floridan aquifer and disrupt localized groundwater flow to the river (Flannery, 2026). There have also been large historical changes in groundwater use in the upper river basin, much of which occurred when water use records were not nearly as complete as today.

From an ecological perspective, the organisms, habitats, and biogeochemical processes that the MFLs are designed to protect do not respond to arbitrary monthly categorizations of groundwater influence. Fish passage, floodplain inundation, sediment transport, nutrient cycling, and detrital transfer are all driven by actual flow conditions in the river at any given time—not by the calendar month in which that flow occurs. A fish moving through a reach on the last day of one month experiences the same hydraulic conditions as on the first day of the next month if the flow is the same. Similarly, floodplain connectivity and the biogeochemical processes it supports are governed by the magnitude and duration of flows, not by monthly administrative boundaries. Applying different groundwater adjustments to identical river conditions solely because of a calendar date change introduces an artificial discontinuity that has no ecological basis and no relationship to the continuous physical processes occurring in the river system.

The ecological deficiency of the monthly adjustment factor approach is compounded by the fact that each monthly rate adjustment is applied as a fixed flow quantity regardless of the rate of flow in the river. As Flannery (2026) has demonstrated, because the adjustment factor for a given month does not vary with the flow rate, the resulting determination of allowable withdrawals produces anomalous seasonal patterns that bear no rational relationship to the ecological needs of the river system. For example, using the District's methodology at the Fort Meade gage, at a gaged flow of 150 cfs in June, an allowable net withdrawal of 9.6 cfs can be calculated, yet at that same 150 cfs flow rate no water can be withdrawn at all during August, September, October, November, or December—months that are generally less ecologically sensitive than the early summer period when fish spawning and recruitment are active. In September, no water can be withdrawn until gaged flows reach 314 cfs or greater. These results are ecologically counterintuitive: the monthly adjustment rates effectively permit withdrawals during ecologically critical low-flow periods in some months while prohibiting withdrawals during less sensitive high-flow periods in other months, solely because of how the fixed monthly adjustment interacts with the rate of flow.

This fundamental mismatch between the adjustment factor methodology and the ecological realities of the river undermines the capacity of the proposed MFLs to fulfill their statutory mandate of preventing "significant harm" to the water resources and ecology of the Upper Peace River. The purpose of an MFL is to ensure that withdrawals do not cause unacceptable ecological degradation; yet a methodology that produces arbitrary seasonal variations in water availability—unrelated to actual ecological sensitivity or the magnitude of flow—cannot reliably achieve that objective. Flannery (2026) has recommended that the District examine adjustment rates based directly on the rate of flow, possibly incorporating a seasonal component, which would more accurately reflect the hydrologic and ecological characteristics of the river and provide a more scientifically defensible basis for protecting the system from significant harm.

4.5 Alternative Approach Using a Single Groundwater Adjustment Rate

In place of the twelve monthly adjustment factors, the District could also consider applying a single average annual groundwater impact adjustment rate at each MFL index gage location. The long-term average values from the PRIM2 model, as reported in the Draft MFL Report Table 5-6, provide a straightforward basis for such an approach: +13.4 cfs for Bartow, +17.1 cfs for Fort Meade, and –6.5 cfs for Zolfo Springs. Applying a single adjustment rate at each gage would eliminate the artificial monthly discontinuities that create operationally impractical and ecologically meaningless transitions in the determination of allowable withdrawals. For MFL implementation and compliance, substituting a single annual average groundwater adjustment rate for the monthly rates would have a negligible effect on the estimated long-term water availability but would provide substantial operational and ecological advantages.

A single annual adjustment rate would make practical operation of a surface water supply project simpler and more predictable, while still being protective of the water resources and ecology of the system. The single rate would also better reflect the underlying reality that groundwater interactions with the river are continuous processes that are more accurately characterized by long-term averages than by month-to-month fluctuations in a model output. It is recommended that the District consider adopting this approach for the operational implementation and ongoing compliance of the proposed MFLs.

5 Conclusions

The Upper Peace River is both an ecologically significant waterbody and a vital potential source of water supply for the citizens of Polk County. The Cooperative recognizes that the District has a statutory obligation to establish MFLs that prevent significant harm to the water resources and ecology of the river. At the same time, Section 373.042, Florida Statutes, requires that the establishment of minimum flows account for the needs of both the natural system and reasonable-beneficial uses of water, including public water supply.

This analysis has identified a number of ecological, methodological, and technical deficiencies in the Draft Report that, if left unaddressed, will result in MFLs that are unnecessarily restrictive without providing a corresponding ecological benefit—thereby depriving the citizens of Polk County of a critical water supply resource without adequate scientific justification. The District should revise the Draft Report to address the following concerns.

