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Technical Memorandum

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Prepared for: Northwest Florida Water Management District

Project Title: Independent Technical Peer Review of the Recommended Minimum Flows for Wakulla and Sally Ward Springs, Wakulla County, Florida

Project No: 156014

Subject: Wakulla and Sally Ward Springs Minimum Flows and Levels Peer Review Report

Date: March 1, 2021

To: Kathleen Coates, Chief, Bureau of Water Resource Evaluation

From: Gregg Jones, Senior Expert, Hydrogeology

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List of Abbreviations

ADCP	acoustic Doppler current profiler
ATM	Applied Technology and Management
BMAP	Basin Management Action Plan
cfs	cubic foot/feet per second
District	Northwest Florida Water Management District
EFDC	Environmental Fluid Dynamics Code
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
F.S.	Florida Statutes
FFWCC	Florida Fish and Wildlife Conservation Commission
GWCA	groundwater Contribution Area
HEC-RAS	River Analysis System
IUCN	International Union for Conservation of Nature
IV	importance value
LiDAR	light detecting and ranging
MFL	minimum flow and level
MGD	million gallons per day
NAVD88	North American Vertical Datum of 1988
NWFWMD	Northwest Florida Water Mangement Districts
NWI	National Wetlands Inventory
Panel	Peer Review Panel
PHABSIM	Physical Habitat Simulation Model
POR	period of record
ppt	part(s) per thousand
RPI	Research Planning Inc.
SAV	submerged aquatic vegetation
SEFA	System for Environmental Flows Analysis
SJRWMD	St. Johns River Water Management District
SKT	Seasonal Kendall Test
SRWMD	Suwannee River Water Management District
SWFWMD	Southwest Florida Water Management District
TMDL	Total Maximum Daily Load
USGS	U.S. Geological Survey
WRV	water resource value

Executive Summary

Introduction

The Northwest Florida Water Management District (District) contracted technical experts to provide independent scientific peer review of the report titled Recommended Minimum Flows for Wakulla and Sally Ward Springs (MFL Report), Wakulla County, Florida".

The Peer Review Panel (Panel) received the MFL Report and appendices on December 2, 2020 and began its review. The Panel participated in a kickoff conference call with District staff on December 10, 2020. District staff delivered a presentation on all aspects of the process to develop a minimum flow for Wakulla and Sally Ward Springs. Following the call, the Panel agreed on review assignments, reviewed the MFL Report, appendices, and other pertinent documents, and prepared its reviews. The Panel Chair compiled the reviews into a single document, which was reviewed and edited by all Panel members and the Panel Chair into the final Peer Review Report. Peer Review comment forms, a compilation of the comments each Panel member included in the Peer Review Report, were also submitted to the District.

Peer Review Panel

The District assembled a Panel consisting of the following staff with expertise in hydrology, hydrogeology, statistics, modeling, and riverine and wetlands ecology:

- Gregg Jones, Ph.D., P.G.: (Panel Chair): karst hydrogeology, groundwater quality
- Paul Leonard: fisheries science, aquatic ecology, hydrology, modeling
- Adam Munson, Ph.D.: hydrology, statistics

As per the task order, the Panel has prepared a report of the findings and recommendations related to the peer review of the MFL Report. The following is a summary of the Panel's major findings.

Major Findings

The Panel concludes the District had sufficient data to address the complete range of flows currently likely to be observed on the Wakulla River through its consideration of various WRVs and use of several metrics to evaluate the potential for "significant harm" against the baseline period. The District focused on minimum flow requirements but did not limit its assessment to just low flows. The District has addressed low flows, instream flows, and high flows where the latter are intended to protect floodplain wildlife habitats (plant communities) from significant harm due to flow reductions.

The District evaluated the WRV metrics most likely to be limiting across the range of flows to develop the recommended minimum flow for the Wakulla and Sally Ward springs system for which there was adequate data. A single metric (safe manatee passage) at Wakulla River transect 41707.76 was found to be the most limiting, allowing for a flow reduction of 59.21 cfs (38.3 mgd) in the combined spring flows from Wakulla and Sally Ward Spring that would be protective of resource values.

After a thorough review of the MFL Report, appendices, and supporting documents, the Panel finds the District's approach to developing the minimum flow based on the safe manatee passage metric to be reasonable. Wakulla and Sally Ward Springs is a highly complex system. It has experienced a considerable increase in flow in recent years, is subject to the effects of sea level rise, and has been altered by a recent hurricane. The inherent complexity of the spring system makes it very challenging to develop a full understanding of the relative contribution of surface water to the system and flow reversals resulting from its connections to the submarine Spring Creek Springs located in the coast estuary. These factors contribute to uncertainty in the establishment of the MFL, which the available data cannot fully resolve at this time.

However, the risk that these uncertainties would result in an inappropriate or flawed MFL or harm to the system is very low due to the higher flows in the system and the restriction on flow reductions resulting from the proposed MFL anchored by the MFL established by the safe manatee passage WRV. In addition, groundwater withdrawals in the groundwater contribution area (GWCA) of the springs that could reduce spring flow over the next 20 years are projected to be very small, which considerably decreases the risk that the proposed MFL would be reached in the foreseeable future or before the MFL is re-evaluated in the review cycle. This will provide the District an opportunity to collect additional information and analyze data in the next MFL review cycle in an adaptive management mode.

The Panel has identified a number of technical issues that are elaborated on in the following sections and made recommendations as to how these issues might be addressed. With the exception of recommending the District re-examine Wakulla River transect 41707.76, which encompasses the limiting impediment for Manatee passage, none of the issues were substantial enough for the Panel to require additional analysis before completion of the MFL. However, the Panel recommends the District modify the text of the MFL Report in several places to provide clarification and discuss issues that should be addressed with further monitoring and analysis for the next re-evaluation of the Wakulla and Sally Ward Springs Recommended Minimum Flows.

Section 1: Introduction

1.1 Background

The Northwest Florida Water Management District (District) is mandated by the Florida Statutes (F.S.) to establish minimum flows and levels (MFLs) for priority surface waters and aquifers within its boundaries for the purpose of protecting the water resources and ecology of the aquatic ecosystems from "significant harm" (F.S. §373.042, 1972 as amended). In this report, minimum flows are proposed for the Wakulla and Sally Ward Springs system in Wakulla County, Florida.

Under the statutes, MFLs are defined as follows:

- A minimum flow is the flow of a watercourse below which further water withdrawals will cause significant harm to the water resources or ecology of the area
- A minimum level is the level of water in an aquifer or surface water body at which further water withdrawals will cause significant harm to the water resources of the area

The statutes require the District to annually develop and update a list of priority water bodies for which MFLs are to be established and identify those that will be subjected to a voluntarily independent scientific review. The District's Governing Board is committed to voluntarily submit MFLs determinations for independent scientific peer review.

The Florida Statutes also provide for the MFLs to be established using the "best available information," for the MFLs "to reflect seasonal variations," and for the District's Governing Board, at its discretion, to provide for "the protection of non-consumptive uses." In addition, F.S. §373.0421 states that the District's Governing Board "shall consider changes and structural alterations to watersheds, surface waters and aquifers, and the effects such changes or alterations have had, and the constraints such changes or alterations have placed on the hydrology of the affected watershed, surface water, or aquifer…."

The State Water Resources Implementation Rule (Florida Administrative Code [F.A.C.] Chapter 62-40.473) contains additional guidance for the establishment of MFLs, providing that "…consideration shall be given to the protection of water resources, natural seasonal fluctuations, in water flows or levels, and WRVs associated with coastal, estuarine, aquatic and wetlands ecology, including:

1. Recreation in and on the water;
2. Fish and wildlife habitats and the passage of fish;
3. Estuarine resources;
4. Transfer of detrital material;
5. Maintenance of freshwater storage and supply;
6. Aesthetic and scenic attributes;
7. Filtration and absorption of nutrients and other pollutants;
8. Sediment loads;
9. Water quality; and
10. Navigation."

1.2 Peer Review Panel

The District assembled a Peer Review Panel (Panel) consisting of the following staff with expertise in hydrology, hydrogeology, statistics, modeling, and riverine and wetlands ecology:

- Gregg Jones, Ph.D, P.G.: (Panel Chair): karst hydrogeology, groundwater quality
- Paul Leonard: aquatic ecology, hydrology, modeling
- Adam Munson, Ph.D.: hydrology, statistics

As per the task order, the Panel has prepared a report of the findings and recommendations related to the peer review of the Recommended Minimum Flows for Wakulla and Sally Ward Springs, Wakulla County, Florida. The following is a summary of the Panel's major findings.

1.3 Charge for Peer Review Panel

The District provided the Panel with the following charge:

- Review the draft MFL technical assessment report and appendices which summarize the data and methods used to develop the proposed minimum flow criteria for Wakulla and Sally Ward Springs.
- Evaluate the data, analyses, models, and methodologies used by the District to determine the proposed minimum flow(s).
- Complete the following tasks and include responses or comments on each task in a written report provided to the District.
- Responses and comments reflecting views shared by the peer reviewers will be presented collectively in a written report compiled by the CHAIRPERSON (Gregg Jones).
- Disagreements, if any, between peer reviewers concerning responses and comments on each task will also be identified.
- In their review, per reviewers will use the Peer Review Comment Forms provided by the District, to provide responses.

1. Supporting Data and Information: Review the data and information that supports the conclusions made in the report to determine:

a. The data and information used was properly collected;

b. Reasonable quality assurance assessments were performed on the data and information;

c. Exclusion of available data from the analyses was justified; and

d. The data used was the best information available.

Note: The reviewers are not to provide independent review of standard operating procedures used as part of institutional programs that have been established for the purpose of collecting data, such as the U.S. Geological Survey and the DISTRICT's hydrologic monitoring network.

2. Technical Assumptions: Review the technical assumptions inherent to the analysis used in the MFL report to determine whether:

a. The assumptions are clearly stated, reasonable and consistent with the best information available;

b. Other analyses that would require fewer assumptions but provide comparable or better results are available.

3. Procedures and Analyses: Review the procedures and analyses used in the MFL report to determine whether:

a. The procedures and analyses were appropriate and reasonable, based on the best information available;

b. The procedures and analyses incorporate all necessary factors;

c. The procedures and analyses were correctly applied;

d. The limitations and imprecision in the information were reasonably handled;

e. The procedures and analyses are repeatable;

f. Conclusions based on the procedures and analyses are supported by the data.

g. Determine if the methods used in establishing the MFL are scientifically reasonable. If a proposed method used in the MFL report is not scientifically reasonable, the Panel shall:

1. List and describe scientific deficiencies and, if possible, describe potential implications of the error associated with the deficiencies;

2. Determine if any identified deficiencies can be remedied:

a. If the identified deficiencies can be remedied, then describe the necessary remedies and if possible provide an estimate of time and effort required to develop and implement each remedy.

b. If the identified deficiencies cannot be remedied, then, if possible, identify one or more alternative methods that are practical, cost-effective, and scientifically reasonable. If an alternative method is identified, provide a qualitative assessment of the relative strengths and weaknesses of the alternative method(s) and the effort required to collect data necessary for implementation of the alternative methods.

1.4 Review Constraints

The Panel was requested to acknowledge that review of certain assumptions, conditions, and established legal and policy interpretations of the Governing Board are not included in the Scope of Work. These included:

a. The selection of water bodies or aquifers for which minimum levels are proposed to be set

b. The definition of what constitutes "significant harm" to the water resources or ecology of the area

c. The evaluation and selection of priority water resource values (WRVs)

d. The method(s) used to establish MFLs for water bodies outside of the District

e. Standard procedures used as part of institutional programs that have been established for the purpose of collecting data, such as the U.S. Geological Survey (USGS) and District hydrologic monitoring networks

The Panel received the MFL Report and its five supporting appendices and began its review on December 2, 2020. The Panel participated in a kickoff conference call with District staff on December 10, 2020. District staff delivered a presentation on all aspects of the process to develop a minimum flow for the Wakulla/Sally Ward Springs system. Following the call, the Panel agreed on review assignments, reviewed the MFL Report, appendices, and other pertinent documents, and prepared its reviews. The Panel Chair compiled the reviews into this draft document, which was then reviewed and edited by all Panel members and the Panel Chair to finalize this draft Peer Review Report.

