A Review of

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

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by

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EXECUTIVE SUMMARY

This is a summary of the Scientific Peer Review Panel's ("Panel") evaluation of the scientific and technical data, assumptions, and methodologies used by the Southwest Florida Water Management District ("District") in the development of proposed minimum flows and levels (MFLs) for the upper and middle Withlacoochee River.

The approach used in setting MFLs for the upper and middle Withlacoochee River follows the common practice and established protocols that have been effectively used by the District in the past. The Panel endorses the District's overall approach for setting MFLs in riverine ecosystems and finds particular merit in the use of seasonal building blocks, multiple benchmark periods based on multi-decadal climate variability, the use of multiple analysis tools for protecting both low and high-flow regimes and the expression of MFLs as a combination of both percent flow reductions and absolute cut offs. The application of this approach for the upper and middle Withlacoochee River is thorough and defensible. The methodology is sound, the data are appropriate for the task, and the findings are based on best available science. The assumptions, that are inherent in the scientific approaches that are employed, are sufficiently documented and represent current understanding of how best to protect healthy aquatic ecosystems. The derived MFLs are reasonable and likely to sustain the ecological health of the upper and middle Withlacoochee River.

Overall, the Panel finds the methodologies used by the District are appropriate and they are to be commended for their innovation. It is evident that District staff members have clearly spent a great deal of time and effort trying to arrive at a scientifically reasonable set of recommendations within a specified time frame and budget. The authors are also to be commended for addressing one of the most difficult issues when carrying out these types of studies, trying to interpret exactly the intention of the legislators when they drafted the legislation. The discussion relating a good instream flow standard in context of the legislation, specifically preventing significant harm, is well thought out and articulate. However, additional clarity with regard to defining the benchmark condition (natural vs. historic/existing condition) and how existing changes in flow were accounted for in the MFL evaluation are suggested.

As with previous Panels, this Panel also believes that the adequacy of the low-flow threshold, and the use of a *de facto* significant harm criterion based on a 15% reduction in habitat availability from current or historical conditions has not been rigorously demonstrated. This *de*

facto criterion requires further validation with regard to its application, in this case to Outstanding Florida Waters. The precision of the low-flow threshold and reduction criteria will remain presumptive until such time as the District commits to the monitoring and assessment necessary to determine whether these criteria are truly protective of the resource. We encourage the District to build on their growing experience and expertise and to take visible steps to reduce the uncertainty and subjectivity associated with these criteria and urge them to move towards developing and implementing an adaptive management framework that will facilitate such assessments.

INTRODUCTION

The Southwest Florida Water Management District (SWFWMD) under Florida statutes provides for peer review of methodologies and studies that address the management of water resources within the jurisdiction of the District. The SWFWMD has been directed to establish minimum flows and levels (designated as MFLs) for priority water bodies within its boundaries. This directive is by virtue of SWFWMD's obligation to permit consumptive use of water and a legislative mandate to protect water resources from significant harm. According to the Water Resources Act of 1972, minimum flows are defined as *"the minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area"* (Section 373.042 F.S.). A minimum level is defined as *"the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area."* Statutes provide that MFLs shall be calculated using the best available information.

The process of analyzing minimum flows and levels for the upper and middle Withlacoochee River is built upon the analyses previously performed on various reaches of several rivers including the: Anclote, Alafia, upper Braden, Chassahowitzka, Hillsborough, Myakka, Peace, and Weeki Wachee (Southwest Florida Water Management District 2002, Southwest Florida Water Management District 2005a,b,c, Southwest Florida Water Management District 2007a,b, Southwest Florida Water Management District 2008, Southwest Florida Water Management District 2010a,b) all of which were peer reviewed (Cichra et al. 2005, Cichra et al. 2007a,b, Gore et al. 2002, Shaw et al. 2005). The upper and middle Withlacoochee River MFL methodologies incorporate many of the recommendations of these earlier peer reviews, as well as key improvements developed by District staff. Establishment of minimum flows and levels generally is designed to define thresholds at which further withdrawals would produce significant harm to existing water resources and ecological conditions if these thresholds were to be exceeded.

This review follows the organization of the Charge to the Peer Review Panel and the structure of the draft report. It is the job of the Peer Review Panel to assess the strengths and weaknesses of the overall approach, its conclusions, and recommendations. This review is provided to the District with our encouragement to continue to enhance the scientific basis that is firmly established for the decision-making process by the SWFWMD.

THE CHARGE

The charge to the Peer Review Panel contains five basic requirements:

1. Review the draft DISTRICT document, entitled Proposed Minimum Flows and Levels for the Upper and Middle Withlacoochee River.
2. Review, as appropriate, documents and other materials supporting the concepts and data presented in the draft DISTRICT document.
3. Participate in an open (public) meeting at the DISTRICT's Brooksville Service Office for the purpose of developing a written report as described in charge number 4 below.
4. By certain dates, mutually agreed upon by the DISTRICT and the peer review team, provide the DISTRICT, written reports that include a review of the data, methodologies, analyses, and conclusions outlined in the document.
5. Render follow-up services where required.

In conducting the review and pursuant to these basic requirements, the Panel is assigned three specific tasks:

1. Determine whether the conclusions in the Withlacoochee River MFL report are supported by analyses presented.
2. If a proposed method used in the Withlacoochee River MFL report is not scientifically reasonable, then the Panel will identify the scientific deficiencies, determine if the identified deficiencies can be remedied, if the identified deficiencies cannot be remedied then identify alternative methods that are scientifically reasonable, and
3. If a given method or analyses used in the Withlacoochee River MFL report is scientifically reasonable, but an alternative method is preferable, then list and describe the alternative scientifically reasonable methods including a qualitative assessment of the effort required to collect data necessary for implementation of the alternative methods.

RESULTS OF THE PEER REVIEW

Executive Summary

On page vii, third paragraph, it is stated, *"The low flow threshold is defined to be a flow that serves to limit surface water withdrawals, with no surface water withdrawals permitted unless the threshold is exceeded."* While the intent of what is being said is understood, perhaps a better way to make this statement is, *"The low flow threshold is defined to be a* *flow that serves to limit surface water withdrawals, with surface water withdrawals permitted when flows are above, or greater than, the threshold, and no withdrawals are permitted when flows are below, or less than the threshold."*

On page vii, third paragraph, last sentence it is stated; *"Percent of flow reduction limits were calculated to be 11, 15, and 13 percent of the flow as measured at the Croom, Wysong, and Holder gage sites respectively. These determinations were based on nine PHABSIM sites and historic flow records for the Croom, Wysong, and Holder gages."* Here and throughout the report, the authors should ensure they clarify that the MFLs are based on historic, or existing flows. The percent flow reductions are reductions from historical, not natural (pre-settlement) flows. A brief discussion on the differences between natural and historical flows should be presented along with a discussion of what these changes mean, or do not mean, to the existing natural resource values. Providing data on the current and historical status of fish and wildlife resources would be beneficial in that it would put the flow reduction recommendations in context of the goal of "no significant harm".

Chapter 1: Minimum Flows and Levels

The overall context and District approach to MFL establishment is well defined in this chapter and lays the foundation upon which specific analysis related to MFL determination is applied. Overall this section is well supported, scientifically sound and critical distinctions among commonly used terms are discussed. It is recommended that additional information be provided in two sections of this chapter.

In Section 1.4, there is a discussion of ecosystem integrity and significant harm. The term significant harm is highly subjective, often based on a weighting of losses versus benefits, and was poorly defined in the original legislative mandate. As such, the determination of whether or not a water resource impact has reached a threshold of significant harm has often been difficult to determine. However, in later chapters of the document, it is clear that the District has adopted a quantitative threshold of significant harm whereby impacts greater than15% loss in time or space of a particular water resource are considered significant harm. The adoption of this threshold is predicated on findings from Gore et al. (2002) and at least one previous MFL peer review panel (Shaw et al. 2005). The District is to be complemented for attempting to establish a quantitative threshold for significant harm as it makes MFL determination less subjective and more repeatable. This fundamental assumption associated with the threshold of significant harm should be clearly defined in this section.