Choice of Floodplain Metric. The Draft Report uses inundated floodplain area as the primary ecological metric for establishing the Block 3A and 3B flow restrictions. Recent peer-reviewed research indicates that inundation frequency, duration, and timing are more ecologically important than total inundation area. The District should provide additional justification for its reliance on inundated area or, alternatively, incorporate frequency- and duration-based metrics that more accurately reflect floodplain ecological function.

Non-Linear Ecological Reponses and the 15% Habitat Loss Threshold. The Draft Report assumes that maintaining at least 85% of baseline floodplain inundation area is necessary to prevent significant harm. However, floodplain ecosystems exhibit threshold effects and non-linear responses to flow changes, not the linear relationship implicit in a fixed percentage standard. The District should evaluate whether a 15% reduction in inundated area actually produces measurable ecological harm or falls within the range of ecological resilience, and should justify the selected threshold with site-specific data rather than relying on a generalized assumption.

Percent-of-Flow Methodology. The District applies a percent-of-flow methodology to establish the Block 3A and 3B minimum flows. While the District has a long and defensible history of using this approach, the scientific community has increasingly recognized the limitations of percent-of-flow methods for assessing ecological impacts. The District should consider supplementing or refining its approach by evaluating whether specific flow reductions actually compromise identifiable ecological functions—such as fish migration, floodplain connectivity, and sediment transport—rather than relying exclusively on a fixed percentage reduction.

Groundwater Adjustment Rate Methodology. The District's use of monthly-averaged groundwater adjustment rates derived from the PRIM2 model to estimate baseline flows raises three distinct concerns. First, the monthly adjustment rates create operationally impractical discontinuities at calendar month boundaries, where the allowable withdrawal can change abruptly from one day to the next despite no change in actual river flow. Second, the monthly adjustments are ecologically unsound because groundwater interactions with the river are continuous processes that do not follow the calendar, and the organisms and habitats that the MFL is designed to protect respond to actual flow conditions, not to administrative monthly categories. Third, because each monthly adjustment rate is a fixed quantity applied regardless of the actual rate of flow, the methodology produces anomalous seasonal patterns in water availability that bear no rational relationship to the ecological sensitivity of the river at different flow magnitudes—undermining the capacity of the proposed MFLs to fulfill their statutory mandate of preventing significant harm. The District could consider replacing the twelve monthly adjustment factors with a single annual average adjustment rate at each gage, as doing so would produce a negligible difference in long-term water availability while eliminating the operational and ecological deficiencies of the monthly approach. Alternatively, the District could also examine whether adjustment rates based directly on the rate of flow would more accurately reflect the hydrologic and ecological characteristics of the river.

The Cooperative is committed to working constructively with the District to develop minimum flows that are scientifically defensible, ecologically protective, and operationally workable. The Upper Peace River can and should serve both ecological and water supply functions. The issues identified in this analysis are not insurmountable, but they require the District to revise the Draft Report so that the proposed MFLs are grounded in sound science, reflect the severely altered condition of the upper river watershed, and appropriately balance the statutory objectives of environmental protection and the provision of water for the reasonable-beneficial use of the citizens of Polk County.

6 References

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April 17, 2026

SF-17 A review of methods for assessing if the Upper Peace River is meeting the proposed minimum flows at the three index gages and the determination of allowable withdrawals for potential new water users

Submitted by: Sid Flannery

Summary

This memorandum reviews the methods the District has used to determine if the Upper Peace River is meeting the proposed minimum flows for the three segments of the upper river. This is followed by a discussion of how maximum allowable withdrawals are determined for these same three segments.

In sum, there is very strong evidence that the Upper Peace Rive at the Ft. Meade gage is not meeting the minimum flows associated with that gage a large portion of the time over much of the flow regime of the river. As discussed in previous documents I have submitted, this is very evident from the monthly adjustment method the District has identified to determine if the daily flows at each of the three index gages are meeting the proposed minimum flows.

I recently received outputs for daily flows predicted by the PRiM2 model for the Upper Peace River and they support the same conclusion regarding the Ft. Meade gage. I also discuss that the method the District's comparison of mean PRIM modeled values in Table 7-1 in the draft report to conclude that the river is meeting the minimum flows at Ft. Meade is inappropriate and not technically compatible with the proper application of the percent-of-flow method.

Also, the methods District describes in the most recent draft report to determine allowable maximum withdrawals at Zolfo Springs, where the modeling results indicate the gaged flows are frequently higher that the baseline flows, either needs clarification or revision. In that regard, I have proposed a technically sound method to determine the maximum allowable withdrawals at Zolfo Springs. Maybe this is what the District intends, but one cannot tell from the report. The method I recommend determines the maximum allowable withdrawals by applying the minimum flow percentages to the daily gaged flows of the river in those months for which the adjustment values listed in the report indicate the gaged flows are greater than the baseline flows.