Section 2: Supporting Data and Information

a) The data and information used were properly collected.
b) Reasonable quality assurance assessments were performed
c) Exclusion of available data from the analysis was justified
d) The data used was the best information available

The Panel has evaluated the information that pertained to data collection, use, quality assurance, and availability that was included in the Minimum Flow Report and its appendices. The following is the Panel's assessment of the data in terms of the District's evaluation criteria listed above.

2.1 Flow, Temperature, Rainfall, Ground and Surface Water Quality Data

The Panel concludes that based on the documentation in the reports, the data used in the Districts analyses was the best available. Flow data was collected by or with USGS, which sets the standard for flow data collection. Rainfall data was collected from National Weather Service and District gauges and follows documented collection protocols. Stage and water quality data near the Wakulla Spring pool is currently monitored by the USGS. Prior to January 2017 it was monitored by the District. This data was used for River Analysis System (HEC-RAS) and thermal Environmental Fluid Dynamics Code (EFDC) model development and calibration.

Five temporary data collection stations were established by the District for use in the estuarine EFDC model development and calibration. Each station was equipped with continuous recording sondes measuring stage, temperature, and specific conductivity. A total of 29 in situ, vertical profile stations located along the length of the rivers were sampled monthly for depth, temperature, and conductivity to support additional estuarine EFDC hydrodynamic model calibration. Thermal profile data was collected between the Wakulla Spring pool and Wakulla Boat Tram for the calibration of a thermal EFDC model.

Although the Minimum Flow Report provided some documentation on the operation of data collection stations, data collection procedures, sampling protocols, instrument calibration, and quality control procedures, it was not comprehensive. However, the Panel believes the acknowledged expertise and long-term experience of the agencies involved in the collection of data ensures the data are of high quality.

The following are comments provided to improve the minimum flow as part of future re-evaluations.

1) As the District and the Davis and Verdi report have shown, the hydrogeology in the vicinity of Wakulla/Spring Creek Springs is extremely complex and the fact that there are 6 hypotheses to explain why flows have been increasing at Wakulla Springs, demonstrates that it is not well understood. Figure 46 in the Minimum Flow Report shows there are only 16 wells monitoring the Floridan aquifer in the entire Wakulla Spring Groundwater Contribution Area (GWCA). In addition, there are only 3 wells within 5 miles of the Wakulla/Spring Creek Springs vicinity. The Davis and Verdi paper makes it clear that the seasonally changing head relationships between Wakulla Springs and the Spring Creek Springs play a major role in determining how groundwater moves between the springs. The current well network provides very little data on these head relationships. The Panel agrees the data used was the best available at the time and the District's analyses were as thorough as could be expected given the limited availability of groundwater data.

The Panel has recently been made aware that the District has substantially upgraded and expanded their data collection networks. A brief discussion of this should be added to the MFL Report to document the District Efforts.

2) On page 80 in the Minimum Flow Report, it is stated that "Additional research and the continued collection and review of hydrologic data over time is required to better understand the causal mechanisms driving long-term changes in Wakulla Spring flow." The change in Wakulla Springs flows and changes in

hydraulics (stage-discharge) over time seems to be one of the largest, if not the largest, source of uncertainty in this minimum flow determination. The section posits five potential causes but does not sufficiently describe how additional research and monitoring would address this trend and how monitoring might be used to differentiate the possible reasons.

3) Because the District requires its MFL peer review panels to address the quality of supporting data, the District should supply more information on how it ensures that its data is of high quality. The District should also require its consultants that write supporting documents to provide comprehensive information on the quality of data used in their analysis.

2.2 Water Resource Values

The following is a discussion of the Panel's review of supporting data and information for the District's priority water resource values that were used to develop the minimum flow. These include:

- Recreation in and on the Water
- Fish and Wildlife Habitats and the passage of fish
- Estuarine Resources
- Water Quality

2.2.1 Recreation in and on the Water

The District relied upon general criteria for safe boat use including safe boat passage on the river. The criteria used were obtained from the literature. The Panel evaluated the data collected to support the safe boating criteria for the state park tour boats, private recreational power boat use, and canoes and kayaks. Data on river dimensions that was obtained from cross sections across the shoals where depth profiles were measured and the thalweg for canoes and kayaks determined was also reviewed. The Panel concludes that this data was properly collected, reasonable quality assurance assessments were performed, and the data used was the best information available

2.2.2 Fish and Wildlife Habitats and the Passage of Fish

For this WRV, the District evaluated Fish Passage, Manatee Passage and Thermal Refuge, Instream Woody Habitat Inundation, and Floodplain Vegetation Inundation. The primary tool for simulating inundation and depth, and volume over a range of flows within the channel was the HEC-RAS model. The data used the in the model includes in channel surveys supplemented with LiDAR data as well as USGS gauge information, including Shadeville Road (USGS 02327022 gage) and the HD-3 monitoring station.

The District recognized that channel changes may have occurred during Hurricane Michael in 2018 and so collected additional bathymetric data. Data were collected along 12 new instream cross sections. The data were evaluated and used to either augment or replace preceding data. The collection of new data was appropriate and provided greater accuracy for the model.

Some data was excluded from the HD-3 station (2016-2018) because the station's data logger did not record the full tidal range during that period. This omission was prudent. The HD (including HD-3) sites were all collected as part of the hydrodynamic model development and are evaluated in that section. The Panel sees no reason to not to use the HD-3 as a boundary for the steady-state HEC-RAS model as it appears to be the best available for that purpose.

It is noted that the HEC-RAS steady state model was calibrated to Shadeville Road (USGS 02327022 gage) providing simulated river stages accurate to an average error of +/- 0.5 feet. The river stage and discharge data was collected by the USGS and is the best available. It was collected following the widely reviewed standards and practices of the USGS.

2.2.3 Estuarine Resources

EFDC Model. The District contracted to have the bathymetry of the river assessed. An assumption is that the bathymetry was adequate for determination of volume and bottom surface area. Appendix D points out that interpolation between measurement points was needed for establishing the three-dimensional model grid. The grid resolution appears to have been made based on the measurement resolution, a generally reasonable choice.

Data to parameterize the EFDC model came from multiple sources (various rain gauges, weather stations, solar radiation stations, etc.) with various degrees of accuracy and distance from the modeled area. However, they are typical of most modeling of this type, and sensitivity to variations in more important variables was investigated by the modeler and deemed to be small. The Panel agrees that the data collection for use in the model was appropriate. Other data were collected but used only for descriptive purposes. The Panel supports having descriptive data and also supports not using them in analyses where simpler metrics are available.

2.2.4 Water Quality

There is a long history of water-quality data collection and characterization efforts to support studies in the Wakulla/Sally Ward GWCA and Wakulla River Watershed that were focused on the sources of nitrogen and the drivers of water clarity in the Wakulla/Sally Ward Spring System. There have also been concerted efforts by the FDEP, City of Tallahassee, Florida Department of Health, and the District to reduce nitrogen loading to groundwater, which ultimately has reduced the concentration of nitrate discharging from the springs. Information that describes the collection of water quality data for these studies and characterizations could be expanded for greater clarity in the MFL Report. However, the Panel believes the acknowledged expertise and long-term experience of the agencies involved in the collection of the data ensures that established sampling protocols and quality assurance requirements are followed. The Panel concludes that the data used were properly collected, reasonable quality assurance assessments were performed, and was the best information available.

Section 3: Technical Assumptions

a) The assumptions are clearly stated, reasonable, and consistent with the best available information.
b) Other analyses that would require fewer assumptions but provide comparable or better results are available.

3.1 Introduction

The Panel generally supports the technical assumptions used to develop the minimum flow for the Wakulla/Sally Spring System. The following is a summary of the Panel's findings on the technical assumptions including suggestions for the near-term for improving the quality of the current report and appendices and future re-evaluations of the MFL.

3.2 Habitat-Based Approach

The District applied a habitat-based approach for a number of the WRVs to establish minimum flows for the Wakulla/Sally Ward Springs System under the assumption that protecting a wide range of habitats will protect the species known to inhabit the river, spring run, and floodplain. This assumption is reasonable, consistent with the best available information, and consistent with minimum flows established by other water management districts.

3.3 Water Resource Values

The following is the Panel's review of the District's assumptions relating to the District's evaluation of WRVs that were selected to develop the minimum flow.

General. In the Executive Summary (MFL Report Page 12), the assumption is made that *"Although there is generally not sufficient data to quantify relationships between the non-quantified WRVs and changes in spring flow, maintenance of flows protective of the WRVs evaluated are expected to extend protection to remaining WRVs."* This assumption carries with it the implicit assumptions that protective flows for one or some WRVs will be protective of other WRVs; and that basing the minimum flow recommendation primarily on one metric for one WRV is sufficiently protective. While this may be a supportable assumption, it is not possible to fully assess its veracity because no evidence or rationale is provided to support it. The Panel recommends that this assumption be supported with an explanation of its basis and with examples if possible.

3.3.1 Fish and Wildlife Habitat and the Passage of Fish

Manatee Passage. The analysis of the potential effects of flow reductions on manatee includes unsupported implicit assumptions about manatee behaviors, habitat use, and foraging support to manatees that are not explained and supported by literature on manatee ecological requirements. This relates closely to the use of a "carrying capacity" approach based on the space needs of individual manatee, and how many manatees can be physically "fit" into the available thermally suitable space. As pointed out in other comments, this analysis is insufficiently supported with relevant and information on manatee behaviors, habitat use, and foraging support. The Panel recommends that either the questionable "carrying capacity" approach be dropped, or the analysis be supported by the necessary ecological information and citations.

3.3.2 Water Quality

Several water quality parameters were evaluated to ensure that potential reductions in spring flow would not cause significant harm to Wakulla and Sally Ward Spring water quality. The District makes a number of assumptions regarding water as discussed below.

Nitrate. The MFL Report states that: *"the potential dilution effect of declining nitrate concentrations with increased flows should be accounted for …."* This statement appears to assume that groundwater that will be diverted to Wakulla Springs that will increase its flow as sea level rises, will not contain significant concentrations of nitrate. While this may be the case, the District should explain that they have not evaluated what the concentration of nitrate will be in water that may increase the flow of the spring in the future. The District should also explain whether they consider this to be an issue of concern for future re-evaluations of the MFL.

3.4 Appendix D. Hydrodynamic Model Development and Calibration

The District contracted to have the bathymetry of the river assessed. An assumption is that the bathymetry was adequate for determination of volume and bottom surface area. It is stated in Appendix D that interpolation between measurement points was needed for establishing the three-dimensional model grid. The grid resolution appears to have been made based on the measurement resolution, a generally reasonable choice.

3.5 Other Assumptions

Stabilization of Spring Flow. The MFL Report seems to have the implicit assumption that that current flows in Wakulla Springs have "stabilized" at recent levels and would stay that way for the foreseeable period that the MFL would be in place such that the MFL would remain protective during that period. The Panel recommends this issue be explicitly discussed. As this is an area of uncertainty in the development of the MFL, it may be advisable to also discuss it as part of the District's adaptive management approach.

Flow Reductions. Some of the MFL analyses (water quality, water temperature) seem to rely on the assumption that "flow reductions" used to test whether the 15 percent threshold would come at the vent, rather than somewhere upgradient in the groundwater-shed and that the flow reductions do not change the proportional flow from various sources or flow reversals. If this is an unavoidable assumption, then narrative should be added to the report to explain this and why it is a supportable assumption, how it may have affected the analysis, and how it may be addressed in the future.