Specifically, it is stated, *"Not only must "significant harm" be defined so that it can be measured, it is also implicit that some deviation from the purely natural or existing long-term hydrologic regime may occur before significant harm occurs."* This is a true statement, and it would be helpful if the authors were to present a scale that shows natural, historical and the significant harm values. As the authors state, *"The goal of a minimum flow would, therefore, not be to preserve a hydrologic regime without modification, but rather to establish the threshold(s) at which modifications to the regime begin to affect the aquatic resource and at what level significant harm occurs."* It would be beneficial to provide a relative scale to show how the reductions from historical flows, as opposed to natural flows, sets the significant harm threshold. It is further stated that, *"If recent changes have already "significantly harmed" the resource, or are expected to do so in the next twenty years, it will be necessary to develop a recovery or prevention plan."* This is a good policy position, and again, having a scale of environmental impact for natural, historical and significant harm, would help to better understand limits of withdrawal.

In Section 1.5.1 on 1.7 it is stated, *"Although in most cases, the District does not expect to recreate pre-disturbance hydrographic conditions through MFLs development and implementation, the building block approach is viewed as a reasonable means for ensuring the maintenance of similar, although dampened, natural hydrographic conditions."* It is most reasonable to state the MFL would not be equal to "natural" pre-settlement conditions. It would be very rare to find a watershed in North America where "significant harm" would be defined as the natural flow. If this were the case, there could be no human use of water. The approach of the District of using a "building block approach" is also most reasonable for the relevant and logical reasons provided in the first paragraph of Section 1.5.1. Given the building block method, which emerged in the late 1990s (Tharme and King 1998), and all the subsequent similar methods used in South Africa, New Zealand and Australia, for example; bottom up, top down, benchmarking, etc., start with or identify the natural flow as a benchmark (Acreman and Dunbar 2004, Arthington and Zalucki 1998, Arthington et al. 2003, Arthington et al. 2004, Arthington et al. 2006, Brizga 2001, Gippel 2001, Hughes 2003, Jowett 1993, King and Brown 2006, King and Brown 2009, King and Louw 1998, King et al. 2000, King et al. 2003, Tharme 2003) then providing an assessment of the changes in hydrology, and subsequent natural resource values between natural and historical is beneficial. It is noted in Section 4 on pages 4.1 to 4.26, an extensive analysis of hydrology is presented. On page 4-26 it is stated, *"Predicted baseflow decline for the Withlacoochee River under current pumping conditions at all* *gaging stations was less than three percent."* Given this is a very small change, and assuming this represents the sum total of all anthropogenic factors that account for any change between what would have been the natural and historical flows due to land use changes, water permits issued, etc., the District should make a statement that while the habitat reduction criteria used to define the no significant harm threshold is based on the historical flow record, it is in essence as if it is based on the natural flow since the differences are very small, less than 3%. However, the Panel notes there was no quantification of the surface water changes due to the Wysong Dam AWCS structure and diversions to the Tsala Apopka Chain of Lakes. Therefore, the Panel questions whether the existing conditions should be considered equivalent to natural. Since the District shows confidence in their groundwater pumping model, then they should equally report how this information addresses the question of what is the benchmark condition against which significant harm is being tallied. Presenting data on historical populations, or some type of health indicator of the fish, amphibian, bird, or reptile populations would help to demonstrate the historical condition is virtually the same as the natural condition or is in "good" condition.

The building block approach is a means to partition the water year into discrete units based on relatively predictable annual variations in flow pattern and it is commendable and superior to a single value applied throughout the year. However, the specific methodology used to partition the year into discrete blocks is not provided. Depending on the methodology and assumptions used, four versus three blocks might result whereby block 2 is partitioned into a fall low and spring high. This could have implications for season dependant aquatic life use and vegetative recruitment of floodplain habitat. It is recommended that methods and assumptions used in determining the number of blocks and method of partition between blocks are further elaborated on.

For Figure 1-1 on page 1-8, for clarification purposes only, it is recommended that one of three possible modifications to improve reader interpretation of Block time periods is adopted:

1) add the three block periods to the graph by shading blocks or providing bracket labels, similar to layout in Figures 8-15 through 8-17
2) change x axis on Figure 1-1 to months of the year, or
3) add Julian day range for blocks 3 and 2 in text.

This recommendation is mainly to provide consistency between the figure (Julian days) and the text (months of the year).

In Section 1.6, the distinction between flows, levels and volumes and how it is used for each physical and biological entity is a refined level of effort that is not normally seen in similar studies. The District is to be commended for applying this depth of knowledge and understanding.

Chapter 2: Basin Description

This chapter provides a good geographical context within which the proposed MFL is being evaluated. However, there are two aspects of the basin's characteristics that the Panel believes warrant additional information and characterization which should either be elaborated on in this chapter or elsewhere under the appropriate subject. The first relates to existing structural alterations to the watershed and the second is related to the Withlacoochee River's designation as an "Outstanding Florida Water" (62-302.700 (9)(i) F.A.C).

Consideration of Structural Alterations

During the peer review panel's site visit we stopped at the Wysong Adjustable Water Conservation Structure (AWCS) and were made aware of diversion canals associated with water flows to the Tsala Apopka Chain of Lakes. In reading through the report there was limited discussion of the influence these hydaulic structures might have on the basin, both now and during the POR used to benchmark flows. In one of the few places in the report where the Wysong AWCS structure was referenced it was identified as having *"…significantly altered the existing river flow regime"* (page 7-14 third paragraph as noted by Engineering & Applied Science, Inc (2010)). A more detailed discussion of the Wysong AWCS and Tsala Apopka Chain of Lakes canal structures and its history is provided in Section 2.4 HEC-RAS appendix. In that summary the influence of a water control structure at Wysong appears to be variable during the POR with initial construction and operation of a dam occurring between 1964 and 1988. No structure was apparently present between 1988 and 2002 with a new Adjustable Water Conservation Structure being established in 2002 which is still in operation. Flows directed to the Tsala Apopka Chain of Lakes have not been monitored and therefore these redirected flows from the river were not included in the HEC-RAS modeling effort. Because of the likely influence of these structures on existing and historic flows during much of the POR, some explanation of assumptions made related to the influence of these structures is prudent.

Clarifying these assumptions with regard to determination of reference or benchmark flow conditions is probably most important. This also pertains to some semantics that will be addressed later in this review with regard to the definition of "historic" conditions used for comparison with MFL prescribed conditions or used as a reference against which a determination of loss is being quantified. Clarifying whether or not the influence of these control structures is being included or excluded as part of the "historic" or reference condition is necessary to determine if losses resulting from prescribed withdrawals are being based on conditions where structural modification have been excluded (loss estimates associated with MFL are not additive) or included (loss estimates associated with MFL are additive to losses or gains associated with structural modifications) in the analysis.

It is recommended that additional discussion related to these structures be provided as context within which hydrologic analysis and water resource impacts were evaluated.

Outstanding Florida Waters

The second comment specific to this chapter relates to the designation of the Withlacoochee River as "Outstanding Florida Waters" (OFW). As a result of the declaration of this designation in the document, but limited context to determine the implication an OFW designation has on determination of an MFL, the Panel looked up the definition of OFW. As defined in section 62-302.700 F.A.C; Special Protection, Outstanding Florida Waters, Outstanding National Resources Waters: *"It shall be the Department (Florida Department of Environmental Protection) policy to afford the highest protection to Outstanding Florida Waters... No degradation of water quality, other than that allowed in subsections 62-4.242(2) and (3), F.A.C is to be permitted in Outstanding Florida Waters."* The designation of OFW as well as Outstanding National Resources Waters (ONRW) is reserved for those waters that are *"…worthy of special protection because of their natural attributes."* 403.061(27) F.S. Waters associated with National Parks, National Wildlife Refuges, National Seashores, National Preserves, National Marine Sanctuaries and Estuarine Research Reserves, National Forests (certain waters), State Parks & Recreation Areas, State Preserves and Reserve, State Ornamental Gardens and Botanical Sites, Environmentally Endangered Lands Program, Conservation and Recreational Lands Program, and Save Our Coast Program Acquisitions, State Aquatic Preserves, and Scenic and Wild Rivers (both National and State) are automatically granted OFW or ONRW status. The intent of an OFW designation is to maintain ambient water quality, even if these designations are more protective than those required under the waterbody's surface water classification.

