Scientific Peer Review of the Recommended Minimum Flows for the St. Marks River Rise and Spring Run Report

September 2018

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Document Information

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List of Abbreviations

ADCP	acoustic Doppler current profiler
ARIMA	auto-regressive integrated moving average
ATM	Applied Technology and Management
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
IUCN	International Union for Conservation of Nature
IV	importance value
LiDAR	light detecting and ranging
MFL	minimum flow and level
NAVD88	North American Vertical Datum of 1988
NWI	National Wetlands Inventory
Panel	Peer Review Panel
PCQ	point-center-quarter
POR	period of record
ppt	part(s) per thousand
SAV	submerged aquatic vegetation
SJRWMD	St. Johns River Water Management District
SKT	Seasonal Kendall Test
SMR	St. Marks River Rise and Spring Run
SMR Minimum Flow Report	*Recommended Minimum Flows for the St. Marks River Rise and Spring Run*
SRWMD	Suwannee River Water Management District
SWFWMD	Southwest Florida Water Management District
USGS	U.S. Geological Survey
WRV	water resource value

Executive Summary

The Northwest Florida Water Management District (District) contracted Cardno to provide independent scientific peer review of the report titled *Recommended Minimum Flows for the St. Marks River Rise and Spring Run* (SMR Minimum Flow Report) and appendices.

ES 1 Charge to the Peer Review Panel

Cardno was provided with the following charge:

1. Determine whether the methods used for establishing the minimum flows are scientifically reasonable.
    a. Supporting data and information: Review the data and information that support the method and the proposed minimum flows, as appropriate. The reviewer shall assume that the data and information used were properly collected and reasonable quality assurance assessments were performed on the data and information.
    b. Technical assumptions: Review the technical assumptions inherent in the methodology and determine:
        1. If the assumptions are clearly stated, reasonable, and consistent with the best available information
        2. If the assumptions were eliminated to the extent possible, based on available information
    c. Procedures and analyses: Review the procedures and analyses used in developing quantitative measures and determine qualitatively whether:
        1. The procedures and analyses were appropriate and reasonable, based on the best available information
        2. The procedures and analyses incorporate appropriate factors
        3. The procedures and analyses were correctly applied
        4. Limitations and imprecision in the information were reasonably handled
        5. The procedures and analyses are repeatable
        6. Conclusions based on the procedures and analyses are supported by the data
2. If a proposed method used in the minimum flow and level (MFL) report is not scientifically reasonable, the CONTRACTOR shall:
    b. Deficiencies: List and describe scientific deficiencies and associated remedies.
    b. Remedies: Determine if the identified deficiencies can be remedied and provide suggested remedies.

1. If the identified deficiencies can be remedied, then describe the necessary corrections and, if possible, provide an estimate of the time and effort required to develop and implement.
2. Remedies shall be reasonable and practical, cost-effective, and feasible and utilize existing best available data.
3. Alternatively, remedies that cannot be feasibly implemented using existing best available data within a reasonable period (e.g., several days up to 3 months) should be specifically identified as recommendations for the District to consider during the next reevaluation of the minimum flow regime.

ES-2 Review Constraints

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

1) The selection of water bodies or aquifers for which minimum levels are proposed to be set
2) The definition of what constitutes "significant harm" to the water resources or ecology of the area
3) The evaluation and selection of priority water resource values (WRVs)
4) The method(s) used to establish MFLs for water bodies outside of the District
5) 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 SMR Minimum Flow Report and began its review in late June 2018. The Panel participated in a kickoff conference call with District staff on June 28, 2018. District staff delivered a presentation on all aspects of the process to develop a minimum flow for the SMR. Following the call, the Panel agreed on review assignments, reviewed the SMR Minimum Flow Report 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.

ES-3 Peer Review Panel

Cardno 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 chairman): karst hydrogeology
Paul Leonard, Ph.D.: aquatic ecology, hydrology, modeling
Shirley Denton, Ph.D.: wetland floodplain communities, ecology

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 SMR Minimum Flow Report. The following is a summary of the Panel's major findings.