Finally, I believe that Florida Statutes that deal with recovery measures for waters that are not meeting their minimum flows, such as the Upper Peace River at the Ft. Meade gage, allow for technical and economic factors to be considered when determining what recovery steps are practical and worth pursuing. This is a much better and more credible approach than not analyzing the data sufficiently nor properly to incorrectly conclude that the minimum flows are being met at the Ft. Meade gage,

The determination if the minimum flows are being met at the Ft. Meade and Zolfo Springs gages.

I have discussed this topic in previous documents that I have submitted to the District and the review panel, but I briefly reiterate a few key points from them in this document. First, however, I want to discuss the method the District has presented in the second and third drafts of the minimum flows report to incorrectly conclude the minimum flows at Ft. Meade gage are being met.

In these drafts, the District has presented in Table 7-1 mean values for various flow conditions in including the baseline flows, the existing or current flows (which should mimic the gaged flow record), and the flows after the minimum flows are applied. All of these values were generated using the PRIM2 model for the river for the period 2003 to 2018.

As I have said before, the comparison of average flows over a broad flow range, even within the blocks for the Upper Peace River, is not in keeping with the original technical development of the percent-of-flow method and obscures the analytical power of the method and its ability to protect the environment. As I have demonstrated in other documents I have submitted, this because the values at high flows, when the relative differences between gaged flows and baseline flows may be small, can overwhelm large proportional differences the values at low and medium flows.

This is a real shortcoming of the mean value approach, because large percent flow reductions at low flows can be very damaging to the environment, but the effects of these flow reductions can be completely ignored using the averaging method when it is applied over too broad a flow range. This is especially a problem in the upper and middle segments of the Upper Peace Rive, where it well known that the low flows have been most impacted, but sufficient rain and prolonged high flows can periodically overcome some impacts.

Previous documents I have submitted (SF-4, SF-11, SF-12 and SF-14) show such relationships at the Ft Meade gage, and these findings have clearly shown the river is not meeting the minimum flows for a large majority of the time using the monthly adjustment method the District is proposing to apply to the daily gaged flows to determine to what extent the minimum flows are being met. Table 5 in document SF-4 shows the minimum flows at Ft. Meade were met only 40% of the time during the years 2003 to 2018, and only 20% of the time during critical Block 2 which corresponds to the instream habitats of the river.

The panel has commented on these relationships, and one member showed my table of results for the 2016 to 2022, when the Lake Hancock project was operable. Even then, the minimum flows were achieved only 59% of the total days and 30% of the days in Block 2 during this wet period. As a follow-up to this point, I want to reiterate than in document SF-6 I calculated moving average flows for seven-year periods in the entire period the District estimated baseline flows. Of the 42 years for which seven-year flows could be calculated, the period from 2016 to 2022 was ranked second highest from the top. As the panel has discussed, the wet climatic period from 2016 to 2022 had much to do with the improved conditions in the river.

Before leaving this topic, it is important to note similar analyses I conducted on the flow records at Zolfo Springs indicate the river is meeting the minimum flows nearly all the time at that gage. Similarly, the flow rates are much greater there, with a median gaged flow of 250 cfs compared to 78 cfs at Ft. Meade for the 1975 to 2002 period assessed in the report.

In short, the likely practical scenario that any future water supply withdrawals from the Upper Peace River would be from the lower river segment associated with the Zolfo Spring gage. As such, the correct conclusion that the minimum flows are not being met at the Ft. Meade gage represents no practical hindrance to using the Upper Peace River for future water supply.

Limitations of Table 7-1 in the District report and considerations for applying the results of the PRIM2 modeling of the Upper Peace River

The District report discusses the mean flow values listed in Table 7-1 to conclude that the minimum flows are being met at all three index gages in the Upper Peace River, and the problem with using averages over a large range of flows was previously discussed.

What I emphasize now is that all the values listed in Table 7-1 were generated from the PRIM2 model for years 2003 to 2018. First, this is very good period for analysis at it covered a range of climatic conditions as opposed to the wet 2016 to 2022 period which has been widely discussed.

Without question, the PRIM2 model is a very useful tool and the District and its consultants are to being commended for developing it. However, like all models, the assumptions, data limitations, and potential inaccuracies in the modeling need to be considered when making water management decisions. Having said that, it is best when the modeling results support what we know about the Upper Peace River from the numerous studies and data collection programs that have been collected there. Having said that, with proper application and interpretation the findings of the PRIM2 modeling can be used to make sound management decisions for the Upper Peace River.