Because water quality is one of 10 water resources to be considered in establishment of MFLs, as well as the special protection attributed this river because of its natural attributes, it is recommended that some additional discussion and guidance be provided by the District with regard to how the District interprets the threshold of significant harm when determining an MFL on an OFW. Have other MFLs been established on waters with OFW designations that could be used to establish a precedent? It would seem that a higher standard in the determination of significant harm would need to be applied when developing an MFL for an OFW. Further discussion of this topic is provided in Chapter 5 related to water quality.

On page 2-2, Figure 2-1, it would be useful to designate the extent of the watershed boundary in the figure and possibly to have the full river extent and watershed outlined with the upper and middle reaches of the river highlighted (similar to Figure 4-6). An inset in the figure identifying the location of the watershed within the state of Florida or at least the SWFWMD boundaries would also be helpful.

Chapter 3: Land Use

The approach and assumptions used to characterize and quantify land use activities in the watershed are scientifically sound.

On pages 3-7 & 3-8, in Tables 3-1 and 3-2, as mentioned in the document, land use changes for the whole watershed and those upstream of the Croom site were described as similar, but Tables 3-1 and 3-2 are exactly the same. This may actually be the case, but when looking at land use area (Figures 3-5 and 3-6) some values do not appear to be the same at the two watershed scales. This is most apparent when looking at Upland Forest in Figure 3-6 and Table 3-2 for 1974 data. In the table, Upland Forest is ranked 3rd in land cover by percentage, but it is 4th by area. It is recommended that the tables (or figures) be checked.

The data presented in this chapter on land use and changes in land use are comprehensive. A discussion on the degree to which, or if these land use changes have had any impact on the flows and or subsequent habitat and fish and wildlife habitat or populations would be beneficial.

Chapter 4: Hydrology

The District has done a commendable job at describing the longer cycle climatic patterns associated with the Atlantic Multidecadal Oscillation (AMO) and partitioning these events into cool and warm periods for analysis. In addition, a discussion of Florida river flow patterns provides the underling evidence and justification in support of a building block approach to MFL development. This approach is highly supported, but as suggested earlier, a description of the methods used to determine the number of blocks and point of transition between blocks is recommended.

Determination of changes in POR flow associated with groundwater withdrawals was well documented and methods to determine baseflow condition in the river are scientifically sound. The significant baseflow contributions in low flow years was illustrative of the dynamic differences in water sources contributing to flows from year to year and the significant groundwater inputs contributing to flow in dry years especially at the Croom and Holder sites.

There seemed to be a significant omission of information in Section 4.2 under Hydrologic Analysis of Flow Declines. This information gap is related to the quantitative determination of changes in flow associated with the Wysong AWCS structure and diversions to the Tsala Apopka Chain of Lakes. As noted by Engineering & Applied Science, Inc (2010), *"The Wysong AWCS has significantly altered the existing river flow regime"*. It is recommended that estimates of changes in flow due to the Wysong AWCS and Tsala Apopka Chain of Lakes be established similar to those developed for changes associated with groundwater pumping.

The discussion on page 4-23, Section 4.2.2.2 regarding modeling to determine changes in baseflow due to pumping is commendable and facilitate a quantitative determination of existing changes to flow in the river due to groundwater withdrawal. It is recommended that baseflow changes due to pumping also be predicted for 2004, which was an extremely wet year with the lowest percent groundwater contributions of the four years analyzed as well as 2006, which had the highest percent groundwater contribution to flow of the four years analyzed. This will provide context across a wider range of likely conditions under which changes due to pumping can be evaluated. In addition, some discussion of how these values were integrated into the determination of significant harm associated with MFL determination is recommended. It does not appear that existing reductions in flow due to pumping of groundwater were taken into account when quantifying the threshold of significant harm for the proposed MFL.

It is noted on page 4-1, Figure 4-1, that between 1970 and the mid 1990's there appears to be at least 8 years where discharge at Wysong exceeded discharge at Holder, with additional years having almost equal discharge levels. After the mid 1990's only two years appear to have discharges at Wysong greater than Holder. Are these visually apparent differences statistically significant in the POR and if so can it be explained by the presence (1964-1988) then absence (1988-2002) of the Wysong Dam or does it relate to AMO which was in a cool period between 1970 and 1999? If flows at Wysong were indeed higher than at Holder for these 8 event years, where did the water go between Wysong and Holder? Under most years the flow at Holder appears to be at least 50% greater than at Wysong?

On page 4-2 and Figure 4-2 unimodal and bimodal patterns of river flow are discussed and illustrated suggesting most rivers south of the Suwannee River and big Bend area on the gulf coast will have a unimodal distribution with highest flows in summer. Yet when looking at Figure 1-1 (page 1-8) for the Withlacoochee River (south of the Suwannee River) there appears to be a biomodal distribution of flow with unequal highs and unequal lows more similar to those rivers falling in a zone from NE Florida to the Suwannee. The distinction is important as it relates to the appropriate blocking periods used to determine various flow regimes and by which the MFL is being evaluated. A unimodal flow pattern would allow for two contiguous time blocks to adequately capture average temporal flow dynamics, whereas a biomodal flow pattern would require either two blocks with two separate time periods each if flows during the two peak and two low flow periods are similar or between three and four blocks to accurately capture the temporal differences in flow pattern. Depending on the interannual variance associated with the mean daily discharge data reported in Figure 1-1, it would appear that four flow blocks (winter high (day 11-110), spring low (day 111- 210), summer high (day 211-310) and fall low (day 310-10) might be an equally appropriate blocking period for MFL development. As previously outlined under Chapter 1 of this review, clarification of the methods used to determine the number of blocks and transition point between blocks is recommended.

Chapter 5: Water Chemistry

In response to the designation of the Withlacoochee River as an OFW, and that designation's associated antidegradation policy with regard to water quality, additional scrutiny was applied to this section. The relative contribution of groundwater versus surface runoff to overall flow and its potential affect on water chemistry is illustrated quite clearly when looking at Magnesium concentrations versus flow at Croom. As stated in the document, Magnesium is a "rock indicator" suggesting that elevated Magnesium levels in surface water may be an indication of increased groundwater contributions. As illustrated in Figure 4-4 2006 analysis, baseflow contributions to overall river flow can be significant at lower flow periods and therefore the contribution of groundwater chemistry to overall surface water chemistry in the river would increase.

As a result of the likely relationship between water source contribution to river flows and water quality, changes in flow resulting from water withdrawals may have implications for water quality. In the case of additional groundwater withdrawals, it is not likely that there would be a negative effect on river water quality, however in the case of surface water withdrawals, the relative contribution of groundwater inputs would increase resulting in an increase in the influence of groundwater chemical constituents. This potential connectivity is further illustrated by a summary statement in the 2006 Water Quality Assessment Report of the Withlacoochee River by the Florida Department of Environmental Protection (2006) which stated *"Because of the proximity of the upper Floridan aquifer to the land surface, groundwater baseflow should be considered as a potential water source whenever low DO values are encountered. This specifically applies to spring runs, Lake Panasoffkee, and segments of the Withlacoochee River. Ground water discharge via springs could contribute to elevated nutrients in the lower Withlacoochee River, which is impaired"*

In some instances direct surface water withdrawals could also lead to an increase in chemical constituent concentration. For example if a surface water withdrawal occurred at Croom and an input of nutrients occurred downstream of Croom, then the volume of water available to dilute the nutrient input downstream of Croom would no longer be available and concentration would likely go up. This would not be the case for nutrient loads which would be reduced due to water (and chemical constituent) withdrawal.