ES-4 Major Findings

The Panel concludes that the District had sufficient data to conceptually address the complete range of flows likely to occur on the St. Marks River through its consideration of various WRVs and use of several metrics to evaluate "significant harm" against a baseline period. The District focused on minimum flow requirements, but did not limit its assessment to just low flows. The District has explicitly addressed low flows, instream flows, and out-of-bank flows where the latter are intended to protect floodplain wildlife habitats (plant communities) from significant harm.

The District used the smallest allowable reduction in spring flow corresponding to a 15 percent reduction in inundation frequency to determine the proposed minimum flow for the River Rise. The most limiting WRV metric was the frequency of inundation of the cypress hardwood mix community located at river station 53367.25. The allowable flow reduction is 34 cubic feet per second (cfs) for a spring flow of 452 cfs.

After a thorough review of the SMR Minimum Flow Report, appendices, and supporting documents, the Panel supports the District's approach to developing the minimum flow and its selection of the inundation frequency of the cypress hardwood mix community, a wetland community where many of the component species have a close relationship with river hydrology for many of their life-cycle needs.

The Panel has identified several technical concerns that are elaborated on in the following sections and made recommendations as to how these concerns might be addressed.

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 St. Marks River Rise and Spring Run (SMR), which extends approximately 11.4 miles from the River Rise to the confluence of the Wakulla and St. Marks rivers.

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

Cardno 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 chairman): karst hydrogeology
Paul Leonard, Ph.D.: aquatic ecology, hydrology, modeling
Shirley Denton, Ph.D.: wetland floodplain communities, ecology
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 the St. Marks River Rise and Spring Run* (SMR Minimum Flow Report). 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:

1. Determine whether the methods used for establishing the minimum flows are scientifically reasonable.
   a. Supporting data and information: Review the data and information that support the method and the proposed minimum flows, as appropriate. The reviewer shall assume that the data and information used were properly collected and reasonable quality assurance assessments were performed on the data and information.
   b. Technical assumptions: Review the technical assumptions inherent in the methodology and determine:
      1. If the assumptions are clearly stated, reasonable, and consistent with the best available information
      2. If the assumptions were eliminated to the extent possible, based on available information
   c. Procedures and analyses: Review the procedures and analyses used in developing quantitative measures and determine qualitatively whether:

1. The procedures and analyses were appropriate and reasonable, based on the best available information
2. The procedures and analyses incorporate appropriate factors
3. The procedures and analyses were correctly applied
4. Limitations and imprecision in the information were reasonably handled
5. The procedures and analyses are repeatable
6. Conclusions based on the procedures and analyses are supported by the data

2. If a proposed method used in the MFL report is not scientifically reasonable, the CONTRACTOR shall:
   b. Deficiencies: List and describe scientific deficiencies and associated remedies.
   b. Remedies: Determine if the identified deficiencies can be remedied and provide suggested remedies.
      1. If the identified deficiencies can be remedied, then describe the necessary corrections and, if possible provide an estimate of the time and effort required to develop and implement.
      2. Remedies shall be reasonable and practical, cost-effective, and feasible and utilize existing best available data.
      3. Alternatively, remedies that cannot be feasibly implemented using existing best available data within a reasonable period (e.g., several days up to 3 months) should be specifically identified as recommendations for the District to consider during the next reevaluation of the minimum flow regime.

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:

1. The selection of water bodies or aquifers for which minimum levels are proposed to be set
2. The definition of what constitutes “significant harm” to the water resources or ecology of the area
3. The evaluation and selection of priority water resource values (WRVs)
4. The method(s) used to establish MFLs for water bodies outside of the District
5. 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 SMR Minimum Flow Report and began its review in late June 2018. The Panel participated in a kickoff conference call with District staff on June 28, 2018. District staff delivered a presentation on all aspects of the process to develop a minimum flow for the SMR. Following the call, the Panel agreed on review assignments, reviewed the SMR Minimum Flow Report 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.

2 Supporting Data and Information

The Data and Information Used Were Properly Collected
Reasonable Quality Assurance Assessments Were Performed
Exclusion of Available Data from the Analysis Was Justified
The Data Used Was the Best Information Available

In this section the Panel has evaluated all the information that pertained to data collection, use, quality assurance, and data availability that was included in the SMR Minimum Flow Report, its appendices, and selected supporting documentation. The Panel generally supports the collection, use, and quality assurance of the supporting data with the exception of a few issues discussed below.