Section 4: Procedures and Analyses

The procedures and analyses were appropriate and reasonable, and based on the best available Information.

a) The procedures and analyses were appropriate and reasonable, and based on the best available Information.
b) The procedures and analyses incorporate all necessary factors.
c) The procedures and analyses were correctly applied.
d) The limitations and imprecision in the information were reasonably handled.
e) The procedures and analyses are repeatable.
f) Conclusions based on procedures and analyses are supported by the data.

4.1 Introduction

The Panel generally supports the procedures and analyses used to develop the MFL for the Wakulla/Sally Ward Spring System. The Panel supports the elements of the District's approach including the identification of relevant WRVs that could be used in the analysis, determination of metrics for the selected WRVs as indicators of potential impacts of flow reductions, and synthesis of the critical flow metrics for the WRVs into an MFL.

For the most part the procedures and analyses incorporated appropriate factors and were correctly applied, and, with some exceptions discussed in this section, the documentation of limitations and imprecision in the information were reasonably handled and the procedures and analyses would be repeatable. The Panel provided suggestions for how the MFL Report and its supporting appendices could clarify certain explanations.

Conclusions based on the procedures and analyses are generally supported by the data. The following is a summary of the Panel's findings on the procedures and analyses of the MFL Report including suggestions for the near term and future re-evaluations of the minimum flow for improving the quality of the current report and appendices.

4.2 Conceptual Approach

The District's conceptual approach to the MFL uses a reasonable set of WRVs and accompanying metrics; modeling of river flows, stages, and estuarine salinity levels; and synthesis of those data to evaluate the potential reductions in the WRV metrics into a recommended MFL based on the concept of allowable withdrawals that would result in no more than a 15 percent reduction. For the most part, analyses presented in the MFL Report were thorough, scientifically reasonable, and based on the best available data. Many of the metrics used for the analysis of flows that would support WRVs are a continuation of technical approaches and analyses used successfully for the establishment of other MFLs in Florida.

4.3 Water Resource Values

General Comments. The District determined that the four WRVs that were most appropriate for the establishment of the MFL for the Wakulla and Sally Ward Spring System were: 1) recreation in and on the water, 2) fish and wildlife habitats and the passage of fish, 3) estuarine resources, and 4) water quality. These WRVs were selected by the District because they were considered to be the most relevant to the spring/river system, have the potential to be affected by spring flow reductions, and sufficient data for the WRV was available for an assessment.

For each of these four WRVs, quantitative metrics were utilized to relate WRVs to spring flows and to assess potential effects of reductions in flows from Wakulla and Sally Ward springs. The Panel supports the

District's selection of these WRVs and their approach to evaluating them. However, the Panel has concerns that are listed below.

1) The MFL Report states that *"Although there is generally not sufficient data to quantify relationships between the non-quantified WRVs and changes in spring flow, maintenance of flows protective of the WRVs evaluated are expected to extend protection to remaining WRVs."* The Panel recommends the District add additional narrative that provides objective support for this assertion, including an example if possible.

The Panel suggests the District provide more information on their conceptualization of the clarity issue in Wakulla Springs in the MFL Report. The current description is an over-simplification of a complex process that makes it difficult for the Panel to evaluate the District's rationale for not investigating the issue further. The Panel recommends that the District take the steps necessary to fully evaluate the clarity issue during the next re-evaluation of the minimum flow.

2) The Panel is concerned that the District did not include Aesthetics and Scenic Attributes as a priority WRV. The following are the Panel's comments regarding these concerns.

a) The District's position on considering the clarity aspect of Aesthetics and Scenic Attributes as a priority WRV is explained as follows: "*The available data indicate that water clarity is inversely related to spring discharge with high water clarity correlated with reduced spring discharge. By definition, MFLs are defined as the allowable reduction in spring flow corresponding to the threshold for significant harm to a WRV and are not suitable for assessing WRVs which are improved with reduced flows. Since reduced spring discharge corresponded with higher water clarity, reductions in spring flow were determined to not be significantly harmful to water clarity so this metric was not considered further for MFL quantification".*

The Panel recommends the District provide more information on their conceptualization of the clarity issue in Wakulla Springs in the MFL Report.

b) Water clarity is discussed in the MFL Report on pages 39 and 99. The District concludes that clarity is inversely proportional to vent flow. This is unusual and speaks to the complexity of source water in this system. This also is related to the idea of dilution. It is noted that higher concentrations of fluorescent, dissolved organic material, chlorophyll-a, and turbidity are seen. There should be little chlorophyll-a from groundwater and increasing flow should decrease residence time. In short, as is mentioned above, these flows probably represent other surface waters making their way to the spring vent. Therefore, these do not represent high flows from groundwater which is the water that the minimum flow would restrict. Therefore, the dilution effect of the groundwater might have value in protecting the water clarity of the Wakulla River and Spring system.

c) MFL Report, page 98. *"Reductions in spring flow were determined to not be significantly harmful to water clarity so this metric was not considered further for MFL quantification." "Little information exists concerning the relationship of flow and nuisance and exotic vegetation cover in the Wakulla River, making this potential metric unable to be reliably quantified."*

The Panel has seen all of these discussed as potential scenic attribute standards for water bodies. It is true that we are often unable to effectively set or measure a standard as each of these relationships with flow or level can be difficult to quantify. However, it is concerning that in a spring as unimpacted as Wakulla, an aesthetic value cannot be quantified. We are especially uncertain about the clarity standard being correctly evaluated (discussed in the previous comment). It is suggested that the District reconsider the Scenic and Asthenic Value WRV in the next re-evaluation of the MFL. It might be that the data is not currently available and so it will not alter this MFL recommendation, but it is an opportunity that can be included in the adaptive management approach.

d) Regarding the District's evaluation of whether an increase in filamentous algal cover in rivers represents a decrease in the aesthetics of a system, the following statement is made on page 98 of the MFL Report: *"However, little information exists concerning the relationship of flow and algal* *cover in the Wakulla River, making this potential metric unable to be reliably quantified. Specific data on water velocity across a river station and detailed information on the location and densities of submerged aquatic vegetation are both unavailable."* The Panel recommends that a clear distinction be made between "algal cover" and "algal mats" and rooted aquatic vegetation as they are referred to here as if they are the same. The Panel also described that simulated depth and velocity information may be obtained from the steady state HEC-RAS model, and should be considered for future MFL re-evaluations for the Wakulla and Sally Ward Spring System. As described in previous comments, the HEC-RAS model is capable of providing simulated depths and velocities at some number of points along each HEC-RAS transect for each simulated flow.

e) MFL Report page 98: *"Future work and data collection are recommended to better understand the complex relationship between velocity and filamentous algae in the Wakulla River".* The Panel concurs with this recommendation, and possibly more important, we recommend that additional research and targeted monitoring be directed towards the identification of factors that result in reduced water clarity, despite the observation that lower spring flows are associated with higher water clarity.

The following is the Panels review of the Priority WRVs the District selected.

4.3.1 Recreation in and on the Water

Recreation was evaluated in terms of the frequency of sufficient water depths for recreational motorized boat and canoe/kayak passage in the Wakulla River below the Shadeville Road bridge. In addition, boat passage was evaluated within the State Park at transects located along the established tour boat route. Each metric is described below. The Panel agrees with the use of recreation in and on the water as a priority WRV but has comments for future consideration of the metrics.

The Wakulla River is utilized by recreational boaters including both State Park sponsored tour boats within park boundaries and intensive use by private boat use outside of the park boundaries. Reduced water levels can increase the chances of damage to river substrates (such as prop scarring to SAV habitats) and damage to outboard motors from hard substrates such as the limestone outcroppings present along many parts of the Wakulla River. The intensive recreational boat use along portions of the Wakulla River makes safe boat passage an important MFL metric. For the Wakulla Spring MFL determination, three separate boat passage metrics were utilized to account for different uses along the river.

State Park Tour Boats. Private boat use is prohibited within the boundaries of the State Park; however, the park provides river tours from the spring vent to approximately 1.0 mile downstream. The river tour boats travel downstream along the south side of river and return upstream along the north side of the river. Along both banks where the boat tour operates are deeper water levels presumably as a result of the structural alterations previously described. The State Park utilizes multiple similar pontoon boats to conduct river tours. When a tour boat was removed from the water for maintenance, the distance between the algae line on the boat and the bottom of the motor was measured to be 3.0 ft. As a result, a metric of 3.0 ft of water depth across two continuous 20 ft widths along the established tour boat route was used as the safe boat passage metric within the State Park.

The Panel generally supports this metric but suggests the District consider the comments listed below.

1) The distance between the algae line and the bottom of one pontoon boat was measured when the boat was removed from the water. The Panel suggests that a better method to measure the required boat depth for passage would be to measure the boat's draft when fully loaded with passengers. Another question was are all of the boats exactly the same, requiring the same passage depth? What is the width of a boat and what is the rationale for using a minimum 30-foot width?

Private Power Boats. Use of private power boats is allowed below the Shadeville Road bridge. For private recreational boat use in this region, a minimum water depth of 2.0 ft across a continuous channel width of 30 ft was used as the metric to evaluate safe boat passage. The Panel has seen a minimum 2-foot depth across a continuous 30-foot channel width used (NWFWMD 2019, SRWMD 2016a) and agrees it's use is appropriate for establishment of this minimum flow.

Canoe/Kayaks. The lower Wakulla River is commonly used for canoeing and kayaking. The U.S. Hwy 98 bridge is a popular destination for recreational users. The extensive use of the lower Wakulla River for canoeing/kayaking makes safe canoe and kayak passage an appropriate metric for this system. A minimum thalweg depth of 1.5 ft was used as the metric for safe canoe/kayak passage, similar to previous MFL evaluations (SRWMD 2013, NWFWMD 2019). This metric was not assessed within the boundaries of the Edward Ball Wakulla Springs State Park since recreational canoeing/kayaking is prohibited within park boundaries. The Panel supports use of this metric for Canoe/Kayak passage and has no comments.

4.3.2 Fish and Wildlife Habitat and Passage of Fish

Metrics for Fish and Wildlife Resources were designed to protect sufficient water depths and frequencies for the passage of fish and manatees and the availability of adequate warm-water refuge habitat for manatees (during winter months).

Fish Passage. The SWFWMD determined in 2002 that 0.6 ft was most representative of the body depth of most individuals of the largest fish species known to inhabit the Peace River (largemouth bass). A screening of the fish species known to inhabit the freshwater portion of the Wakulla River revealed that largemouth bass and long-nose gar were the fish species capable of reaching the largest body depth. While a fish depth of 0.6 ft has been established and accepted as a minimum depth for largemouth bass, no such depth is available for long-nose gar. Information provided by Florida Fish and Wildlife Conservation Commission (FFWCC) biologists indicates that a 0.6 foot depth used for largemouth bass should also be protective of long-nose gar passage. As a result, a minimum thalweg depth of 0.6 ft was utilized as the minimum depth required for fish passage. No minimum channel width was used for this metric since largemouth bass and long-nose gar do not gather in large spawning migrations which require a large cross-sectional area for moving upstream or downstream. This metric was assessed at all channel transect locations along the Wakulla River and Sally Ward Spring run. The Panel supports the District's analysis, conclusions, and application of this metric for fish passage and has no comments.

Manatee Passage. Manatee have been reported to use the Wakulla River and spring year-round for foraging since 2006, with increasing use in recent years for what appears to be warm-water refuge during cold periods, based on the timing of use by most of the manatees.

Required flows for safe manatee passage were evaluated using a minimum water depth for manatee passage of 3.8 ft across a minimum continuous 3.8 ft channel width; this was the same metric used for the nearby St. Marks River Rise MFL evaluation (NWFWMD 2019) and other cited MFL reports. Rouhani et al. (2007) described a manatee depth and width of 3.8 ft for the average adult for use in the establishment of the minimum flow regime for Blue Spring in Volusia County, Florida, while a channel width of 3.8 ft was used for manatee passage. The Panel generally supports the District's analysis and conclusions and application of metrics for manatee passage. However, the Panel has a number of concerns listed below for the District's consideration.