If the overall concentration of nutrients found in the Withlacoochee River were significantly below any thresholds of concern then the influence of a withdrawal might not be significant. However, a quick comparison between nitrogen and phosphorus concentrations presented in the report and recently proposed numeric nutrient criteria suggest existing levels in the river are very close to possible thresholds of concern. In the report, Friedemann and Hand (1989) criteria are used to suggest 90% of all Florida streams exhibited Total Phosphorus (TP) concentration less than 0.87 mg/l and that levels in the Withlacoochee are well below those values. Although this statement is true, it is misleading due to the wide range of naturally occurring phosphorus levels throughout the state and across water body types. A more appropriate reference value would be waterbody specific and regionally defined to minimize natural variance due to geological source of phosphors.

USEPA's proposed numeric nutrient standards for Florida (Federal Register 2010) were derived from a regional aggregation of reference streams determined to be minimally impacted from anthropogenic sources and biologically healthy. Taking the 90th percentile of reference streams in the Peninsular region of Florida (within which the Withlacoochee River occurs) a TP value of 0.107 mg/L was determined

(1.205 mg/L for Total Nitrogen (TN)). This value indicates that 90% of the flowing waters within the Peninsular region of Florida have TP concentrations below 0.107 mg/L, 8 times lower than Friedemann and Hand (1989). Using this value as a more regionally appropriate reference, a fair number of phosphorus values presented in this report exceed this threshold. When looking at NOx-nitrogen at Croom, concentration values for NOx alone (not including NH_4, organic or particulate forms of nitrogen) already exceed the threshold of 1.205 mg/L for Total Nitrogen at low flow values.

It is recommended that a further analysis of the impact of proposed MFLs on water quality be investigated. Due to existing impairment in portions of the river, the river's designation as an OFW, and the close proximity of existing nutrient levels to proposed numeric nutrient criteria, it seems prudent to confirm that any water withdrawals will not have a negative effect on water quality parameters in the river.

On page 5-2 at the end of the 1st paragraph it is stated, *"Figures not displayed in this chapter can be seen in Appendix Water Quality"*. We could not locate a section on Water Quality in the Appendix.

On page 5-2 it is stated, *"For the Holder site, a statistically significant increasing trend was noted in the POR dataset and in the USGS dataset (Table 5-4 and 5-6). When the District dataset was analyzed independently, this trend was not present"*. Does this suggest there is a methods issue between the District and USGS data or that because of a shorter POR any statistical trend is no longer discernable? If methodology is equivalent then there should be no reason to analyze the data independently. If the data are not comparable due to methodology then the data should always be analyzed independently. The Panel recommends the data be analyzed in a combined form unless there is a documented reason to do otherwise.

On page 5-4, Figure 5-2, middle graph, the graph provided is the same as the first graph on the page. Should this graph be Phosphorus concentration versus Flow?

Similar to Figure 5-2, on page 5-8, Figure 5-5, middle graph, the graph provided is the same as the first graph on the page. Should this graph be Phosphorus concentration versus Flow?

On page 5-10 it is stated, that, *"D.O. trends were intensively monitored during 2006-2007 to determine, if there are any issues with low D.O. concentrations under low flow conditions."* Providing a few summary statistics for flow would give the reader a sense of how low the flows were relative to, for example, an average flow year.

Also on page 5-10 further elaboration of the statement, *"Concentrations remained above the Environmental Protection Agency standard of 5 mg/L during periods when fish passage requirements (0. 6 feet) were met or exceeded"* is warranted. If this implies that flows in 2006 - 2007 were very low, so low such that there was only 0.6 feet of depth at the shallowest transect, then this is significant empirical evidence the low flow threshold, as described in Section 7.8.2, does not cause water quality thresholds to be exceeded.

Chapter 6: Goals, Ecological Resources of Concern and Habitat Indicators

The District has recommended that *a "15% change in habitat availability as a measure of significant harm for the purpose of MFLs development"* be used based in part on findings from Gore et al. (2002), Dunbar et al. (1998) and Jowett (1993). This recommendation was later supported by Shaw et al. (2005). However, the Panel is not aware if any of these assessments were being applied to a waterbody whereby *"The Commission may designate a water of the State as a Special Water after making a finding that the waters are of exceptional recreational or ecological significance and a finding that the environmental, social, and economic benefits of the designation outweigh the environmental, social, and economic costs" 62-302.700(5),* which is one criteria by which the designation of Special Waters / Outstanding Florida Waters is granted. Therefore the Panel recommends the District make a statement as to whether the quantitative threshold of significant harm meets the criteria for an Outstanding Florida Water when considering that most other Outstanding Florida Waters and Outstanding National Resources Waters are typically designated for waterbodies of State and National significance.

The District's efforts to focus on a range of key habitat indicators from fish passage to macroinvertebrates and woody habitat are commendable. The authors provide a thorough and comprehensive discussion on the various biological components and therefore need to address all flow ranges when making an instream flow recommendation, i.e., setting minimum flows and levels. Recognizing the important function and value of these components and evaluating the potential impact on this breadth of ecologically important components is critical to establishing an appropriate MFL. Use of the various methods and models, for example, the PHABSIM model and Wetted Perimeter Inflection Point technique are suitable for this purpose. The overall discussion describes relevant literature and makes compelling arguments for the need to address all biological communities affected by river flows. The District clearly shows they are building upon their past experiences in setting MFLs.

The District is to be commended for expanding the discussion on the setting of thresholds using references to other similar studies in other parts of the world. As stated by Gore et al. (2002) when they peer reviewed an earlier District MFL report that, *"...a loss of more than 15% habitat, as compared to undisturbed or current conditions, to be a significant impact..."* In the third paragraph it is further stated, *"Jowett (1993) used a guideline of one-third loss (i.e. , retention of two-thirds) of existing habitat at naturally occurring low flows..."* As noted, reductions in habitat to set thresholds is a common practice. As stated earlier, an important point to note is the reductions are from the natural flow condition. The Panel notes the statement by Gore et al. (2002) is somewhat vague in that they suggest the habitat reduction can be made from either an "undisturbed" or "current" condition. If "undisturbed" means "natural" and natural conditions are different from current conditions, then this needs to be clarified. A 15% reduction from one benchmark will not be equivalent to a 15% reduction from a different benchmark. It is the assumption of the Panel that the differences in natural and historical flows, as described in Section 4, are so small as to be negligible, therefore the habitat reduction criteria are essentially from natural. However, the Panel notes there was no quantification of the surface water changes due to the Wysong Dam AWCS structure and diversions to the Tsala Apopka Chain of Lakes. Therefore, information should be presented to demonstrate that existing surface water conditions are essentially equivalent, or near equivalent to natural. Since the District is confident in their groundwater pumping model, they should make an assessment as to the change from the natural condition and how this information can address the question of what is the benchmark condition against which significant harm is being tallied. Rather than leave any ambiguity, the Panel recommends that text should be provided to describe the differences, if any, in natural and historical flows and subsequent natural resource values.

Chapter 7: Technical Approach for Establishing Minimum Flows and Levels for the Withlacoochee River

HEC-RAS Modeling

When reviewing a numerical hydraulic / hydrodynamic study, there are basic questions that the reviewer seeks to answer. These include (1) was the appropriate model employed, (2) was there sufficient geometric / bathymetric data available to generate a numerical grid, (3) does the numerical grid have sufficient resolution to address issues the modeling is expected to resolve, (4) are there sufficient data to set boundary conditions, (5) was the model sufficiently calibrated / validated, (6) was the model appropriately applied, and (7) was the model output appropriately employed.