I think the PRIM2 model may underestimate the baseline flows in the upper river. The panel has discussed that doubling the simulated streamflow gains between the 100% and 50% groundwater pumping scenarios to estimate flows for a zero-pumping condition is a big assumption, as it does not account for that greater rates of streamflow gains would be expected for the zero percent pumping scenario when the potentiometric surface of the Upper Floridan aquifer would be above the river bed. One would think this assumption would lead to an underprediction of baseline flows with no groundwater withdrawals.

Another thing that has been identified in recent District responses to the panel, but has not been widely discussed, is the large effect that structural changes to the watershed that have resulted from widespread phosphate mining in the river basin, much of it in very close to the river channel and tributaries. This includes many large clay settling ponds in very close proximity to the river channel, which can be up to 40 feet thick and contain highly impermeable clays, which hinder recharge and lateral groundwater flow to the river. It is the common observation that where the river tends to go dry first is in the area where these old clay settling ponds are near the river channel.

It is my understanding the occurrence of the clay settling ponds was essentially covered as the background condition in the PRIM modeling. As such, I think that the calibration of the model to the flow regime of the river was to an already impacted condition, which may also act to underpredict baseline flows in upper and middle sections of the Upper Peace River.

In this regard, I think it is important to consider and compare the gaged flows of the river to the modeling results when assessing how much flows in the river have been reduced by various anthropogenic factors. It is therefore important to again reiterate the average values listed in Table 7-1 were all taken from PRIM2 model generated values.

On page 240 the report states that means for the current (gaged) flows are greater than the means if the minimum flows are applied at all three gages. Similarly, this comparison is used to conclude that the minimum flows at the Ft. Meade gage are being met.

However, the mean flow for the USGS gage at Ft. Meade for Block 2 during this same period was 45.7 cfs, which is 6.3 cfs (or 12.9%) less than the corresponding mean value for current flows (50 cfs) derived from the PRIM model. It is also less that the modeled mean value of 48 cfs listed for the minimum flows, which does not support the District's conclusion that the minimum flows are being met in Block 2 at Ft. Meade.

The results are similar for Blocks 3A and 3B at Ft. Meade, as the mean gaged flow is 228 cfs for Block 3A, compared to a modeled current conditions value of 264 cfs. Similarly, this 228 cfs mean gaged value represents a 20 percent reduction from the modeled baseline value of 286 cfs, which is double the 10 percent withdrawal limit proposed for Block 3A at Ft. Meade. Similarly, the mean gaged flow of 228 cfs for Block 3A is well below the 257 cfs minimum value, which would indicate that comparing the mean values, the minimum flows are not being met if the gaged values are used for comparison

I realize this may be an apple vs. oranges issue, as it can be argued that model to model comparisons are most applicable, in that they use a similar method with boundary conditions, groundwater data, and other model input parameters. However, it an be argued that the gaged flows are by far the most accurate values representing the actual flows of the river, and it is very useful to compare the modeled values to the gaged flow to see if they tell the same story and lead to the same management conclusions. They do for the Zolfo Springs gage, where the mean gaged flow of 545 cfs for Block 3A is within 1 percent the modeled current conditions value of 551 cfs, and greater than the modeled mean minimum flow (500 cfs) for that Block. However, the mean gaged flow values at Ft. Meade are considerably less than the means computed from the PRIM2 model, which leads to different management considerations.

Having all this, I reiterate that comparing mean values over a broad range of flows, even within blocks, is not the appropriate method to determine if minimum flows are being met. However, the much closer agreement of the gaged and modeled values at Zolfo Springs indicates that management decisions based solely on modeled values are probably more technically sound at that location.

Percent flow reductions as a function of flow using the PRIM2 model values

As previously mentioned, I recently requested and received from the District PRIM2 model output for the baseline and current conditions flows for the Ft. Meade gage. I did this to see how the modeled flows correspond to the gaged flows over time, and also to examine if adjustment factors to calculate baseline flows could be determined as function of flow, rather than the monthly adjustment method the District has proposed which applies the same adjustment factor within a month regardless of the rate of flow.

Much to everyone's relief, I did not come up with another method for baseline correction factors, but did examine the results using modeled existing conditions flows vs. gaged flows, which was informative. Before presenting those results, I want to say that the monthly adjustment method that the District has developed basically works. Although that it is very unlikely that the same adjustment factor would truly apply between low and high flows in a month, it in effect does indicate that a given flow reduction, say 10 cfs in November, is more of a problem at a flow rate of 30 cfs that it is at 10 cfs, when the same adjustment factor to calculate baseline conditions.