2.1 **Baseline Time Series**

The District rigorously evaluated several of the data sets before using them for various analyses. An example of this includes development of the baseline unimpacted spring flow record in Appendix B where the quality of the rainfall, groundwater levels, evapotranspiration, and river flow data were evaluated by developing time-series plots for each site and data type and then conducting trend analyses.

The Panel concludes that the data used in the analyses to determine the minimum flow were the best available. The flow data were collected by or with USGS and represent the standard for flow data collection. Rainfall data were collected from both National Weather Service and District gauges and follow documented collection protocol. It is safe to assume that the standard operating procedure for USGS, the National Weather Service, and the District is to employ rigorous quality control procedures as part of the data collection process.

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

2.2.1 Recreation in and on the Water

The District relied upon general criteria for safe boat use including use of boat ramps and safe boat passage on the river. The criteria used were obtained from the literature. The characteristics of the lower end of the boat ramps were inspected and potentially measured. After observing that the ramp at St. Marks was usable at all flows and that the ramp at Newport was never used at low tide, no further data collection was undertaken.

Data on river dimensions were obtained from cross sections across the shoals where depth profiles (for motorized boats) were measured and the thalweg for canoes and kayaks determined. The Panel believes this was appropriate.

2.2.2 Fish and Wildlife Habitats and the Passage of Fish

Floodplain Plant Communities

Appendix C of the SMR Minimum Flow Report, "MFLs for Sally Ward, Wakulla, and St. Marks River Rise Springs Systems for the Northwest Florida Water Management District: Floodplain Forest and Instream Woody Habitat Data Analysis," summarizes floodplain forest data collection, which involved identification of ecological community data based on overstory vegetation and soils along 11 river floodplain transects.

The Panel questions the presumption that trees and soils should be the only indicators of floodplain plant communities. It is clear from the results of the tree sampling that there is considerable overlap in tree composition between the various identified wetland forest communities. Herbaceous plants and shrubs could have been, and likely were, informally used in identifying the plant communities.

The Panel believes that recording those plants at a general level might have assisted in the identification of the plant communities. Despite the assumption that the trees integrate the communities better (Appendix C, p. 12), many herbaceous species and shrubs are long-lived and highly diagnostic of environmental conditions. While Appendix C-2 of the SMR Minimum Flow Report) has general photographs at each transect, the Panel suggests that in future MFL studies, a sampling plan that includes rigorous use of photography would provide a rapid and cost-effective way of sampling the entire plant community. For this purpose, we suggest that photographs be taken at surveyed locations, and at enough locations to show consistency within sampled communities and show contrasts between adjacent communities. Photographs could also document microhabitats and channels that are not consistent with the overall plant communities.

Issues with Point Center Quarter Sampling of Riparian Communities

The Panel agrees that point-center-quarter (PCQ) sampling can be used for this purpose and that it is simple to apply. However, the PCQ needs to meet basic sample size requirements. In this case, the sampling was used to create importance values (IVs) for each species in each identified plant community. The computed IVs were then used as observations in other statistical analyses.

To use it this way, an adequate sample size would be needed for each species in each community, with an adequate number of points available for all or at least most species in all communities. The number of samples needed could have been estimated based on a preliminary survey for each vegetation community. This was not done.

The environmental literature has numerous examples of PCQ sample sizes for different forested community types. Each was a single community, and the goal was to compute a single value (generally total basal area or tree density). The number of points needed varies, but recommendations, based on field conditions and in the absence of using a preliminary sample to calculate the needed sample size, are on the order of 15 to 20 points (for 60 to 80 trees). That is for a single statistic in a single plant community. See Bonham (1989). Ellenberg and Dombois (1974) recommended a minimum of 20 points. Not mentioned (Bonham 1989) is that this sample size is for estimating single statistics, without regard to multiple forest community types or estimating the statistic for individual species. A minimum of 3 points per plant community per transect (12 trees) is highly unlikely to ever be adequate for natural, moderate- to high-diversity plant communities.