The Panel accepts the use of HEC-RAS, a one dimensional (1D) numerical hydraulic model that computes discharge and water surface levels along rivers. The portions of the Withlacoochee River where the HEC-RAS model was applied is purely riverine with the river being relatively narrow. The use of a 1D hydraulic model such as HEC-RAS is certainly appropriate. The Panel acknowledges the HEC-RAS modeling system, developed by the US Army Hydrologic Engineering Center, has been extensively applied by virtually all of the US Army Corps of Engineers Districts.

The Panel notes a Triangular Irregular Network (TIN) was constructed using extensive LIDAR data characterizing the overbank areas along with extensive river bathymetric data collected by the District. From this TIN, cross sectional data along the river in the form of flow area as a function of water surface elevation were determined. The LIDAR and bathymetric data available were certainly extensive enough for this model study.

The HEC-RAS model covers some 77 miles of the Withlacoochee River. In excess of 1000 cross sections were generated from the TIN mentioned above. Thus, on the average, the computational spatial step was about 370 feet. Most HEC-RAS models of this extent have spatial steps greater than this. Therefore, the Panel agrees the computational grid certainly has the necessary resolution for computing the hydraulics of the system to be used in determining the MFL.

The report clearly articulates the segmentation of the river into three distinct sections. The lower segment extended from the Holder gage to Wysong Dam. The middle segment extended from Wysong Dam to the Croom gage, whereas, the upper segment extended from the Croom gage to the Dade City gage. Historical flow data along with rating curves were available from the USGS at the Holder, Wysong Dam, Croom, and Dade City gages, as well as, at several interior stations. For the lower segment, the rating curve at Holder was used as the downstream boundary and flow at the upstream boundary at Wysong Dam was the boundary condition there. For the middle segment, a rating curve at Wysong Dam was the downstream boundary and flow at Croom was the upstream boundary. For the upper segment, the rating curve at Croom was the downstream boundary and flow at Dade City was the upstream boundary. Since most of the flow records covered several years, the Panel concludes that sufficient boundary condition data existed.

The manner in which the operation of the Wysong Dam is modeled is adequately discussed. It is noted that very little data exist to relate gate openings to flow through the dam. Gate openings for the 17 flows were determined by matching the Wysong rating curve to the rating curve at the Floral City gage.

For each of the segments or HEC-RAS models, steady state solutions were generated. The basic approach was to generate flow profiles for 17 different constant flows at the downstream of each model. To generate the 17 flow profiles a linear regression analysis was conducted relating the discharge at the interior historical stations to the historical discharge at the downstream boundary. Linear interpolation was then used to set the discharge at each cross section. Each of the 17 flow profiles was then inserted into HEC-RAS and the steady state river stages corresponding to the inserted steady state flow profile were computed. This procedure was employed for each of the three segments modeled for 17 different flows at the downstream end of the segment.

When analyzing the flows computed from the regression analysis at each of the interior stations (and adding tributary flows at locations such as Gum Spring), it can be seen that at times downstream stations have less discharge than upstream stations and sometimes more. This indicates there are sinks (e.g. recharging of aquifers) and sources (e.g. springs) along the river. Thus, although there are no data to absolutely quantify these sources and sinks and their locations along the river, the manner in which the modeling is conducted does account for them in some sense.

The Panel notes that often in 1D riverine modeling studies, if a steady state is desired, it is generated by running the model in a time varying mode with constant inflows / outflows. When the solution for the discharge and stage at each of the computational nodes is no longer varying, a steady state solution has been obtained. However, as discussed above, that approach was not taken in this study. It would be interesting to generate steady state solutions in this fashion to see how closely they compare with those generated in this study.

It is stated in the report that one reason for employing three segments to generate three separate HEC-RAS models is because of the complexity of handling the outflow from the river into the Tsala Apopka Chain of Lakes and the outflow from the lakes back into the river. However, the inflow from the river into the Tsala Apopka Chain of Lakes was not modeled and neither was the inflow from the lakes into the river. It was stated that no data exist to attempt to model these. Model runs could have been made in a sensitivity sense to determine the importance of these flows. However, in the middle segment HEC-RAS model, the river stages in these areas are basically controlled by the backwater created by the dam. Thus, not modeling these flows may not be too important.

For model calibration / validation, a criterion of ± 0.5 ft was set as the criterion on computed water surface elevations for determining if the model was calibrated. It is unclear where this criterion came from. The criterion was satisfied except for high flows at Wysong Dam. It is a little surprising that HEC-RAS model results were essentially independent of Manning's n. However, this is probably because the model was broken into three relatively short segments. Model results were essentially determined by the boundary conditions. If the entire river had been modeled by one segment it is likely that interior results would have been more sensitive to varying Manning's n along the river.

HEC-RAS output was used in several ways to aid in determining the MFLs. For example, output was used to determine the low flow threshold MFL. Computed water surface elevations were used to determine the impact of flow reductions on the fish passage criterion, as well as, determining the impact on the lowest wetted perimeter inflection point at each of the 1000 plus cross sections. The higher of the two flows was selected to be the flow below which no withdrawals would be allowed.

HEC-RAS computed river stages for various flow profiles were also essential for determining inundation levels of various habitats. The long-term analysis of inundation levels also used measured elevations of specific habitats and historical flow records. When a flow reduction resulted in a decrease of at least 15% in the number of days of inundation, the MFL was determined. If the HEC-RAS model was applied using historical time varying flow boundary conditions, the frequency and duration of inundation for certain water surface elevations could be determined directly from the model.

While the HEC-RAS modeling might have been conducted differently, it is the opinion of the Panel that the computed water levels at each of the cross sections for the 17 flow profiles in each of the three segments is a reasonable representation of the hydraulics of the Withlacoochee River and can be used in the MFL analysis. If the District were to consider additional HEC-RAS modeling, the Panel would like to see the entire 77 miles of river modeled as one reach, i.e., one HEC-RAS model. The Wysong Dam could be modeled as an internal boundary condition. This could be accomplished by specifying the rating curve used in the current analysis or perhaps by forcing an upstream target elevation of 38.63 ft (the current target). In this complete HEC-RAS model it is likely that the computed solution would show some dependence on bottom friction. Some of the current analysis of establishing flow profiles could be used to help set sink / sources as lateral outflows / inflows along the river. Sensitivity studies could be conducted to establish the importance of the flow into the Tsala Apopka Chain of Lakes and the outflow from the lakes into the Withlacoochee River.

Floodplain Vegetation

Methods used to assess vegetation characteristics along floodplain transects are adequate. Use of the Point Centered Quarter method may not have been able to resolve the specific change point between two different communities along the transect, but based on the relatively low slope along most floodplain transects and the diffuse transitions between communities described in the vegetation appendix, the frequency of sampling between 50 and 200 feet apart is likely adequate for the intent of determining average wetland community elevation. However, it is recommended that some estimate of the acreage change in vegetation communities as a result of the proposed MFL be provided. For this purpose it would be desirable to have a sampling technique designed to determine the point of transition between communities. Such methods would include a line intercept approach for groundcover and a belt transect for large shrubs and trees. Best professional judgment could be used to optimize these more intensive sampling efforts to areas where transition between communities occurs. The reason to focus on the transitional end members of a community along a hydrologic gradient is that these extremes will be at the extent of their hydrologic tolerance/competitive existence and therefore most likely to respond to changes in hydrologic condition.

The reason an estimate of area impacts to floodplain and wetland acreage is recommended is to more quantitatively determine the effects of proposed withdrawals when integrated with topographic relief of the floodplain. In areas where slope is high the area influenced by a 15% change in frequency of flooding is small, if however the slope is low, then the area influenced by a 15% change in hydropattern could be quite large. As discussed previously, some clarification with regard to the temporal and or spatial application of 15% as an acceptable threshold of significant harm should be provided and an evaluation for each of these potential impact factors should be considered in determining an appropriate MFL.