As I have previously demonstrated, applying this method to the Ft. Mead gage, as the District intends to do to assess compliance with the minimum flows, strongly indicates the river is frequently not meeting the minimum flows at the Ft. Meade gage. However, using this same method, the river is meeting the minimum flows at Zolfo Springs.

Back to the PRIM modeled values, on page 184 the most recent draft report states "Because groundwater withdrawals in PRIM2 were simulated on a monthly basis, the model's daily streamflow outputs were averaged to monthly values." Similarly, on page 178 the first draft of the report stated "Given the uncertainties associated with model inputs and simplified assumptions and approximations of complex hydrologic interactions, daily flows generated by PRIM2 were average to monthly values."

In keeping with this approach, I averaged the daily PRIM2 model flows I received from the District to monthly values, resulting in 192 monthly values for the sixteen-year period over which the PRIM2 model was run. I also created similar monthly flows for the gaged flows at the Ft. Meade gage for this same period.

Two graphics of percent reductions in modeled monthly baseline flows represented by monthly gaged and modeled existing flows were created. Again, the term existing flow refers to model predictions that should correspond to the gaged flows in the river.

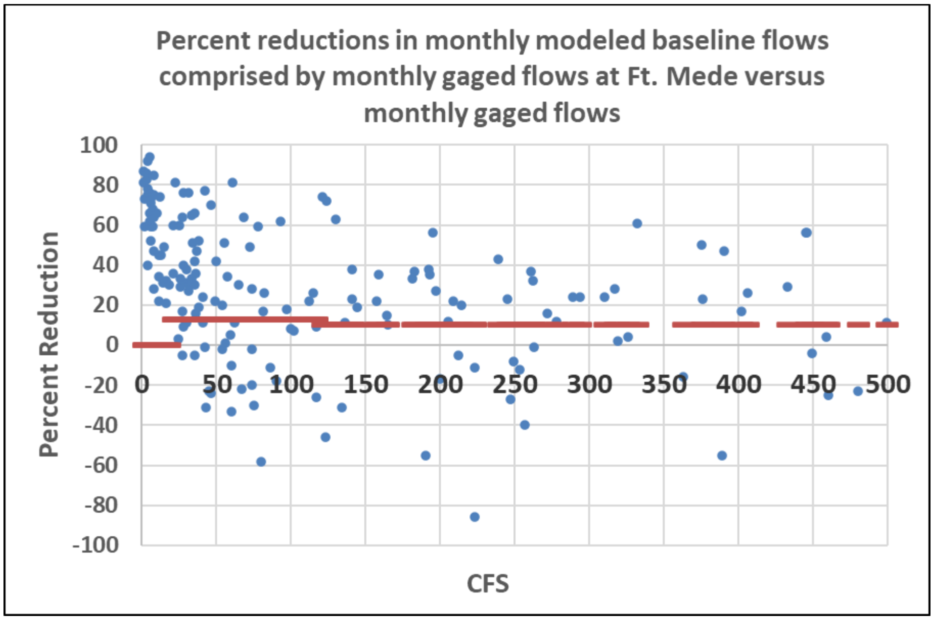

Figure 1. Percent reductions in modeled monthly baseline flows comprised by the monthly gaged flow within that month versus the average monthly gaged flow for each value

It is clear from Figure 1 that the gaged flows frequently represent percent flow reductions considerably greater than the maximum allowable percent flow reductions allowed for the three Blocks shown by the red horizontal lines. As with the method using the monthly adjustment factors and gaged flows, the most pronounced percent flow reductions are at low flows, which makes sense give the nature of the impacts to the Upper Peace River and confirms the utility of the monthly adjustment approach proposed by the District.

Text continues on the following page

Percent flow reductions in baseline flows comprised by the modeled existing conditions flows are plotted versus the modeled monthly baseline flows in Figure 2. The percent flow reductions are smaller than for the gaged flow values, but that is not surprising as the modeled monthly existing conditions flows tended to be greater than the corresponding gaged flows. However, the percent flow reductions based solely modeled values show the same pattern as when the gaged flows are used, as the greatest percent flow reductions are at low rates of flow. Even when using the modeled existing flow values, there are frequent times at low flows when the percent flow reductions are greater than the amounts allowed by the minimum flows.*