1) MFL Report page 103: *"Therefore, the constructed Wakulla River steady-state model is considered suitable for use in MFL determinations and the associated assessment of water resource values."* The implications of using a steady-state HEC-RAS model for determining critical elevations could be more fully discussed to add clarity.

Tides do seem to matter to Florida manatee. For example, from Rappucci et al. (2012): Tides influence the movements of manatees (Hartman, 1979) and, therefore, their distribution. During high tide, manatees may have access to channels that are otherwise too shallow to traverse. Zoodsma (1991) found that during both cold and warm months, manatees in southeastern Georgia traveled more frequently during high and mid-tides than during low tide (Rappucci, and others, 2012. Tidal Cycle Effects on the Occurrence of the Florida Manatee (Trichechus manatus latirostris) at the Port Everglades Power Plant).

2) Because manatee passage is the singular basis of the proposed minimum flow, and because the depth limitation occurred at transect 41707.76, it may be advisable to survey this transect during the current MFL establishment process to confirm that sufficient detail is provided, especially in regards to river width with sufficient depth. During that survey, the bottom and substrate at that location should be examined to determine their composition so that some conclusion can be made on the expected permanence of the bottom. Is it a persistent feature like a shoal, or a more erodible bottom that would likely change? Any differences found in the bottom elevations should be related back to changes that may have occurred during Hurricane Michael.

3) Increase in spring flows in recent years may be a substantial factor in why many of the WRV metrics did not show a 15 percent or greater impact. That is, the greater than historical flows and levels may be obscuring the response of the WRV metrics, and as a result, affect the eventual recommended minimum flow.

Because the reason for the increase in flows has not been definitively identified, it is a source of uncertainty, and the reasons for it should be addressed between now and the next MFL re-evaluation and/or description of the adaptive management approach, including developing hypotheses (such as those listed in Section 2.7, page 79 of the MFL Report) and investigating them through targeted data collection or monitoring.

The recommended MFL hinges entirely on manatee passage critical depth at one transect - 41707.76. It is advisable to review the bathymetry of the Wakulla River developed by Wantman Group (2016), and supplemental bathymetry data collected since (noted on Page 101, "…bathymetric survey along the Wakulla River and Sally Ward Spring run in August 2019 following Hurricane Michael; no citation provided for the survey). Does this data represent shallow areas generally within this segment of the Wakulla River or is this thought to be an atypical transect? Is the transect a rocky shoal or other fluvially stable substrate? Does it appear to have been influenced or created during the scouring noted to occur during Hurricane Michael? It would seem valuable to understand the answer to these questions to better understand the nature of areas potentially important to manatee passage.

Manatee Thermal Refuge. Florida manatee are susceptible to cold stress during winter months when water temperatures fall below 18°C to 20°C for extended periods or below 10°C to 12°C for periods less than a few hours. Although Wakulla Spring has not been designated as a primary warm water refuge, increased numbers of manatees have been observed overwintering near the Wakulla Spring pool since the winter of 2007/2008. Many previously established MFLs in Florida have two temperature thresholds for thermal habitat (Rouhani et al. 2006, SJRWMD 2007, SWFWMD 2008, SWFWMD 2012a, SWFWMD 2012b, SWFWMD 2017). The chronic stress criteria states that water temperatures must not fall below 20°C (68°F) for more than three days (72 hours), and the acute stress criteria states that water temperatures must not fall below 15°C (59°F) for more than four hours. Wakulla Spring is unique among Florida springs in that the temperature of water being discharged from the spring regularly and naturally falls below 20°C but has not been recorded below 19°C (often for longer than 3 days) during the winter months when manatees are using the spring as a thermal refuge. The Panel generally supports the District's analysis, conclusions and application of metrics for manatee thermal refuge. However, the Panel has a number of concerns listed below for the District's consideration.

1) MFL Report page 93. *"Many previously established MFLs in Florida have two temperature thresholds for thermal habitat"* and this statement is supported by a number of references. This statement is incomplete until the reader is told which two temperature thresholds were used in each study and whether they were all the same, or different. The MFL Report should provide the rationale for the selection of the temperature criteria used.

2) MFL Report page 93. *"The chronic stress criteria states… the acute stress criteria states that water temperatures must not fall below 15°C (59°F) for more than four hours."* The District should provide citations for these criteria and whether they are the same or different that those described in the comment immediately above.

3) MFL Report page 112. *"…selected as they are the winters when manatees have been documented using Wakulla Spring as a thermal refuge."* How is it "documented" that manatees are using the spring as a thermal refuge? Versus foraging or other use? It is unclear why the selection of representative cold periods was limited to years when manatee were apparently using the Wakulla Spring.

4) Generally, the sections on Florida manatee do not appear to include an understanding or some potentially relevant ecological literature (carrying capacity, movements, etc.) which may be helpful in supporting the analyses for warm water refuge and safe passage.

Instream Woody Habitat Inundation. Submerged woody habitat has been identified as being important habitat and food for invertebrate species in streams of the southeastern United States. These macroinvertebrates provide food for larger fauna including the recreationally important sunfishes and largemouth bass. In addition, woody habitat alters streamflow characteristics and helps create multiple habitat types including pools and bars habitat.

Two types of instream woody habitat were observed along the Wakulla River. Dead woody debris consists of tree stumps and fallen logs/branches present and inundated along the edge of the river channel. Live roots include tree roots, cypress knees, etc. found along the river edge that are routinely inundated by river flow or have become exposed due to erosion from water flow. Dead woody debris often tends to be found deeper in the river channel and at a lower elevation than live roots.

Floodplain Vegetation Inundation. The presence, survival, and reproduction of wetland tree species are dependent in large part on the depth and frequency of inundation. The numerous wildlife species which utilize the Wakulla River rely heavily on the river's adjacent floodplain for their survival. The inundation of floodplain habitats has been used as WRV metrics in prior established MFLs for river systems and was evaluated for its appropriateness as a metric in this study. Due to the low ability for a discriminant function analysis to properly categorize different floodplain community types, the riparian communities were treated as a single unit and individual vegetation community types were not used. Wetland edges were delineated in the field across the river and from upland to upland. Land elevation points within the ten floodplain transects were surveyed by a licensed surveyor and analyzed to determine the percent of elevations which were at or below that elevation and could be considered to be inundated at a specified water surface elevation. Water surface elevations at each transect were determined which would inundate 5 percent, 25 percent, 50 percent, and 75 percent of the floodplain elevations and were analyzed for MFL determination.

The following are the Panel's comments related to Floodplain Vegetation Inundation.

1) Executive Summary, page 14. *"However, the available data and modeling results indicate that floodplain communities are maintained largely by direct precipitation and high water-table….woody habitat."* These assertions, even though they are in the Executive Summary, should be supported by a citation to the supporting appendix, report, or supporting data. In this case, the Panel believes the supporting study is the Floodplain Forest and Instream Woody Habitat Data Analysis to Support MFL Development for Wakulla, Sally Ward, and the St. Marks River Rise Springs Systems (NWFWMD 2013), which we were not provided for review, but we have it from the Peer Review for the St. Marks River Rise MFL. The NWFWMD (2013) report implies some of this, but not definitively. Was other analysis or information used to arrive at this conclusion?

2) MFL Report page 95. *"Due to the low ability for a discriminant function analysis to properly categorize different floodplain community types (NWFWMD 2016), the riparian communities were treated as a single unit and individual vegetation community types were not used."* This statement does not seem to be supported by the Research Planning Inc. (RPI) Report, which is cited as NWFWMD (2016) instead of RPI (2016). There does not appear to be anything in the RPI report to the effect that discriminant function analysis failed to properly categorize different floodplain community types, nor that they should

be treated a single unit. This appears to be a decision made after the District's review of the RPI (2016) report and the rationale for this decision should be described. Some of the reasons seemed to be the shallow depth to groundwater in the floodplain and the importance of direct precipitation; these should be more directly linked to the decision.

Other Fish and Wildlife Habitat Considerations. Physical habitat models such as PHABSIM and System for Environmental Flows Analysis *(*SEFA) relate changes in flow to usable habitat by aquatic species and were considered for use in MFL determination, but not used. Preliminary field work was performed to identify suitable transects and characterize velocities and substrates along the Wakulla River. The field investigation revealed that Wakulla River is tidally influenced and characterized by dense aquatic vegetation. These characteristics were described as precluding the development of reliable relationships among channel profiles, velocities, and substrates (Gore, 2015). Multiple alternative habitat metrics including estuarine habitats (reduced salinity), floodplain habitats, instream woody habitats, and fish and manatee passage are included as metrics in this minimum flow evaluation to address and protect the range of flows supporting aquatic habitats.

The Panel does believe that the difficulties of collecting the necessary data and simulating the depths and velocities needed for application of PHABSIM or SEFA can be overcome and should be considered for future MFL re-evaluation.

1) MFL Report pages 13 and 95*. "Physical habitat models such as Physical Habitat Simulation (PHABSIM) and the (SEFA) were considered; however, tidal fluctuations and changes in vegetation density throughout the Wakulla River precluded the development of reliable relationships among channel profiles, velocities and substrates (Gore, 2015)."*

It is accepted that the application of PHABSIM is challenging in rivers with an abundance of rooted and submerged aquatic vegetation and that tidal influences are a challenge as well. However, these factors can no longer be said to necessarily preclude the use of PHABSIM or SEFA. Gore (2015) is used as supporting this statement for the District's conclusion, but review of Gore (2015), which is unpublished (found in the Appendix E from St. Marks River MFL Report) does not fully support the conclusion. Gore (2015) says nothing about tidal conditions, so the implication that Gore (2015) addresses tidal conditions should be corrected. More should be said about why these factors precluded this development versus just making it more challenging.

Gore (2105) also points to emerging techniques to apply PHABSIM without its normally used hydraulic models, citing Casper et al. (2011). It has been almost 10 years since that publication and methods have evolved further and been applied to generate the necessary depth and velocity predictions needed to drive the PHABSIM habitat models (See Page 2 of Adeva-Bustos et. al. 2019, Ecohydraulic Modelling to Support Fish Habitat Restoration Measures).

Also, one of the most widely used hydraulic models is HEC-RAS, which can be used to generate the necessary transect cell depth and velocity estimates (HEC-RAS River Analysis System Release Notes Version 5.0.5 June 2018). This has been done in another recent MFL study. *"However, to include the backwater effect of the Withlacoochee River in the PHABSIM-based simulations of the Rainbow River System, the hydraulic modeling component of the PHABSIM model system was not used. Rather, output from the HECRAS model for the 15 flow-profile simulations discussed previously was used as input for the PHABSIM model runs. The substrate composition and cover characteristics obtained during the field study and predicted velocities and depth values by the HEC-RAS model…"*

The issue of unsteady flow can be addressed by converting HEC-RAS simulations into steady flow outputs (i.e., the HEC-RAS steady-state model runs), just as was done in the Wakulla and Sally Ward Springs MFL Study. The remedy for this issue is unlikely to be feasibly implemented using existing best available data within a reasonable time period so the District should consider this for the next re-evaluation of the MFL. Because the Work Plan for this study (Atkins et. al. 2014) stated that PHABSIM would be used, and because using PHABSIM with the hydraulic outputs of HEC-RAS or other hydraulic models are possible, some explanation should be included in the MFL report.

4.3.*3* Estuarine Resources

Appendix D of the MFL Report explains the development and application of the EFDC model, particularly the downstream tidally influenced freshwater and estuarine reaches of the Wakulla River and St. Marks River. The EFDC model is a widely used hydrodynamic model well-suited for this application. The Panel finds that the model development, calibration, and validation were well organized and documented and the model performance was well within the range needed for confidence in supporting minimum flow establishment based on the estuarine resources WRV using the volume and areal extent of low salinity (oligohaline) as the WRV metrics. A more thorough review of Appendix D is provided later in this report.