There are several references to “historic” data in this chapter yet there is no clear definition of what time period the term is being applied to. This definition becomes critical with regard to how existing withdrawals and proposed new withdrawals are applied to any quantitative assessment of significant harm. Does “historic” mean predevelopment conditions whereby both existing and any proposed new withdrawals would be cumulatively applied toward significant harm of the 10 water resource values? Or does historic mean existing conditions whereby any impacts of new proposed withdrawals are not additive to impacts resulting from existing withdrawals. It is recommended that clarification of the benchmark condition under which prescribed MFL impacts are being assessed be provided, and specifically how existing impacts have been quantified and assessed in the proposed MFL.

Physical Habitat Modeling

In general, the overall descriptions in Sections 7.1 to 7.2.2 of the use of the PHABSIM group of models is straightforward and the explanation for establishing the nine representative study sites is clear. There are some commonly accepted “guidelines” for applying PHABSIM, however, it is quite acceptable to deviate from these guidelines given site-specific circumstances. For example, it is generally accepted that 5-7 transects are required to describe a riffle – pool sequence. Given the Withlacoochee River has an extremely low gradient, there are no sudden changes in cover or substrate, has very subtle transitions from pools to runs and, it is very homogeneous in terms of habitat types, then it is acceptable to describe the habitat in a given reach with three transects. The Panel assumes this is the rationale used by the District for the three transect approach and therefore recommends putting the supporting documentation in the report. The use of a "representative" study site means the ratio of habitat types (riffle / run / pool) that are represented in the study site by the three transects should be equal to the ratio of these habitat types in the reach of the river that the study site represents. Presenting the data would address this key issue.

The description in Section 7.6.2.1 of how the various habitat suitability criteria (HSC) curves were created, Types I, II and III is informative and shows the District used the best possible approach to develop each HSC curve. The amount and type of information for each species varies, which the District recognized, and took an approach that was best for each species or guild. It should be noted that regardless of the type of curve that is created, Type I, II or III, it is common practice to have all HSC curves reviewed by a panel of experts. This is especially important when using "bluebook" or any HSC curves that were developed outside the watershed. Also, some effort should be expended collecting as much data as is feasible to ensure real data fits into the final curve that is used. The District is to be commended for developing the two fish guild HSC curves, the shallow-fast and deep-slow fish guilds. This is a highly recommended approach when carrying out PHABSIM analysis in southeastern US streams (Persinger et al. 2010). It is noted that for the Holder gage reach, the shallow-fast fish guild was used to set the habitat reduction flow recommendation.

General

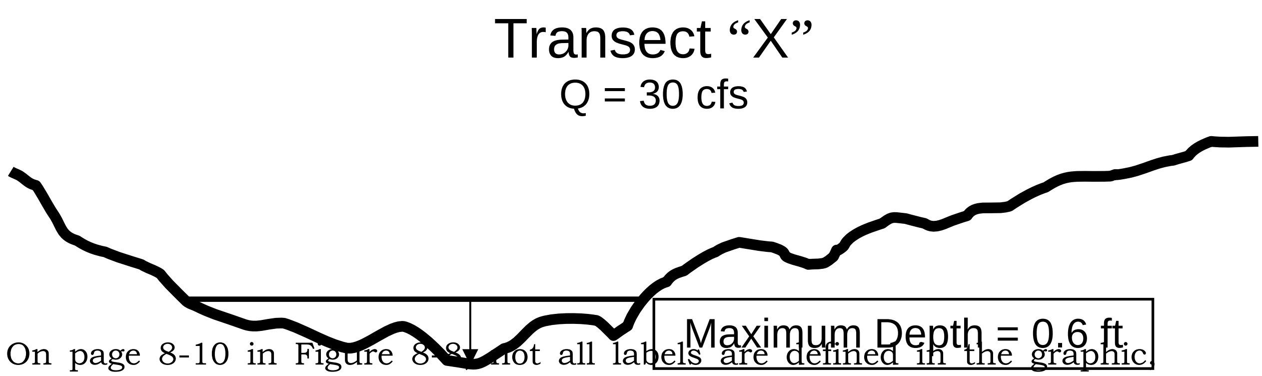
The Panel noted on page 7-6 in Section 7.2.2 there are no transects established between Trilby and Croom. Was this intentional and if so providing rationale would be beneficial.

On page 7-7, Section 7.2.3, the Entrix 2010 reference is not in the Literature Cited section, however it is in the Vegetation Appendix. The Panel suggests just referencing the appendix in the main report not Entrix 2010 report specifically.

On page 7-8, Section 7.5, a graphic example of how wetted perimeter is applied and interpreted would be useful. Similar to Figure 1-1 in the hydrology section which describes the building block approach, or 7-8 which describes the output of PHABSIM, visualizing the wetted perimeter approach and how values are interpreted would be helpful.

Chapter 8: Results and Recommended Minimum Flows

At the bottom of page 8-1 and continuing on to page 8-2 it is stated, *"...flows at Croom necessary to maintain fish passage were above the lowest modeled flow at nine transects. All of these transects require 30 cfs or less at Croom to maintain fish passage with the exception of one transect requiring 62 cfs at Croom."* It would be beneficial to provide a map to show where the 30 cfs transects are located and specifically which transect is the one that requires 62 cfs. It would be helpful to present the shoal transects graphically (see example graph below) and to show their location on a map. It is then further stated, *"Because only one transect requires greater than 30 cfs at Croom to maintain fish passage and this flow only occurs 61% of the time historically under Block 1 conditions, a flow of 30 cfs at the Croom gage was used to define the fish passage criterion."* More information should be presented to justify why the one transect that requires 62 cfs to pass fish can be eliminated in favor of the 30 cfs transect. The Panel does not understand the justification of choosing 30 cfs versus 62 cfs for the low flow threshold at Croom. It would appear that for a fish passage criterion, the shallowest transect that fails to meet the 0.6 foot depth represents a restriction to fish passage and therefore the more restrictive (62 cfs) transect should be used to set the MFL. Furthermore, the selection of the 30 cfs transect would cause an increase in the frequency of no fish passage periods at the 62 cfs section and would exceed the 15% loss of fish passage threshold of significant harm. A similar event return frequency justification was applied on Page 8-6, Section 8.3.1 second paragraph which states *"since these flow values occurred less than 5% of the time in the historical record, they are unlikely to affect the overall estimate of MFL's at a 15% habitat loss".* The Panel recommends either adopting the more restrictive 62 cfs flow threshold at Croom or clarifying the rationale and quantitative threshold by which the return frequency of an event is invoked as a modifier of the 15% threshold of significant harm. The Panel recognizes there are possible reasons for the approach taken by the District such as, fish historically do not move this far upstream, or if fish cannot access this part of the river there is sufficient habitat downstream to carry out all their life history phases, etc. Whatever the reasons, they should be provided.



On page 8-10 in Figure 8-8, not all labels are defined in the graphic, specifically "PE", "MWF", "HW" and the significance of "Ground Elevation" as part of the plot is not clear. The Panel suggests clarifying and removing unnecessary information.

On page 8-13 in Section 8.4.2.3 the difference in elevation between hydrologic indicators and the palmetto edge may be explained by the duration of hydrologic exposure required to establish a lichen line versus establish the palmetto edge. Lichen inundated for even short periods of time can be killed due to lack of sufficient oxygen for normal respiration, however if the duration of flooding is not extensive or occurs during cooler months when soil and plant respiration may be low, then it is likely that the palmetto and other vegetation could survive. Therefore, the difference in the two lines is suggestive of different durations and frequency of hydrologic events with the lichen line indicating a short term event and the palmetto line indicating a longer duration or more frequently recurring event.

On page 8-15 in Table 8-4, by using the mean values associated with a particular flood plain community there is an inherent buffering of change in hydrologic conditions built into any analysis. Instead of plotting the mean community elevation, it would be more informative to determine the change point between different communities. We know that the distribution of wetland species can be significantly influenced by the depth, duration, frequency and timing of flooding and therefore if there is a gradient of these hydrologic variables there will be a zonation of vegetation communities along this gradient. The mean elevation of a particular community would in most instances represent its optimal hydrologic regime, whereas the edges of the community where it transits into another community would represent the limits of both communities under the additional influences of competition. Therefore, it is recommended that instead of modeling the hydrologic conditions required to maintain the community represented by the mean elevation, it would be more informative and integrative of topography to determine the hydrologic conditions benchmarked relative to its upper and lower elevation limits.