The actual number of points per plant community (summed over all transects) sampled along the SMR were limited. In at least four of the plant communities, sample sizes were inadequate to estimate the percent occurrence or IVs of individual species, resulting in a lack of robustness that dilutes any statistical analysis that is reliant on the data.

The Panel concedes that if a suitable number of observations to characterize each species in each community were collected, PCQ sampling would be inefficient and expensive. The Panel is aware of other water management districts using PCQ sampling in MFL studies. However, sample size adequacy was evaluated and in at least one case an attempt at getting adequate sample size at a community level (a single statistic for an identified floodplain plant community) was difficult and time-consuming.

The Panel suggests the following minor updates to the SMR Minimum Flow Report:

- Verify that the identification of the species *Acer saccharum* (sugar maple) is correct. We suspect a good identification because sugar maple is highly recognizable. However, it is the first entry in Table 7 Appendix C, where it is called OBL (wetland obligate) and it is discussed as an obligate in the text. In fact, the Florida Department of Environmental Protection (FDEP) does not list *Acer saccharum* as a wetland species (F.A.C. 62-340.450, effective July 1, 1994). The species listed in 62-340.450 F.A.C as an obligate is *Acer saccharinum*, the silver maple. It is possible that *Acer saccharinum* was the species actually present, or that both *A. saccharum* and *A. saccharinum* could be present. If both are present, we suspect they would be in hydrologically different parts of the floodplain.
- Verify the identification of the species *Fraxinus profunda*. It is reported to be very abundant in the sampled communities. According to ash experts, and in recent studies of the distribution of *Fraxinus profunda*, it was considered to be extinct in Florida and rare throughout its range and reported by the International Union for Conservation of Nature (IUCN) as likely to be extinct in Florida (Westwood et al. 2017). It is difficult to distinguish from *Fraxinus pensylvanica* (green ash) (Nesom 2010), which occurs frequently in floodplain plant communities from central Florida to southern Canada. The ecology of these two species is notably different, with *F. profunda* typically being found in wetter sites than *F. pensylvanica*. The sites where *F. profunda* is being reported in this study appear to be predominantly short hydroperiod sites, especially the ash swamp, whose elevation approximates that of the nearest upland. The Panel also has no way to verify if pop ash (*F. caroliniana*) was correctly identified, especially in the ash

swamp, but it is generally associated with long hydroperiods and often deep water.

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 Environmental Fluid Dynamics Code (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.

3 Technical Assumptions

Assumptions Are Clearly Stated, Reasonable, and Consistent With the Best Available Information
Assumptions Were Eliminated to the Extent Possible, Based on Available Information

3.1 Introduction

The Panel generally supports the technical assumptions used to develop the minimum flow for the SMR River Rise and Spring Run. 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 updates of the minimum flow.

3.2 Supporting Data and Information

The Panel was instructed to assume that the supporting data and information used were properly collected, and that reasonable quality assurance assessments were performed. The Panel concludes that this assumption is generally valid with some exceptions as detailed in Section 2.

3.3 Fifteen Percent Impact Threshold for Significant Harm

The goal of an MFL determination is to protect the aquatic resources from significant harm due to water withdrawals, broadly defined as the limit at which further withdrawals would be significantly harmful to the water resource or ecology of the area (F.S. §373.042; Munson et al. 2005). As noted by Beecher (1990), "it is difficult [in most statutes] to either ascertain legislative intent or determine if a proposed instream flow regime would satisfy the legislative purpose." The SMR Minimum Flow Report assumes that a 15 percent change is the threshold for defining significant harm. The Panel believes that the adoption of a 15 percent threshold value, as it relates to allowable habitat loss, and the presumption that this value will prevent significant harm, is not fully supported for all relevant WRVs based on the data presented in the SMR Minimum Flow Report. The Panel also recognizes that much of the biological and ecological data needed to develop quantified relationships between flow reductions and impacts on aquatic resources are generally not available. Many structural and functional components of flowing ecosystems vary continuously with flow and do not exhibit clear thresholds or break points (Holzwart et al. 2016), and the Panel believes this may be true for the SMR. Developing such quantitative relationships and ecological thresholds has been elusive in research on environmental flows generally.