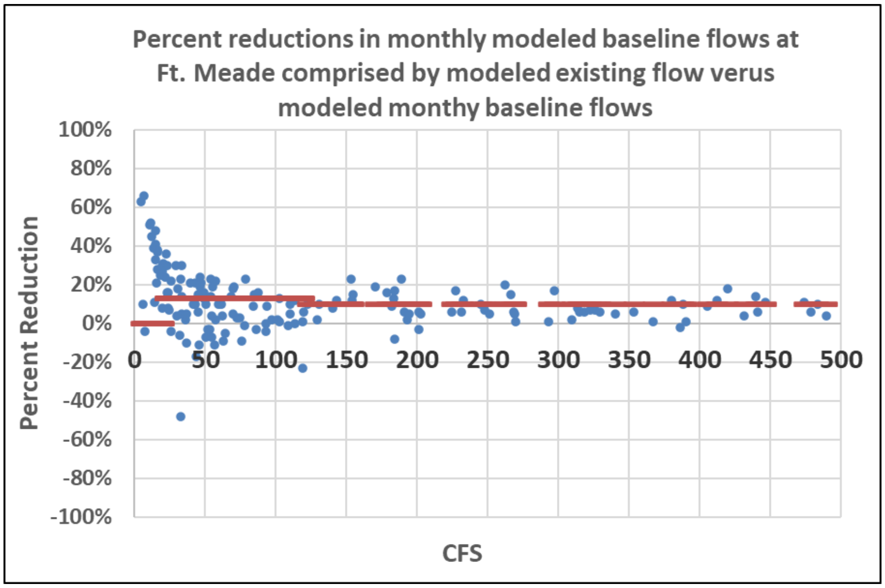

Figure 2. Percent reductions in modeled monthly baseline flows comprised by the modeled existing flow within that month versus the average monthly baseline flow for each value.

In sum, these graphics show there is similar pattern when using either the gaged flows or modeled flows to assess minimum flow compliance, with the greatest percent flow reductions occurring at low flows. This can be partly explained because a small flow reduction can represent a high percentage of flow at low flows, but it also makes sense with what is known about the nature of the physical impacts to the Upper Peace River, in which sinks, crevasses and other karst features can capture substantial proportions of river flow at low flows.

In that same regard, the graphs also demonstrate the problems with using averages over a broad flow range to assess minimum flow compliance, as relatively small differences in flows at high flows will dominate the average values and mask the larger percent, and ecologically important, flow reductions that are occurring at low flows.

* The graphics mistakenly plotted some small overlaps of the maximum allowable percent withdrawals represented by the red horizontal lines

Finally, I think is important to consider the results using both the modeled existing flows and the gaged flows to assess if a river is meeting the minimum flows. In a perfect situation, there would be closed agreement between the two approaches, but it must be considered that the gaged flows are the most accurate measure of the actual flows in the river, and if there is an observable bias with regard to the modeled existing flows, such as the existing flows tending to over-estimate the gaged flows, that should be taken into account in determining the appropriate regulations or management strategy for a river.

In the case, of the Upper Peace River at Ft. Meade, I think the combined results using the gaged flows and the modeled existing flows support the conclusion that the minimum flows are not being met at the Ft. Meade gage. This agrees with the conclusion of when the monthly adjustment method is used, which was described in other documents I have submitted to the District and the panel.

Method to calculate allowable withdrawals during months when the gaged flows are higher than the baseline flows

The most recent draft of the minimum flows report presented language to explain how the minimum flows would be implemented to determine allowable withdrawals from the river. As described in the summary of this document on page 1, I think the methods District describes in the most recent draft report to determine allowable maximum withdrawals at Zolfo Springs, where the modeling results indicate the gaged flows are frequently higher that the baseline flows, either needs clarification or revision. This is a very important issue that needs to be addressed

I submitted a memorandum to the District on April 16, 2026, that explains this issue. That memorandum begins on the following page.

April 16, 2026

Subject: Calculation of maximum allowable withdrawals from the Upper Peace River associated with the Zolfo Springs gage as described in the draft minimum flows report for the upper river.

From: Sid Flannery

The information below and table on the following page were prepared to examine and clarify how much water can be withdrawn from the lower segment of the Upper Peace River within the minimum flows that are proposed in the draft report for the Upper Peace River. A gaged flow rate of 100 cfs during May and June at the Zolfo Springs gage is used as an example.

As described below, based on this example, the text in Chapter 7 of the District's draft minimum flows report needs to be revised, or if the language really means what I think it says, I have serious technical issues with how the minimum flows will be applied for the lower segment of the Upper Peace River associated with the Zolfo Springs gage.

The findings for the Zolfo Springs gage in the minimum flow report differ significantly from the Bartow and Ft. Meade gages in that the monthly adjustment factors to convert gaged flows to baseline flows have negative values for nine months of the year at Zolfo Springs. This means that gaged flows are in effect higher than the baseline flows during those months. On page 241 and 242, the draft report has a good description of how the monthly adjustment factors are to be applied at the Bartow gage and I find no problem with that, as it is accurate and very helpful. However, I think it is the appropriate method only where the gaged flows are less than the baseline flows, using the monthly adjustment method described in the draft report.