4.3.4 Water Quality

The potential to cause significant harm to water quality by reducing spring flows was analyzed using nitrate, specific conductance, dissolved oxygen, and water clarity.

Nitrate. Trends in Wakulla Spring nitrate concentration as a function of time and flow were evaluated using various statistical methods to determine if observed long term declines in nitrate concentration are statistically significant and whether the effect of dilution from increased flow at Wakulla Spring was reducing concentrations in the spring. Results showed an apparent pattern of declining time-adjusted nitrate concentration residuals versus flow, which suggests the presence of a dilution effect, although a high degree of variability exists.

Dissolved Oxygen and Specific Conductance. Both dissolved oxygen and specific conductivity displayed no statistically significant trend from October 22, 2004 to December 31, 2019.

Water Clarity. The Panel's comments on water clarity are included above in Section 4.3, General Comments. The District's analysis of water quality concluded that the groundwater withdrawals allowed by the recommended MFL for Wakulla Spring will not cause significant harm to water quality or impair the designated use of the spring run. The District also concluded that the water quality WRV should be further protected by WRVs such as Fish and Wildlife Habitat and the Passage of Fish (Floodplain Vegetation) which will ensure vegetation is maintained to help uptake, store, and transform nutrients.

The Panel generally concurs with the District's analysis and conclusions regarding water quality, with the exception of water clarity, which is discussed above. The Panel agrees that the District's statistical analyses for nitrate, dissolved oxygen, and specific conductance was properly conducted and that the conclusions were valid. The Panel also supports the District's conclusion that a 9.9 percent reduction in flow allowed by the proposed MFL would not cause significant harm to water quality or impair designated uses of the spring run. The following are the Panel's comments that relate to the District's approach to evaluating water quality and to their conclusions.

1) MFL Report page 36. Although visual observation of Figure 13 suggests a declining nitrate concentration trend, the potential dilution effect of declining nitrate concentrations with increased flows should be accounted for to better discern actual trends in nitrate concentration with time.

This issue is very complicated, and a concern is that the District is limiting its evaluation of nitrate only to the effects of dilution. An important question the District may be overlooking in their analysis of nitrate trends is what is the nitrate concentration of water that is currently being diverted to Wakulla Springs and that will be diverted to Wakulla Springs in the future as sea level continues to rise? How does the District know that increased flows into Wakulla Springs will not bring more nitrate to the spring that might previously have gone to the Spring Creek springs? Is there an adequate record of nitrate data from groundwater discharging in the Spring Creek Springs and are nitrate concentrations in the Floridan aquifer in the Wakulla/Spring Creek Springs vicinity known?

The Panel acknowledges that the significant reduction in nitrate that has occurred at Wakulla Springs due to the efforts to reduce nitrogen inputs in the GWCA near the springs greatly reduces the risk an incomplete understanding of the nitrate issue has on setting the MFL. However, to the extent that the data is available, the District should attempt to enhance their understanding of the nitrate issue in future re-evaluations of the MFL.

2) The Panel is concerned with the implication that the increasing flows have a dilution effect on nitrate concentrations. From Figure 13 it is clear that high nitrate during high flow has not been observed when time is removed. But there is relatively large variation when flows are low. Further, the implication was made that nitrogen loading is reduced due to improved management practices. In fact, it sounds as if the TMDL program is working here and dilution is not the solution? The impression is both that there is a dilution effect but also that the nitrate is not an MFL issue but rather a BMAP/TMDL issue that is being managed. The text would benefit from clarity here. We are left with the impression of uncertainty as to what exactly is the relationship and whether it matters to the establishment of the MFL. We suspect there is a decrease in nitrate loading from the city of Tallahassee but the source of the increase in flow is complicated and the load/concertation of the new water is not well understood. The text should either discuss the importance of this understanding and identify the data that is necessary, or it should express why it is not germane to establishing the MFL.

3) MFL Report page 36. *"This suggests the presence of a dilution effect, although a high degree of variability exists."* The implication of this finding for the analysis should be discussed; if there is a dilution effect, what is the implication"? If not, what is the implication?

4) MFL Report page 41: *"Effects of spring flow reductions on salinity (specific conductance) in the downstream portions of the Wakulla River where estuarine conditions are present will be assessed directly by the Estuarine Resources WRV through the use of an EFDC hydrodynamic model. The potential effects of reduced spring flows on low salinity habitats are addressed under the Estuarine Resources WRV."*

The District is assessing the effects of spring flow reductions on specific conductance in the estuary but what about assessing the effects of spring flow reduction on specific conductance of groundwater discharging from Wakulla Springs? Figure 20 shows that specific conductance frequently doubles due to flow reversals at the Spring Creek Springs. In time, as sea level continues to rise, the Spring Creek Springs may be in reversal mode most of the time. They may only flow during periods of very high rainfall. For future re-evaluations of the MFL, the District may want to consider what effect the predicted sea level elevations will have on the specific conductance of groundwater discharging at Wakulla Springs. Specific conductance is increasing because the concentrations of chemical parameters, most likely sodium and chloride, are increasing. How will increases in these parameters affect the ecology of the spring run?

In the future, as sea level continues to rise, the significance for the proposed MFL is that if a 9.9 percent decline in spring flow due to groundwater withdrawals is allowed, could the increase in the concentrations of the constituents responsible for the increase in specific conductance reach a level where the ecology of the spring and the upper reaches of the spring run could be harmed?

4.4 Adaptive Management

The District emphasizes adaptive management in several places in the MFL Report stating that implementation of the proposed MFL will be updated to address areas of uncertainty following an adaptive management approach, with MFLs periodically reviewed and revised by the District as needed, to incorporate new data and information. The Panel agrees with and supports an adaptive management approach.

The Panel suggests that more information be provided in the MFL Report as to which areas of uncertainty in the MFL analysis would be addressed, thresholds that may drive the reconsideration of the MFL, and any data needs or gaps identified in this review or the District's own review. The following are the Panel's comments relating to adaptive management.

1) The District's approach to and discussion of adaptive management is commendable but also very underdeveloped. The report and the stakeholders interested in the MFL would benefit from the development of a more robust framework stating the data thresholds and desirable data that might trigger a review/re-evaluation. There are examples from the SRWMD's recent MFL report for the lower Santa Fe and Ichetucknee Rivers and its subsequent peer review. First, the 2019 report was a re-evaluation that had been committed to within 5 years of their first report. Second, in the report they detailed specific ongoing data collection which would be used to update MFL recommendations in the future.

Example opportunities might include identifying ongoing efforts that to review/renew MLF tools or ongoing or proposed data collection opportunities such as:

- Continued water chemistry monitoring to better understand the relationship between flow and chemistry.
- The period for which the HEC-RAS model was run was particularly short due to Hurricane Michael. Also, it was necessary to use predicted tides downstream of the model boundary. This is the best data that is currently available but presumably it is also an opportunity to improve the model in the future at a fairly low cost.

2) Suggest providing a bit more to support this statement – what is adaptive management and how does the District apply it in the MFL program? Is there a District explanation of the adaptive management part of the MFL program approach that could be cited? This seems particularly important for this MFL due to some of the uncertainties identified. That process should include the explicit identification of areas of uncertainty and data gaps, the development of monitoring to address the uncertainty, and a plan for addressing as part of the next MFL re-evaluation. The District is encouraged to adopt an explicit adaptive management approach allowing decisions based on limited data to be reinforced or modified as new research and monitoring information becomes available.

4.5 Appendix C. Wakulla Spring MFL: Hydrodynamic Model for Thermal Refuge Evaluation

The Panel generally agrees that the EFDC model calibration and application of the model to estimate the areas of habitat meeting or not meeting the manatee warm-water refuge temperature criteria is appropriate and largely based on the best available data. The Panel has also identified several issues that are discussed below for the District's consideration.

1) Chronic stress to manatees is reported to occur when water temperatures fall below 20°C for 72 hours or longer (Rouhani et al. 2007). Acute stress is reported to occur when water temperatures drop below 15°C for four hours or longer (Rouhani et al. 2007). Other investigators have used different temperature criteria. The main MFL document and Janicki (2020) should both describe the justification for using these criteria.

2) The Panel recommends that the *"Number of manatees supported"* not be used because it has an insufficient technical basis and has the potential to be misleading. The insufficient technical basis comes from a misapplication of this metric as if it is related to ecological "carrying capacity." It is really just a measure of how many manatees you could pack temporarily into an area that meets the temperature criteria. Manatees need more than just physical space, and manatee carrying capacity may be influenced by water temperature, tidal action and access, animal space requirements, available forage, behavioral factors, etc. If the District wishes to continue to use the number of manatees that could theoretically be supported, then the concept of warm water refugia capacity should be used and developed further with supporting ecological scientific information. Another implication of using the calculated numbers of manatees that could be packed into a thermally suitable areas is statements such as *"Assuming each manatee requires a surface area of 28.5 square feet (Rouhani et al. 2007), the spring pool alone could provide thermal refuge for 1,685 manatees."* (Appendix C, Janicki 2020; Page

1.) and *"The remaining periods could support more than 4,460 manatees under reduced spring flow conditions."* This number is greater than the entire known population of manatees in the northern Florida Panhandle. We suggest that the available space under no flow reduction and under flow reduction be used with the statement that it is more than sufficient for the known population using Wakulla Spring as a warm water refuge and leave it at that.

3) Characterization of modeling and analysis by Janicki (2020; Wakulla Spring MFL: Hydrodynamic Model for Thermal Refuge Evaluation) is explained in an overly simplified manner in the MFL Report. It does not explain that the available warm water refuge is not just a simple function of vent flows and at times depends on other factors (cold fronts and surface flows into spring vents that discharge to the Wakulla Spring) and that the chronic thermal refuge criterion for manatees is regularly violated under natural conditions at Wakulla Spring.

4) The Panel agrees with the statement *"…that there is not a straightforward relationship between air temperature and available cold event refuge habitat. The responses in available cold event refuge habitat to potential spring flow reductions is dependent on not only the air temperature during the cold event, but also on the vent discharges and vent water temperatures during the cold event."* For example, flow reductions during a period of time when vent temperatures are greater than 20°C may result in reduced levels of thermal refuge habitat above this temperature, while flow reductions during a period when vent temperatures are below 20°C may result in increased levels of thermal refuge habitat above this temperature, as less cold water enters the system.

5) Referring to *"cold-water refuge"* is confusing, and most of the scientific literature refers to it more commonly as "*warm-water refuge."* Currently the reports use *"thermal refuge habitat" "cold weather refuge habitat", "available cold event refuge habitat",* and *"warm-water refuge."* For consistency with the literature and other studies on manatees, and to avoid confusion, the District should use terminology consistent with other literature and studies on Florida manatees.

6) Page 1 Appendix C describes 4 different temperature criteria from literature/studies. The text provides no basis for the selection of the two temperature criteria used. Was the current scientific literature checked in this process? Or are these used because they are commonly used by others?

7) Page 12 Appendix C. *"The rationale for selecting this period is provided below."* This statement is only marginally accurate – the data used is described, but little rationale is provided; describes what data were used and for what, but not why.

8) Page 34 Appendix C. This section provides quantitative calibration statistics, but then does not provide specific criteria for the values or ranges considered to be good, fair, or poor calibrations, leaving the reader to try to interpret. It goes on to change the name of them from calibration metrics skill assessment criteria. This is confusing and leads to unsupported statements.

9) Page 38 Appendix C. *"…available period of record for vent discharges and associated water temperatures was limited to the period during which manatees have utilized the spring as a cold weather refuge…"* Explain why manatees have to be present to use useful data about flows, water temperatures, and physical processes. The Panel does not concur that manatees must be present in data used to model water temperatures. Why is manatee presence important to understand the range of typical and cold winter periods?