On page 8-18 in Section 8.4.3 the stepped approach is supported for the development of flow reductions for floodplain features. Almost by definition, flows where water levels are still contained within the bank would not be considered influential on the floodplain and therefore should be guided by different flow reduction criteria and conversely, floodplain related flow reduction criteria should not be extrapolated to instream flows that may have other more or less restrictive flow related conditions. This added complexity in the determination of withdrawal thresholds within temporal blocks is commendable.

On page 8-19 in Figures 8-10 through 8-12 it is noted that in all cases the low flow step is protective of the 15% threshold reduction in the number of days flows are achieved. However for the higher flow step there are instances where the 15% threshold in the number of days of flooding is below the red line or proposed acceptable withdrawals. What method is being used to select the acceptable % reduction in flows for each step at each gauge?

On page 8-21 in Figure 8-13 it would be helpful if the various habitat types were identified more clearly either in the figure caption or fully spelled out in the figure legend.

On page 8-25 in Section 8.5.3 it is not clear where the values in this section for allowable percent withdrawals for exposed roots at Croom (23), Wysong (21) and Holder (10) came from. Average values for Croom, Wysong and Holder in Table 8-8 are 16, 13 and 7. These values are also reported in Table 8-10.

On pages 8-27 and 8-28 in Figures 8-15 through 8-17, these figures provide a nice graphic comparison between “historical flows” and flows within MFL prescribed withdrawals. It may be worthwhile to provide “historic flow” values in Tables 8-11 through 8-13 alongside the proposed MFL based flow values so that a direct comparison between the two can be made.

On page 8-3 in Section 8.2.2 it is stated, *"... since only two of the 525 modeled transects had LWPIPs above the lowest modeled flow (15 cfs), it was decided to use the lowest modeled flow as the criteria for the Croom gage."* It is not clear why the LWPIP values from the two transects where there was a change of slope in the wetted perimeter versus discharge curve that occur at a flow greater than 15 cfs would not have been used. Text should be provided to explain why not using the data from these two transects is the best approach to take to set the low-flow threshold (LFT). It must be assumed that if modeling had only been taken down to, for example 30 cfs, then this would be the LFT value and not 15 cfs. Providing rationale for taking the modeling down to 15 cfs is warranted since this is the value that is ultimately used to set the LFT. Once again, showing where the two transects are located on a map would be beneficial. Also, providing a graph indicating the location of the LWPIP would be informative along with a description of the type of habitat it was located in, e.g., shoal, run or pool.

Section 8.6 provides a thorough description on the application of the final criteria from the full suite of criteria that were developed to set the MFLs. Table 8-10 and Figures 8-15, 8-16 and 8-17 clearly show the MFLs in an easy to read format. It would be informative to present the historical and MFLs flow duration curves for the weeks, or perhaps several of the lowest flow weeks, that encompass days 110 to 210, approximately the Block 1 period for the Croom, Wysong and Holder gage sites. Also, describing the low-flow threshold in terms of the weekly historic flow exceedance value would be beneficial since this is a common flow statistic used to describe a low flow threshold.

Overall Summary of the Report

The Panel endorses the District’s approach for setting MFLs for the upper and middle Withlacoochee River. However, the Panel believes the District should 1) clarify the benchmark condition from which MFL proposed withdrawals are being applied and 2) how their position regarding the threshold of significant harm applies to Outstanding Florida Waters as it is the understanding of the Panel that the Withlacoochee River is so designated (62-302.700(9)(i) F.A.C.).

It is the view of the Panel that the data and information used in development of the proposed MFL were properly collected and applied. Reasonable quality assurance assessment was preformed on the data and information provided. Any exclusions of available data (at least that which was made evident in the report) were justified and in most instances the data used were the best information available.

With respect to hydrology, identifying benchmark periods based on different phases of the Atlantic Multidecadal Oscillation (AMO), setting of benchmark periods, examination and identification of climate and anthropogenic-based effects on flows, examination of the historic flow record with other systems is, in the opinion of the Panel, one of the most sophisticated approaches to addressing the hydrology component.

The approach of defining a factor for loss of fish habitat in terms of percent reduction along with setting a low-flow threshold based on fish passage or wetted perimeter analysis is consistent with today's understanding of maintaining self sufficient populations of fish. The integrated approach (fish habitat, macroinvertebrates, water quality, riparian vegetation) using appropriate models for each element or component to identify the most protective minimum flows in each seasonal flow block is consistent with current understanding of flowing aquatic ecosystems and ecological theory.

The legal and institutional mandate of the District is clearly articulated, *"…by virtue of its responsibility to permit the consumptive use of water and a legislative mandate to protect water resources from "significant harm," has been directed to establish minimum flows and levels (MFLs) for streams and rivers within its boundaries (Section 373.042, Florida Statutes)."* The purpose for the report is also very clearly described*, "The District's purpose in establishing MFLs is to create a yardstick against which permitting and/or planning decisions regarding water withdrawals, either surface or groundwater, can be made."* The Panel acknowledges the difficulty in linking natural resource science in terms of limits and thresholds with the legislative intent of legislators. In that regard, the Panel is of the opinion the District has met its mandate.

Overall, assumptions made in the modeling efforts and other technical means of data collection and analysis, assumptions were minimized or were clearly stated. However some assumptions or terminology used were either not stated/defined or were not stated/defined clearly so that a consistent and concise understanding of findings could be made. In addition, there was no stated determination of the effect that the proposed MFL could have on several water resources explicitly outlined in chapter 62-40.473 F.A.C; specifically estuarine resources, aesthetic and scenic attributes, filtration and absorption of nutrients and other pollutants, sediment loads and navigation. It is unclear if these water resources are assumed to be protected or omission was a simple oversight in the document. The Panel recommends the District clarify the potential of significant harm resulting from the proposed MFL on these water resources.

In general, the procedures and analysis used in development of this MFL were appropriate and reasonable in most instances. However, procedures and analysis did not always incorporate all necessary factors as specifically outlined in comments associated with Chapter 5: Water Quality. For those procedures and analysis used, they were correctly applied. In most instances limitations and imprecision's in the information were reasonably handled. However in some instances where data were limited it seems that making certain assumptions about flow conditions would have been better than complete omission. For instance, HEC-RAS modeling efforts associated with river discharge to the Tsala Apopka Chain of Lakes were omitted ("No water level data is available for the Orange State Canal, therefore the flow diversion to the Tsala Apopka Chain of Lakes was not simulated in the HEC-RAS modeling" (Section 2.4.2 HEC-RAS Appendix)). There was also little or no analysis of uncertainty associated with modeling efforts or the confidence level at which any analysis associated with significant harm was being applied. A more thorough discussion of sources of uncertainty and how uncertainty was controlled or dealt with in the analysis, as well as more information on the range of variability of measured elevations, would be helpful additions to the report and would aid in interpreting the results. Most of the procedures and analysis used in determination of this MFL are repeatable with exception of the previous reference to assumptions and terminology used which when clarified should make these procedures and analysis repeatable.

Overall the Panel finds no serious flaws or errors in the District's methodology or their findings. Assumptions of the approach are well documented and are reasonable given today's understanding of aquatic ecosystems. The tools and methods of analysis employed are appropriately used based on best available information. With respect to the "natural flow paradigm", this construct has been more than adequately addressed.

References

Acreman, M. and Dunbar, M.J. 2004. Defining environmental river flow requirements - a review. Hydrology and Earth System Sciences, 8(5), 861-876.

Arthington, A.H. and Zalucki, J.M. (eds.).1998. Comparative Evaluation of Environmental Flow Assessment Techniques: review of holistic methodologies. Occasional Paper no. 26/98. Land and Water Resources Development Corporation, Canberra.