Because the gaged flows at Zolfo Springs are higher than the calculated baseline flows for nine months of the year, it is a very different situation. However, on page 242 in describing the approach for the lower segment, the report states "consistent with the upper and middle segments, allowable withdrawals are calculated as the difference between the measured *(gaged)* and the minimum flow.

I have used this method to calculate the maximum withdrawal rates allowed at the Zolfo Springs gage at a gaged flow rate of 100 cfs during the months of May and June. The methods and factors used to calculate these allowable withdrawals are described on the following page, along a table that lists the resulting values.

Following the methods described in the draft minimum flows report, this would allow for a 23.8% withdrawal of a gaged flow 100 cfs at Zolfo Springs in May and a 34.9% withdrawal of the same gaged flow rate in June. I hope what I have described is not what the District intends, but unless I am missing something, that is what the methods in Chapter 7 describe. In an email submitted with this document, I am asking the District to please clarify what method will be used to calculate maximum allowable withdrawal rates at gages where the monthly adjustment factors indicate the gaged flows are higher than the baseline flows.

Given the uncertainties and limits to the accuracy of the PRIM modeling, combined with what we know about the Upper Peace River, in cases where the monthly adjustment factors indicate the gaged flows are higher than the baseline flows, I think it is much more technically sound to calculate the maximum allowable withdrawals by the applying proposed minimum flow percentages to the gaged flows.

The following steps were taken to calculate the values listed in the table below based on my understanding of the text presented in Chapter 7 of the draft minimum flow report for the Upper Peace River. Examples are provided for a gaged flow rate of 100 cfs at the Zolfo Springs gage during the months of May and June.

1. A flow of 100 cfs corresponds to Block 2 at the Zolfo Springs gage, which extends form flow rates from > 40 cfs to ≤ 274 cfs

2. The maximum allowable percent flow reduction (withdrawal) during Block 2 is 13%, which is applied to the calculated daily baseline flows using the monthly adjustment factors, which are -12.39 cfs for May and -25.18 for June. Applying these monthly adjustment factors results in baseline flows of 87.6 cfs in May and 74.8 cfs in June.

3. Thirteen percent flow reductions were then applied to these baseline flow values to result in allowable flow reductions of 11.4 cfs and 9.7 cfs for May and June, respectively.

4. Subtracting these maximum allowable withdrawals from the calculated baseline flows results in minimum flows of 76.2 cfs and 65. 1 cfs in May and June, respectively.

5. Chapter 7 states that the maximum allowable withdrawal is the difference between the measured (gaged) flow and the minimum flow, which at Zolfo Springs results in a withdrawal of 23.8 cfs in May and a 34.9 cfs in June, corresponding to a 23.8% reduction in the gaged flow of the river in May and a 34.9% reduction of the gaged flow in June, which are two of the most most ecologically sensitive months in the year.

6. Is this what the District intends, or does the text in Chapter 7 need to be clarified?

Table 1. Final net flow reductions (withdrawals) allowed at the Zolfo Springs gage by the proposed minimum flows for a gaged flow rate of 100 cfs during May and June and the values used to make those determinations. The final net withdrawals are expressed as cfs and as a percentage of the previous day gaged flow which was used to calculate the minimum flow for that day, which is then used to determine the allowable withdrawal.

Month	Block	Gaged flow (cfs)	Baseline Adjustment (cfs)	Baseline flow (cfs)	Allowabe MFL Percent Reduction (%)	Allowable MFL Flow Reduction (cfs)	River minimum flow	Allowable withdrawal (gaged flow - minimum flow)	Final withdrawal as percent of gaged flow
May	2	100	-12.39	87.6	13%	11.4	76.2	23.8	23.8%
June	2	100	-25.18	74.8	13%	9.7	65.1	34.9	34.9%

SF-18 Verbal comments to the April 17, 2026 meeting of the scientific review panel for the Upper Peace River minimum flows report

I want to give you an update on a few items regarding the minimum flows analysis.

I requested and received from the District output from the PRIM2 model for the upper river so I could examine ways the model output can be used to determine if the minimum flows, particularly at the Ft. Meade gage, are being met. In a document labeled SF-17 that was posted to the webboard today, there are two hydrographs and a discussion that supports my previous conclusion that the minimum flows at Ft. Meade are not being met for much of the time. However, it is important as part of this process to also compare the gaged flows for the river to the modeled baseline flows to assess minimum flow compliance.