10) Page 49 Appendix C. Explain why discharge variance was much greater in 2017 than 2016, or at least acknowledge the difference.

11) Page 52 Appendix C. The term *"…conservative estimate…."* Explain how this is a *"conservative"* estimate when there is often an inverse, time-lagged response of water temperature to increased flows during winter?

12) Page 57 Appendix C. These statements are based on unsupported assumptions about manatee behaviors, habitat use, and foraging support to manatees that are not explained and supported by literature on manatee ecological requirements.

13) Page 58 Appendix C. *"…Sally Ward water temperatures would provide an acceptable estimate for the Boat Tram water temperatures (Figures 70-73)…"* The contention that variance of temperatures of the two sources is very different seems questionable based on some of the plots. There is a wide divergence during portions of the Winter of 2018-2019.

14) Page 59 Appendix C. This assumes that water use leading to the 30 percent flow reduction would mostly affect the colder, rainfall sourced water than groundwater?

15) Page 63 Appendix C. Needs to be made clear that this examination is for one day and may not be applicable to many days in the record or air temps could be different, making this description less widely applicable to the understanding of flow-water temperature dynamics in the spring and downstream.

4.6 General Modeling Comment

A general comment on use of qualitative language to characterize the degree to which models are calibrated.

1) The main MFL document and the modeling reports often use phrases like "well calibrated", "appropriately calibrated", "calibrated model is sufficient", "relatively good fit", and "relatively tight relationship" are all qualitative statements about calibration quality that should be avoided. The basis for these judgements should be provided in quantitative terms and stated quality criteria.
The Janicki (2020) report does report quantitative calibration statistics on page 34 (Tables 2 and 3) but does not explain them or the judgement criteria very well, and leaves it up the reader to interpret the values in the tables and the quality of the calibration. Similarly, in the ATM (2020) HEC-RAS report, Section 7.1, Model Calibration and Validation Results, provides extensive data on calibration statistics but provides little description of the quality of the calibration based on those statistics. The Panel recommends that when calibration and model performance is presented, they include three things: 1) the calibration metrics, 2) the resultant calibration metric values, 3) criteria for rating the calibration statistics, and 4) a clear characterization.

4.7 Appendix D. Wakula Spring MFL: Hydrodynamic Model for Thermal Refuge Evaluation

The Panel believes the model is generally well calibrated, especially considering the use of predicted tide and the short data window enforced by Hurricane Michael. The model uses the best available data and was updated following the hurricane with new data. The report would benefit from the inclusion of a discussion about how to improve the next iteration of the model. Just simple efforts like collecting boundary conditions (i.e., tidal observations) at the downstream boundary and continuing to collect upstream data so there is less of a need for data filling for development of data sets in the future. Additional comments on the model and suggestions for improvement are included below.

1) Were the St Marks River peer review panel's recommended improvements to the HEC RAS model for that system considered at all for this report?

2) Page 6 Appendix D. *"it is likely that the Wakulla river channel is continuing to change"* and notes substantial changes after Hurricane Michael. Therefore, the District updated model geometry based on new survey. It would be very useful to know more about the critical transect which has determined the MFL recommendation. Are the low spots rocky outcroppings unlikely to change or are they sandy or even silty substrate? If the geometry is likely to change and the MFL is based on this one transect, how often will it be re-surveyed or what type of flow event would trigger a resurvey? The MFL Report would benefit from a physical description of the critical channel cross-section characterizing it as transient or more durable in nature.

3) MFL Report page 2. *"Available light detection and ranging (LiDAR) data were used to extend the transects in the model as needed to fully encompass the potential inundation area."* What is the accuracy of that data?

4) MFL Report page 3. *"Figure 3 presents the stage time series at USGS gage 02327022 (Wakulla River Nr Crawfordville). Evidence of the bathymetric changes is seen in Figure 3, which indicates a different tidal signal is being recorded at the 02327022 gage located approximately 3 miles downstream from the Wakulla spring vent at Shadeville Rd. (Figure 2). The low elevations are approximately 1 foot lower than historically seen."* The report should tell the readers more rather than having them try to figure out what you see.

5) MFL Report page 5. *"Morphological changes were observed in the Wakulla River following Hurricane Michael, as evidenced by survey data comparisons and review of available stage time series in the river reach." Morphological changes were previously referred to as "apparent".*

6) MFL Report page 6. *"The period from January 7, 2019, to September 9, 2019, was used for model testing and initial calibration."*

Why was this period used?

7) MFL Report page 7. *"The model input time series or boundary conditions were stored and processed in Microsoft Office Excel. The processing included calculations to develop the lateral inflows or reach pickup and surface water contributions from contributing basins."* This description is rather cursory and is inadequate considering it is a repeatability standard.

8) MFL Report page 13. *"The net inflow from Basin 2 was input as a uniform lateral inflow. Negative flow values were set to zero".* What is the uniform lateral inflow value? A plot and table should be provided. How often negative? How often not reasonable?

9) MFL Report page 15. "*Given that the flow at the Newport gage was approximately 3.5 times greater than the estimated lateral flow on August 25, 2017, the Newport gage flow time series was divided by 3.5 to estimate the synthetic flow time series for the Basin 4 lateral inflow. The series is named "Basin 4 Lateral Inflow" in the DSS file, SMR_WR_SWS. This flow was input into the HEC-RAS model as a uniform lateral inflow from the USGS 02326900 gage to the location of the ADCP measurement."* This is true for these conditions, but are they representative of the time series? Just one data point, so some uncertainty on uniformity of lateral inflows.

10) MFL Report page 20. *"This would seem to indicate that the Wakulla River is still transitioning following the passage of Hurricane Michael in October 2019, which resulted in some large changes in river morphology."* Is the District saying that changes in river morphology are resulting in better model performance? On what basis is that concluded?

11) MFL Report page 36. *"the stage data measured at the five calibration locations (Sally Ward Spring, USGS 02327000, Boat Tram, USGS 02327022 and USGS 02326900 and flow at USGS 02327022) were used to assess the model performance."* Why different than the performance metrics used in the hydrodynamic model reports?

12) MFL Report page 39. "largely due to timing differences between the simulated and observed stages since comparisons of the simulated and observed stage duration curves match well." Seems to be attributing most of this to timing issues. Provide data or explanation that supports this assertion.

4.*8* Uncertainty

The District should consider adding a section to address uncertainty in the context of adaptive management in the MFL Report that would address and discuss sources of uncertainty in determining the MFL in the future.

1) MFL Report page 80. *"Additional research and the continued collection and review of hydrologic data over time is required to better understand the causal mechanisms driving long-term changes in Wakulla Spring flow."*

The change in Wakulla spring flows and the changes in hydraulics (stage-discharge) over time seems to be one of the largest, if not the largest, source of uncertainty in this MFL determination. The section posits 5 potential causes, but this statement does not sufficiently describe how additional research and monitoring would address this trend and how monitoring might be used to differentiate the possible reasons.

2) MFL Report page 100. *"Additional research and the continued collection and review of hydrologic data over time is required to better understand the causal mechanisms driving long-term changes in Wakulla Spring flow."* This point and other similar points should be repeated as part of the recommended MFL, along with other areas of uncertainty.

Section 5: Deficiencies and Remedies

a) Determine if the methods used in establishing the MFL are scientifically reasonable. If a proposed method in the MFL report is not scientifically reasonable:

- List and describe scientific deficiencies
- Determine if the identified deficiencies can be remedied and provide suggested remedies

5.1 Introduction

Though the Panel's charge uses the word deficiency, we chose to use the word "issue" instead as our conclusion overall is that the MFL Report is not deficient. Rather, it can be improved now and in the future by addressing the issues we have identified.

The following is a compilation of issues in the District's MFL Report and Appendices identified by the Panel and deemed to be significant. The Panel identified numerous minor issues that include changes to text and figures to provide clarity, lack of or incorrect citations, editorial and readability comments, etc. These are listed in Section 4 and on the Peer Review Comment forms for each Panel member but are not included in this section.

5.2 Supporting Data and Interpretation (Section 2)

Issue: Figure 46 in the MFL Report shows there are only 16 wells monitoring the Floridan aquifer in the entire Wakulla Spring Groundwater Contribution Area (GWCA). In addition, there are only 3 wells within 5 miles of the Wakulla/Spring Creek Springs vicinity. Davis and Verdi (2014) makes it clear that the seasonally changing head relationships between Wakulla Springs and the Spring Creek Springs play a major role in determining how groundwater moves between the springs. The current well network provides very little data on these head relationships.
Remedy: The Panel has recently been made aware that the District has substantially upgraded and expanded their data collection networks. A brief discussion of this should be added to the MFL Report to document the District efforts.

Issue: MFL Report page 80. *"Additional research and the continued collection and review of hydrologic data over time is required to better understand the causal mechanisms driving long-term changes in Wakulla Spring flow."* The change in Wakulla Springs flows and changes in hydraulics (stage-discharge) over time seems to be one of the largest, if not the largest, source of uncertainty in this minimum flow determination. The section posits five potential causes but does not sufficiently describe how additional research and monitoring would address this trend and how monitoring might be used to differentiate the possible reasons.
Remedy: Add descriptive information to the MFL Report.

Issue: The District requires its MFL peer review panels to address the quality of supporting data but does not provide sufficient information in the MFL Report and appendices to make this possible.
Remedy: The District should provide more information on how it ensures that its data is of high quality. The District should also require its consultants that produce documents to support MFL development to understand the charge to Peer Review Panels and provide better explanations about the source and quality of the data used, better descriptions of the quality of calibrations, support for assumptions made, and similar items. This should not be a significant change for the supporting consultant reports as they are consistent with scientific and engineering report standards.

5.3 Technical Assumptions (Section 3)

5.3.1 Water Resource Values (General)

Issue: In the Executive Summary (MFL Report Page 12), the assumption is made that "Although there is generally not sufficient data to quantify relationships between the non-quantified WRVs and changes in spring flow, maintenance of flows protective of the WRVs evaluated are expected to extend protection to remaining WRVs." This assumption carries with it the implicit assumptions that protective flows for one or some WRVs will be protective of other WRVs; and that basing the MFL recommendation primarily on one metric for one WRV is sufficiently protective. While this may be a supportable assumption, it is not possible to fully assess its veracity because no evidence or rationale is provided to support it.
Remedy: The District should support this assumption in the current MFL Report with an explanation of its basis and with examples if possible.

5.3.2 Fish and Wildlife Habitat and the Passage of Fish

Issue: The analysis of the potential effects of flow reductions on manatee includes unsupported implicit assumptions about manatee behaviors, habitat use, and foraging support to manatees that are not explained and supported by literature on manatee ecological requirements. This relates closely to the use of a "carrying capacity" approach based on the space needs of individual manatee, and how many manatees can be physically "fit" into the available thermally suitable space. This analysis is insufficiently supported with relevant and information on manatee behaviors, habitat use, and foraging support.
Remedy: The "carrying capacity" approach should be dropped, or the analysis should be supported by the necessary ecological information and citations.

5.3.3 Other Assumptions

Issue: The MFL Report seems to have the implicit assumption that that current flows in Wakulla Springs have "stabilized" at recent levels and would stay that way for the foreseeable period that the MFL would be in place such that the MFL would remain protective during that period.
Remedy: This issue should be explicitly discussed as part of the current MFL establishment effort. As this is an area of uncertainty in the development of the MFL, it is advisable to also discuss it as part of the District's adaptive management approach.