Arthington, A.H., J.L. Rall, M.J. Kennard and B.J. Pusey. 2003. Environmental Flow Requirements of Fish in Lesotho Rivers Using the DRIFT Methodology. River Res. Applic. 19: 641-666.

Arthington, A.H., R.E. Tharme, S.O. Brizga, B.J. Pusey and M.J. Kennard. 2004. Environmental flow assessment with emphasis on holistic methodologies. In: Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume II. Welcomme R. and T. Petr, Eds., FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. RAP Publication 2004/17, p. 37-65.

Arthington, A.H., S.E. Bunn, N.L. Poff and R.J. Naiman. 2006. The Challenge of Providing Environmental Flow Rules to Sustain River Ecosystems. Ecological Applications. 16(4): 1311 – 1318.

Brizga, S. 2001. Proposed Environmental Flow Performance Measures: Pioneer Valley Water Resource Plan. Queensland Government, Department of Natural Resources and Mines. 72 pp.

Cichra, C.E., C.N. Dahm and A. Locke. 2007a. A Review of "Proposed Minimum Flows and Levels for the Upper Segment of the Braden River, from Linger Lodge to Lorraine Road" Prepared for the Ecological Evaluation Section, Resource Conservation and Development Department, Southwest Florida Water Management District. Brooksville, FL.

Cichra, C.E., C.N. Dahm, A. Locke, D. Shaw and M. Stewart. 2007b. A Review of "Proposed Minimum Flows and Levels for the Upper Segment of the Hillsborough River, from Crystal Springs to Morris Bridge, and Crystal Springs" Prepared for the Ecological Evaluation Section, Resource Conservation and Development Department, Southwest Florida Water Management District. Brooksville, FL.

Cichra, C.E., C.N. Dahm and D.T. Shaw. 2005. A Review of "Alafia River Minimum Flows and Levels Freshwater Segment including Lithia and Buckhorn Springs" March 21, 2005 Draft, and "Proposed Minimum Flows and Levels for the Upper Segment of the Myakka River, from Myakka City to SR72" August 10, 2005 Draft. 33 pp.

Dunbar, M. J., A. Gustard, M. C. Acreman, and C. R. Elliott. 1988. Overseas approaches to setting river flow objectives. Institute of Hydrology. R&D Technical Report W6-161. Oxon, England. 83 pp.

Engineering & Applied Science, Inc. 2010. HEC-RAS Modeling of Withlacoochee River. Prepared for the Southwest Water Management District. Brooksville, FL.

Federal Register. 2010. Federal Register, January 26, 2010, Volume 75, Number 16, 4173:4226

Florida Department of Environmental Protection. 2006. Water Quality Assessment Report Withlacoochee, Bureau of Watershed Management, Watershed Planning, Tallahassee, FL pp. 268

Friedemann, M. and J. Hand. 1989. Typical Water Quality Values for Florida's Lakes, Streams and Estuaries. Florida Department of Environmental Protection. Tallahassee, Florida.

Gippel, C. J. 2001. Hydrological analyses for environmental flow assessment. In Ghassemi, F. and Whetton, P. (eds) Proceedings MODSIM 2001. International Congress on Modelling and Simulation, Modelling & Simulation Society of Australia & New Zealand. The Australian National University, Canberra, Australian Capital Territory. p. 873-880.

Gore, J.A., C. Dahm and C. Klimas. 2002. A Review of "Upper Peace River: An Analysis of Minimum Flows and Levels" Prepared for the Ecological Evaluation Section, Resource Conservation and Development Department, Southwest Florida Water Management District. Brooksville, FL.

Hughes, D. 2003. Environmental flow requirements in water resource planning and operation. *In*, Water Resources Systems - Hydrological Risk, Management and Development. Proceedings of symposium HSO2b held during IUGG2003 at Sapporo, IAHS Publ. no. 281, p. 261-268.

Jowett, I. G. 1993. Minimum flow requirements for instream habitat in Wellington rivers. NZ Freshwater Miscellaneous Report No. 63. National Institute of Water and Atmospheric Research, Christchurch. 33 pp.

King, J. and D. Louw. 1998. Assessment of instream flow requirements for regulated rivers in South Africa using the Building Block Methodology. Aquatic Ecosystem Health and Management 1: 109-124.

King, J. and C. Brown. 2006. Environmental flows: striking the balance between development and resource protection. Ecology and Society 11(2): 26.

King, J. and C. Brown. 2009. Integrated basin flow assessments: concepts and method development in Africa and South-east Asia. Freshwater Biology. 20 pp.

King, J.M., Brown, C., and H. Sabet. 2003. A Scenario-based Holistic Approach to Environmental Flow Assessments for Rivers. River Research and Applications, 19, 619-639.

King, J.M., Tharme, R.E., and de Villers, MS. (eds.) 2000. Environmental flow assessments for rivers: manual for the Building Block Methodology. Water Resources Commission Report TT 131/100, Pretoria, South Africa.

Persinger, J.W., Orth, D.J., and A.W. Averett. 2010. Using Habitat Guilds to Develop Habitat Suitability Criteria for a Warmwater Stream Fish Assemblage. River Research and Applications.

Shaw, D. T., C. N. Dahm, and S. W. Golladay. 2005. A review of "Proposed minimum flows and levels for the middle segment of the Peace River, from Zolfo Springs to Arcadia". Southwest Florida Water Management District, Brooksville, FL 23 pp.

Southwest Florida Water Management District. 2002. Upper Peace River An analysis of Minimum Flows and Levels. Ecological Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2005a. Alafia River Minimum Flows and Levels - Freshwater Segment. Ecological Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2005b. Proposed Minimum Flows and Levels for the Upper Segment of the Myakka River, from Myakka City to SR 72. Ecological Evaluation Section.

Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2005c. Proposed Minimum Flows and Levels for the Middle Segment of the Peace River, from Zolfo Springs to Arcadia. Ecological Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2007a. Proposed Minimum Flows and Levels for the Upper Segment of the Braden River, from Linger Lodge to Lorraine Road. Ecologic Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2007b. Proposed Minimum Flows and Levels for the Upper Segment of the Hillsborough River, from Cyrstal Springs to Morris Bridge, and Crystal Springs. Ecological Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2008. Weeki Wachee River Recommended Minimum Flows and Levels. Ecologic Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2010a. Anclote River System Recommended Minimum Flows and Levels. Ecological Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Southwest Florida Water Management District. 2010b. Chassahowiztka River System Recommended Minimum Flows and Levels. Ecological Evaluation Section. Resource Conservation and Development Department. Brooksville, FL.

Tharme, R. E. 2003. A Global Perspective on Environmental Flow Assessment: Emerging Trends in the Development and Application of Environmental Flow Methodologies for Rivers. River Research and Applications, 19(5-6), 397-441.

Tharme, R.E. and J.M. King. 1998. Development of the Building Block Methodology for instream flow assessments, and supporting research on the effects of different magnitude flows on riverine ecosystems. Water Research Commission Report No. 576/1/98. 452 pp.

Errata

1. P 4-5, 2nd para - "...the results from flows records...", "...the results from flow records..."
2. P , 2nd para - "...establishment of a Minimum Flows...", "...establishment of Minimum Flows..."
3. P 5-2, 2nd and 4th para - "...respectively on Withlacoochee River..", "...respectively on the Withlacoochee River..."
4. P 5--7, Fig 5-4, "...River nr Holder", "...River at Holder"
5. P 5-10, 1st para - "...concentrations Withlacoochee River...", "...concentrations in the Withlacoochee River..."
6. P 5-10, 2nd para - "(Table 5-4 through 5-6)", "(Tables 5-4 through 5-6)"
7. P 7-17, Figure 7-8 title, "...spawning activity of Spotted Sunfish...", "...spawning activity of Bluegill Sunfish
8. P 8-27, 2nd para - "...and 16 percent of Block 2 flows.", "...and 7 percent of Block 2 flows."