Second - the information I discussed with you at the last meeting was based on the applying the monthly adjustment factors to the gaged flows, which is how the District plans to assess minimum flow compliance in the coming years. Those results clearly show the minimum flows are not being met for considerable lengths of time at Ft. Meade.

My new document also discusses that the comparison of average flows over a large flow range to assess minimum flows compliance, even within blocks, is not compatible with the conceptual development and analytical power of the percent of flow method, as small percent flow reductions at high flows can mask large percent flow reductions at low and middle flows, which are ecologically very important. This is particularly the case on the Upper Peace River, where the low flows have been most impacted, but sufficient rain and high flows can overcome some of the impacts the river has experienced.

In that regard, the District's comparison of average modeled flow values in Chapter 7 to conclude that the Upper Peace River is meeting the minimum flows at all three index gages is highly inappropriate, and should not be relied on to determine minimum flow compliance. Instead, more conventional analyses indicate that although the river is not meeting the minimum flows at Ft. Meade, the river is meeting the minimum flows at Zolfo Springs and there is considerable water available for supply at that location.

Frankly, I think District wants to conclude the minimum flows for the Upper Peace River are being met to be off the hook for any additional recovery strategies beyond the Lake Hancock project. Based on working on minimum flows for many years, I think the Florida Statutes can allow for technical and economic factors to be considered when determining what recovery steps are practical and should be pursued, which is a much better and more credible approach than not sufficiently nor correctly analyzing the data.

There is also one potential, very important issue that appeared in the most recent draft of the District's report, which was made available earlier this week. In Chapter 7, the report provides a very good description of how the minimum flows are to be implemented at the Bartow gage. However, it seems to state that the same approach would be used for the Zolfo Springs gage, which is a fundamentally different situation, as the monthly adjustment factors have the gaged flows being higher than the baseline flows for nine months of the year.

I don't have time to explain the details now, but yesterday I submitted to the District a memo that includes an example that shows that application of the method described in the District report would allow for a 35% flow reduction at a flow rate of 100 cfs at the Zolfo Springs gage in June.

If the District can clarify this matter today, I will repost my new document with this discussion taken out. But if is this still needs clarification, the discussion of this issue will remain and be found on pages 7 to 9 in the document that posted earlier today.

My recommendation is that in situations where the monthly adjustment factors establish that the gaged flows are higher than the baseline flows, the allowable percent flow reductions can be based on the gaged flows, which is a simple but technically sound approach.

Finally, as a quick side note, a couple of meetings ago, Mr. Loper showed a table from one of my documents that summarized minimum flow compliance for the 2016 to 2022 period when the Lake Hancock project was operative. The panel has commented that was a wet period, so in the new document posted today, I reprinted a statistic that I put in one of my previous documents a couple of months ago, which found that the seven-year average flow for the 2016 to 2022 period was the second highest in 42 years of record. Yes, it was wet.

Thanks for your time, these comments will be posted as document SF-18 to the minimum flows webboard later today.

From: Angel Martin
To: Kristina Deak
Subject: Upper Peace River MFL Peer Review Panel--Meeting 6--April 17, 2026
Date: Friday, April 17, 2026 11:20:39 AM

My comment/suggestion concerning the subject meeting is as follows.

1. Concerning the modeling, additional information/discussion is needed in the report concerning possible future sensitivity analysis. Specific information should be included concerning how the sensitivity analysis will be performed and related parameterization. Suggest some discussion on model limitations and uncertainty..

Thank you for the opportunity to comment on the subject meeting. Please contact me if any additional information/clarification is needed.

____

Angel Martin
813-767-6944

SF-19 Follow-up to peer review meeting on April 17, 2026

I hope the scientific review panel can review document SF-17 that was uploaded to the minimum flows webboard today, as it discusses a subject the panel brought up at the meeting. That is the use of average values to assess minimum flow compliance. As I quickly mentioned at the end of my comments as I was running out of time, it is important to differentiate how averages are used to calculate the monthly baseline adjustment factors versus other uses of average values. Document SF-17 concludes that the District's use of average values for calculating the monthly baseline adjustment factors is a suitable approach.

However, this is fundamentally different that how average values within blocks, which are listed in Table 7-1 in the District report, were used to conclude that the minimum flows are being met at all three index gages. Document SF-17 discusses the limitations of relying solely on modeled values, but more importantly, how using average values calculated over large flow ranges, even within blocks, is not in keeping with the conceptual development and analytical power of the percent-of-flow method and it and should not be used to assess minimum flow compliance. In fact, this grand average approach gives contradictory findings for the Ft. Meade gage compared to assessment method the District is proposing to assess daily withdrawals from the river. Again, these topics are discussed in document SF-17.