5.4 Procedures and Analyses (Section 4)

5.4.1 Water Resource Values

Issue: The Panel is concerned that the District did not include Aesthetics and Scenic Attributes as a priority WRV. The District's position on considering the clarity aspect of Aesthetics and Scenic Attributes as a priority WRV is explained as follows: *"The available data indicate that water clarity is inversely related to spring discharge with high water clarity correlated with reduced spring discharge. By definition, MFLs are defined as the allowable reduction in spring flow corresponding to the threshold for significant harm to a WRV and are not suitable for assessing WRVs which are improved with reduced flows. Since reduced spring discharge corresponded with higher water clarity, reductions in spring flow were determined to not be significantly harmful to water clarity so this metric was not considered further for MFL quantification".*

The Panel recommends the District provide more information on their conceptualization of the clarity issue in Wakulla Springs in the MFL Report. The current description is an over-simplification of a complex process that makes it difficult for the Panel to evaluate the District's rationale for not investigating the issue further.
Remedy: The Panel recommends that the District take the steps necessary to evaluate the clarity issue during the next re-evaluation of the MFL.

Issue: MFL Report page 98. *"Reductions in spring flow were determined to not be significantly harmful to water clarity so this metric was not considered further for MFL quantification." "Little information exists* *concerning the relationship of flow and nuisance and exotic vegetation cover in the Wakulla River, making this potential metric unable to be reliably quantified." "However, little information exists concerning the relationship of flow and algal cover in the Wakulla River, making this potential metric unable to be reliably quantified"*

The Panel has seen all of these discussed as potential scenic attribute standards for water bodies. It is true that we are often unable to effectively set or measure a standard as each of these relationships with flow or level can be difficult to quantify. However, it is concerning that in a spring as unimpacted as Wakulla, an aesthetic value cannot be quantified. We are especially uncertain about the clarity standard being dismissed (discussed in the previous comment) because it is important for the Recreation in and on the Water WRV and is an inherent part of the State Park tour boat experience.
Remedy: The District should reconsider the dismissal of the Scenic and Asthenic Value WRV during the next re-evaluation of the minimum flow.

Issue: Regarding the District's evaluation of whether an increase in filamentous algal cover in rivers represents a decrease in the aesthetics of a system, the following statement is made on page 98: *"However, little information exists concerning the relationship of flow and algal cover in the Wakulla River, making this potential metric unable to be reliably quantified. Specific data on water velocity across a river station and detailed information on the location and densities of submerged aquatic vegetation are both unavailable."*
Remedy: Text should be added to the report that makes a clear distinction between "algal cover" and "algal mats" and rooted aquatic vegetation. The Panel supports the statement on page 98 of the MFL Report that future work and data collection are recommended to better understand the complex relationship between velocity and filamentous algae in the Wakulla River.

Also, consider that it is not really correct to say that data for velocity across the river at a river station is not available. As described in previous comments, the HEC-RAS model is capable of providing simulated depths and velocities at each HEC-RAS transect for each simulated flow. This is something to consider for future re-evaluations of the minimum flow.

5.4.1.1 Recreation in and on the Water

Issue: Is the algae line on the pontoon boats determined primarily during times when the boats are docked and not fully loaded with people? To remove this as a potentially confounding variable, why was the required depth not measured when the boats were fully loaded with passengers? Are all of the boats exactly the same? What is the width of a boat and what is the rationale for using a minimum 30-foot width?
Remedy: Provide additional description in the MFL Report to address this comment.

5.4.1.2 Fish and Wildlife Habitat and Passage of Fish

Issue: MFL Report page 103. *"Therefore, the constructed Wakulla River steady-state model is considered suitable for use in MFL determinations and the associated assessment of water resource values."*
Remedy: The implications of using a steady-state HEC-RAS model for determining critical elevations could be more fully discussed to add clarity, especially given the nature of the system today. The reader should be explicitly provided with tidal range numbers along with these statements so that the reader can understand the variation around the steady-state elevation predictions for any given flow.

Issue: Because safe manatee passage is the singular basis of the proposed MFL and because the depth limitation occurred at transect 41707.76, the District should investigate this transect in greater detail.
Remedy: As part of the current effort to establish the MFL, this transect should be revisited to confirm that sufficient detail is provided, especially in regard to river width with sufficient depth. The bottom and substrate at that location should be examined to determine their composition so that some conclusion can be made on the expected permanence of the bottom at that location. Is it a persistent feature like a shoal, or a more erodible bottom that would likely change? Any differences found in the bottom elevations here should be related back to changes that may have occurred during Hurricane Michael.

Issue: The increase in spring flows in recent years is a substantial factor in the MFL analysis overall, and possibly in the lack of response to the most important WRV metric and in the recommended MFL. Because the reason for the increase in flows has not been definitively identified, it is a source of uncertainty.
Remedy: A more thorough understanding of the causes of the increase in flow should be addressed between now and the next MFL re-evaluation, including developing hypotheses (such as those listed in Section 2.7, page 79) and investigating them through targeted data collection or monitoring.

5.4.1.3 Manatee Thermal Refuge

Issue: MFL Report page 93. *"Many previously established MFLs in Florida have two temperature thresholds for thermal habitat and this statement is supported by a number of references"*. This statement is incomplete until the reader is told which two temperature thresholds were used in each study and whether they were all the same, or different.
Remedy: Provide the rationale for the selection of the temperature criteria used.

Issue: MFL Report page 93. "The chronic stress criteria states… the acute stress criteria states that water temperatures must not fall below 15°C (59°F) for more than four hours."
Remedy: Provide citations for these criteria and whether they are the same or different that those described in the previous comment.

Issue: MFL Report page 112. "…selected as they are the winters when manatees have been documented using Wakulla Spring as a thermal refuge." How is it "documented" that manatees are using the spring as a thermal refuge versus foraging or other use? Is this based on manatee movements into the spring and associated increase in abundance during cold periods?
Remedy: The MFL Report should include a description of how it is known that manatees use the springs as warm water refugia versus other uses such as foraging.

5.4.1.4 Floodplain Vegetation Inundation

Issue: MFL Report Executive Summary, page 14. *"However, the available data and modeling results indicate that floodplain communities are maintained largely by direct precipitation and high water-table….woody habitat."* These assertions, even though they are in the Executive Summary, should be supported by a citation to the supporting appendix, report, or supporting data. In this case, the Panel believes the supporting study is the Floodplain Forest and Instream Woody Habitat Data Analysis to Support MFL Development for Wakulla, Sally Ward, and the St. Marks River Rise Springs Systems (NWFWMD 2013), which we were not provided for review, but we have from the Peer Review for the St. Marks River Rise MFL. The NWFWMD (2013) report implies some of this, but not definitively. Was other analysis or information used to arrive at this conclusion?
Remedy: Add text to address the comment.

Issue: MFL Report page 95. *"Due to the low ability for a discriminant function analysis to properly categorize different floodplain community types (NWFWMD 2016), the riparian communities were treated as a single unit and individual vegetation community types were not used".* This statement does not seem to be supported by the Research Planning Inc. Report, which is cited as NWFWMD (2016) instead of RPI (2016). There does not appear to be anything in the RPI report to the effect that discriminant function analysis failed to properly categorize different floodplain community types, not that they should be treated a single unit.
Remedy: This appears to be a decision made after the District's review of the RPI (2016) report and the rational for this decision should be provided.

5.4.1.5 Other Fish and Wildlife Habitat Considerations

Issue: MFL Report pages 13 and 95. *"Physical habitat models such as Physical Habitat Simulation (PHABSIM) and the System for Environmental Flows Analysis (SEFA) were considered; however, tidal fluctuations and changes in vegetation density throughout the Wakulla River precluded the development of reliable relationships among channel profiles, velocities and substrates (Gore 2015)."*

It is accepted that the application of PHABSIM is challenging in rivers with an abundance of rooted and submerged aquatic vegetation and that tidal influences are a challenge as well. However, these factors can no longer be said to necessarily preclude the use of PHABSIM or SEFA. Gore (2015) is used as supporting this statement for the District's conclusion, but review of Gore (2015), which is unpublished (found in the Appendix E from St. Marks River MFL Report) does not fully support the conclusion. Gore (2015) says nothing about tidal conditions, so the implication that Gore (2015) addresses tidal conditions should be corrected. More should be said about why these factors precluded this development versus just making it more challenging.

Gore (2105) also points to emerging techniques to apply PHABSIM without its normally used hydraulic models, citing Casper et al. (2011). It has been almost 10 years since that publication and more methods have evolved and been applied to generate the necessary depth and velocity predictions needed to drive the PHABSIM habitat models (See Page 2 of Adeva-Bustos et. al. 2019, Ecohydraulic Modelling to Support Fish Habitat Restoration Measures). One of the most widely used is hydraulic models is HEC-RAS, which can be used to generate the necessary transect cell depth and velocity estimates (HEC-RAS River Analysis System Release Notes Version 5.0.5 June 2018).

This has been done in another recent MFL study. "However, to include the backwater effect of the Withlacoochee River in the PHABSIM-based simulations of the Rainbow River System, the hydraulic modeling component of the PHABSIM model system was not used. Rather, output from the HEC-RAS model for the 15 flow-profile simulations discussed previously was used as input for the PHABSIM model runs. The substrate composition and cover characteristics obtained during the field study and predicted velocities and depth values by the HEC-RAS model…"

Remedy: The issue of unsteady flow can be addressed by converting HEC-RAS simulations into steady flow outputs, as was already done in the Wakulla/Sally Ward MFL Study (cite HEC-RAS report). The remedy for this issue is unlikely to be feasibly implemented using existing best available data within a reasonable time period so the District should consider this for the next re-evaluation of the MFL. Because the Work Plan for this study (Atkins et. al. 2014) stated that PHABSIM would be used, and because using PHABSIM with the hydraulic outputs of HEC-RAS are possible, some explanation should be included in the current MFL Report.

5.4.1.6 Water Quality

Issue: MFL Report page 36. *"Although visual observation of Figure 13 suggests a declining nitrate concentration trend, the potential dilution effect of declining nitrate concentrations with increased flows should be accounted for to better discern actual trends in nitrate concentration with time."* This issue is very complicated, and the concern is that the District is limiting its evaluation of nitrate only to the effects of dilution. An important question the District may be overlooking in their analysis of nitrate trends is what is the nitrate concentration of water that is currently being diverted to Wakulla Springs and that will be diverted to Wakulla Springs in the future as sea level continues to rise? How does the District know that increased flows into Wakulla Springs will not bring more nitrate to the spring that might previously have gone to the Spring Creek springs? Is there an adequate record of nitrate data from groundwater discharging in the Spring Creek Springs and are nitrate concentrations in the Floridan aquifer in the Wakulla/Spring Creek Springs vicinity known?

Remedy: The Panel acknowledges that the significant reduction in nitrate that has occurred at Wakulla Spring due to the efforts to reduce nitrogen inputs in the GWCA near the springs greatly reduces the risk an incomplete understanding of the nitrate issue has on setting the MFL. However, to the extent that the data is available, the District should attempt to enhance their understanding of the nitrate issue in future re-evaluations of the MFL.

Issue: The Panel is concerned with the implication that the increasing flows have a dilution effect on nitrate concentrations. From Figure 13 it is clear that high nitrate during high flow has not been observed when time is removed. But there is relatively large variation when flows are low. Further, we feel the implication was made that nitrogen loading is reduced due to improved management practices. In fact, it sounds as if the TMDL program is working and dilution is not the solution? The impression is both that there is a dilution

effect but also that the nitrate is not an MFL issue but rather a BMAP/TMDL issue that is being managed. The text would benefit from clarity here. We are left with the impression of uncertainty as to what exactly is the relationship and whether it matters to the establishment of the MFL.
Remedy: The Panel suspects there is a decrease in nitrate loading from the City of Tallahassee but the source of the increase in flow is complicated and the load/concentration of the new water is not well understood. The text should either discuss the importance of this understanding and identify the data that is necessary, or it should express why it is not germane to establishing the MFL.

Issue: MFL Report page 36. "This suggests the presence of a dilution effect, although a high degree of variability exists."
Remedy: The implication of this finding for the analysis should be discussed; if there is a dilution effect, what is the implication"? If not, what is the implication?

Issue: MFL Report page ? *"Effects of spring flow reductions on salinity (specific conductance) in the downstream portions of the Wakulla River where estuarine conditions are present will be assessed directly by the Estuarine Resources WRV through the use of an EFDC hydrodynamic model. The potential effects of reduced spring flows on low salinity habitats are addressed under the Estuarine Resources WRV."* The District is assessing the effects of spring flow reductions on specific conductance in the estuary but what about assessing the effects of spring flow reduction on specific conductance of groundwater discharging from Wakulla Springs? Figure 20 shows that specific conductance frequently doubles due to flow reversals at the Spring Creek Springs. In time, as sea level continues to rise, the Spring Creek Springs may be in reversal mode most of the time. They may only flow during periods of very high rainfall. In the future, as sea level continues to rise, the significance for the proposed MFL is that if a 9.9 percent decline in spring flow due to groundwater withdrawals is allowed, could the increase in the concentrations of the constituents responsible for the increase in specific conductance reach a level where the ecology of the spring and the upper reaches of the spring run could be harmed?
Remedy: For future reevaluations of the MFL, the District may want to consider what effect the predicted sea level elevations will have on the specific conductance of groundwater discharging at Wakulla Springs.

5.4.2 Adaptive Management

Issue: The District's approach to and discussion of adaptive management is under developed.
Remedy: Develop a more robust framework stating the data thresholds and desirable data that might trigger a review/re-evaluation. What is adaptive management and how does the District apply it in the MFL program? Is there a District explanation of the adaptive management part of the MFL program approach that could be cited? This seems particularly important for this MFL due to some of the uncertainties identified. That process should include the explicit identification of areas of uncertainty and data gaps, the development of monitoring to address the uncertainty, and a plan for addressing it in the next MFL re-evaluation. The District is encouraged to adopt an explicit adaptive management approach for identified areas of uncertainty allowing decisions based on limited data to be reinforced or modified as new research and monitoring information becomes available.

5.4.3 Appendix C. Wakula Spring MFL: Hydrodynamic Model for Thermal Refuge Evaluation

Issue: Chronic stress to manatees is reported to occur when water temperatures fall below 20°C for 72 hours or longer (Rouhani et al. 2007). Acute stress is reported to occur when water temperatures drop below 15°C for four hours or longer (Rouhani et al. 2007). Other investigators have used different temperature criteria.
Remedy: The MFL Report and Janicki (2020) should both describe the justification for using these criteria.

Issue: Using the *"Number of manatees supported"* has an insufficient technical basis and has the potential to be misleading. The insufficient technical basis comes from a misapplication of this metric as if it is related to ecological "carrying capacity." It is really just a measure of how many manatees could be packed temporarily into an area that meets the temperature criteria. Manatees need more than just physical space, and manatee carrying capacity may be influenced by water temperature, tidal action and access, animal

space requirements, available forage, behavioral factors, etc. If the District wishes to continue to use the number of manatees that could theoretically be supported, then the concept of warm water refugia capacity should be used and developed further with supporting ecological scientific information. Another implication of using the calculated numbers of manatees that could be packed into a thermally suitable area is statements such as "Assuming each manatee requires a surface area of 28.5 square feet (Rouhani et al. 2007), the spring pool alone could provide thermal refuge for 1,685 manatees." (Appendix C, Janicki 2020; Page 1.) and "The remaining periods could support more than 4,460 manatees under reduced spring flow conditions." This number is greater than the entire known population of manatees in the northern Florida Panhandle and the approaching the total population of manatees in Florida.
Remedy: The available space under no flow reduction and under flow reduction should be used with the statement that it is more than sufficient for the known population using Wakulla Spring as a warm water refuge and leave it at that.

Issue: Characterization of modeling and analysis by Janicki (2020; Wakulla Spring MFL: Hydrodynamic Model for Thermal Refuge Evaluation) is explained in an overly simplified manner in the MFL Report.
Remedy: It should be explained in the MFL Report that the available warm water refuge is not just a simple function of vent flows but at times depends on other factors (cold fronts and surface flows into spring vents that discharge to the Wakulla Spring) and that the chronic thermal refuge criterion for manatees is regularly violated under natural conditions at Wakulla Spring.

Issue: Referring to "cold-water refuge" is confusing, and most of the scientific literature refers to it more commonly as "warm-water refuge." Currently the reports use "thermal refuge habitat" "cold weather refuge habitat", "available cold event refuge habitat", and "warm-water refuge."
Remedy: For consistency with the literature and other studies on manatees, and to avoid confusion, the District should use terminology consistent with other literature and studies on Florida manatees.

Issue: Page 1 Appendix C describes 4 different temperature criteria from literature/studies. The text provides no basis for the selection of the two temperature criteria used.
Remedy: Explain whether the current scientific literature was checked in this process or that these were used because they are commonly used by others.

Issue: Page 12 Appendix C. *"The rationale for selecting this period is provided below."* This statement is only marginally accurate – the data used is described, but little rationale is provided.
Remedy: Provide a more detailed rationale.

Issue: Page 34 Appendix C. This section provides quantitative calibration statistics, but then does not provide specific criteria for the values or ranges considered to be good, fair, or poor calibrations, leaving the reader to try to interpret. It goes on to change the name of them from calibration metrics skill assessment criteria.
Remedy: Provide specific criteria for the values or ranges considered to be good, fair, or poor calibrations.

Issue: Page 38 Appendix C, *"…available period of record for vent discharges and associated water temperatures was limited to the period during which manatees have utilized the spring as a cold weather refuge."*
Remedy: Explain why manatees have to be present to use useful data about flows, water temperatures, and physical processes. The Panel does not concur that manatees must be present in data used to model water temperatures during representative cold periods. Why is manatee presence important to understand the range of typical and cold winter periods?

Issue: Page 49 Appendix C. Discharge variance is much greater in 2017 than 2016.
Remedy: Explain why or acknowledge the considerable difference in variance.

Issue: Page 52 Appendix C. The term *"…conservative estimate…."* Is used.
Remedy: Explain what conservative means and how this is a "conservative" estimate when there is often an inverse, time-lagged response of water temperature to increased flows during winter.

Issue: Page 58 Appendix C. In the text and in Figures 70 and 71. *"…Sally Ward water temperatures would provide an acceptable estimate for the Boat Tram water temperatures (Figures 70-73)…"* The contention that variance of temperatures of the two sources is very different seems questionable based on some of the plots. There is a wide divergence during a portion of the winter of 2018-2019.
Remedy: Provide an explanation.

Issue: Page 63 Appendix C. This examination is for one day and may not be applicable to many days in the record or air temps could be different, making this description less widely applicable to the understanding of flow-water temperature dynamics in the spring and downstream.
Remedy: Make this more clear in the report.

5.4.4 General Modeling Comment

Issue: The MFL Report and the modeling reports often use phrases like "well calibrated", "appropriately calibrated", "calibrated model is sufficient", "relatively good fit", and "relatively tight relationship" are all qualitative statements about calibration quality that should be avoided. The basis for these judgements should be provided in quantitative terms and stated quality criteria. The Janicki (2020) report does report quantitative calibration statistics on page 34 (Tables 2 and 3) but does not explain them or the judgement criteria very well and leaves it up the reader to interpret the values in the tables and the quality of the calibration. Similarly, in the ATM (2020) HEC-RAS report, Section 7.1 Model Calibration and Validation Results provides extensive data on calibration statistics but provides little description of the quality of the calibration based on those statistics.
Remedy: When calibration and model performance is presented in future re-evaluations of the MFL, three things should be included: 1) the calibration metrics, 2) the resultant calibration metric values, 3) criteria for rating the calibration statistics, and 4) a clear characterization.

5.4.5 Appendix D. Wakula Spring MFL: Hydrodynamic Model for Thermal Refuge Evaluation

Issue: The report should include a discussion about how to improve the next iteration of the model.
Remedy: Include simple efforts like collecting boundary conditions (i.e. tidal observations) at the downstream boundary and continuing to collect upstream data so there is less of a need for data filling for development of data sets in the future.

Issue: MFL Report page 3. *"Figure 3 presents the stage time series at USGS gage 02327022 (Wakulla River Nr Crawfordville). Evidence of the bathymetric changes is seen in Figure 3, which indicates a different tidal signal is being recorded at the 02327022 gage located approximately 3 miles downstream from the Wakulla spring vent at Shadeville Rd. (Figure 2). The low elevations are approximately 1 foot lower than historically seen."*
Remedy: The report should tell the readers more rather than having them try to figure out what you see.

Issue: MFL Report page 6. It is not clear why the period from January 7, 2019, to September 9, 2019, was used for model testing and initial calibration.
Remedy: Explain why this period was used.

Issue: MFL Report page 7: *"The model input time series or boundary conditions were stored and processed in Microsoft Office Excel. The processing included calculations to develop the lateral inflows or reach pickup and surface water contributions from contributing basins."* This description is rather cursory and is inadequate considering it is a repeatability standard.
Remedy: Provide a more thorough description.

Issue: MFL Report page 13. *"The net inflow from Basin 2 was input as a uniform lateral inflow. Negative flow values were set to zero."* It is not clear what the uniform lateral inflow value is.
Remedy: A plot and table should be provided. How often negative? How often not reasonable?

Issue: MFL Report page 15. *"Given that the flow at the Newport gage was approximately 3.5 times greater than the estimated lateral flow on August 25, 2017, the Newport gage flow time series was divided by 3.5 to estimate the synthetic flow time series for the Basin 4 lateral inflow. The series is named "Basin 4 Lateral*

Inflow" in the DSS file, SMR_WR_SWS. This flow was input into the HEC-RAS model as a uniform lateral inflow from the USGS 02326900 gage to the location of the ADCP measurement." This is true for these conditions, but it is not clear if they are representative of the time series. Just one data point, so some uncertainty on uniformity of lateral inflows.
Remedy: Add clarifying test.

Issue: MFL Report page 20. *"This would seem to indicate that the Wakulla River is still transitioning following the passage of Hurricane Michael in October 2019, which resulted in some large changes in river morphology."* Is the District saying that changes in river morphology are resulting in better model performance? On what basis is that stated?
Remedy: Add clarifying text.

Issue: Minimum Flow Report page 36: "*the stage data measured at the five calibration locations (Sally Ward Spring, USGS 02327000, Boat Tram, USGS 02327022 and USGS 02326900 and flow at USGS 02327022) were used to assess the model performance."* Why different than the performance metrics used in the hydrodynamic model reports?
Remedy: Add clarifying text.

Issue: Minimum Flow Report page 39: *"largely due to timing differences between the simulated and observed stages since comparisons of the simulated and observed stage duration curves match well."* Seems to be attributing most of this to timing issues.
Remedy: Provide data or explanation that supports this assertion.

5.4.6 Uncertainty

Issue: MFL Report page 80. *"Additional research and the continued collection and review of hydrologic data over time is required to better understand the causal mechanisms driving long-term changes in Wakulla Spring flow."*

The change in Wakulla spring flows and the changes in hydraulics (stage-discharge) over time seems to be one of the largest, if not the largest, source of uncertainty in this MFL determination. The section posits 5 potential causes, but this statement does not sufficiently describe how additional research and monitoring would address this trend and how monitoring might be used to differentiate the possible reasons.

MFL Report page 100. *"Additional research and the continued collection and review of hydrologic data over time is required to better understand the causal mechanisms driving long-term changes in Wakulla Spring flow."* This point and other similar points should be repeated as part of the recommended MFL, along with other areas of uncertainty.
Remedy: The District should consider adding a section in the MFL Report to address uncertainty in the context of the adaptive management approach that would address and discuss sources of uncertainty in determining the MFL in future re-evaluations.

Section 6: References

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Appendix A Peer Review Panel Comment Form – Gregg Jones

Appendix B Peer Review Panel Comment Form – Paul Leonard

Appendix C Peer Review Panel Comment Form – Adam Munson