Given the District's charge of establishing MFLs for the protection of priority water bodies and the necessity of using a measurable metric, the Panel agrees that the 15 percent reduction has precedent and has continuously been accepted in MFL reports and peer reviews in multiple water management districts in Florida (and thresholds in this percent of flow range close to 15 percent appear to be widely used nationally (Harwood et al. 2014, Richter et al. 2011). In summary, the Panel concludes that the use of a 15 percent threshold by the District for establishment of a minimum flow on the SMR River Rise and Spring Run is reasonable.

Recognizing the compelling need to arrive at a significant harm threshold, and in the absence of key supporting data, the Panel supports the District's choice to adopt an adaptive management approach allowing decisions based on limited data to be reinforced or modified as new research and monitoring information become available.

3.4 Habitat-Based Approach

The District applied a habitat-based approach to establishing minimum flows for the SMR under the assumption that protecting a wide range of habitats will protect the species known to inhabit the River Rise, 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.

3.5 Water Resource Values

The following is a discussion of the Panel's review of the District's assumptions relating to the priority water resource values used to develop the minimum flow

3.5.1 Recreation: Safe Boat Passage

Boat passage was assessed at five shoal transects under low-tide conditions, where shallow water depths were assumed to be most limiting to safe passage of small motorized boats. This assumption is reasonable and consistent with the best available information.

3.5.2 Fish and Wildlife Habitat: Wildlife

The District evaluated available data on wildlife use of the SMR floodplain concluding that the available data were incomplete. Correctly noting that wildlife is dependent on their habitats, the District decided to focus on those habitats based on the assumption that preventing significant harm to the habitats, namely the floodplain plant communities, would prevent significant harm to wildlife. The Panel agrees that this approach is practical, feasible, and appropriate.

3.6 Appendix B. Baseline Time Series

The Panel finds that the discussion of assumptions regarding statistical procedures in Appendix B are well documented, reasonable, and consistent with the best available information. Advantages and disadvantages of the model choices are presented well.

3.7 Appendix C. Floodplain Forest and Instream Woody Habitat Data Analysis

Given the assumption that vegetation is the best and most easily measured "integrator of environmental and landscape conditions" (Light et al. 1993, Bedford 1996), vegetation, soils, and elevations were used to provide information to establish minimum flows and protect the ecology and natural systems of these water bodies. This assumption is reasonable and consistent with the best available information.

3.8 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.

4 Procedures and Analyses

The Procedures and Analyses Were Appropriate and Reasonable, Based on the Best Available Information
The Procedures and Analyses Incorporate Appropriate Factors
The Procedures and Analyses Were Correctly Applied
Limitations and Imprecision in the Information Were Reasonably Handled
The Procedures and Analyses Were Repeatable
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 minimum flow for the SMR River Rise and Spring Run. 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 to maintain the selected WRVs, choice of a protection standard that represents prevention of significant harm, and synthesis of the critical flow metrics for the WRVs into a minimum flow. For the most part the procedures and analyses incorporated appropriate factors and were correctly applied, and, with some exceptions discussed herein, the documentation of limitations and imprecision in the information were reasonably handled and the procedures and analyses would be repeatable. 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 SMR Minimum Flow Report including suggestions for the near term for improving the quality of the current report and appendices and future updates of the minimum flow.

4.2 Conceptual Approach

The District's conceptual approach to the minimum flow uses a reasonable set of WRVs; modeling of river flows, stages, and estuarine salinity levels; and synthesis of those data to evaluate flow metrics for the WRVs into recommended minimum flow based on the concept of allowable flow withdrawals. For the most part, analyses presented in the SMR Minimum Flow 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.

A central concept in the SMR Minimum Flow Report is that the minimum flow is for the establishment of the "spring flow component" of the water discharged from the River Rise based on allowable reductions in the spring flow component.

Spring flow component	=	Total flow from the River Rise	-	Swallet inflow (flow from Upper St. Marks River)

The minimum flow is therefore intended to be set for allowable reductions to the spring flow only. This concept and how analyses based on the total flow of the river are then related back to the spring flow component, should be more clearly described in this section.

4.3 Water Resource Values

The District determined that the three WRVs that were most appropriate for the establishment of minimum spring flows of the River Rise were: (1) recreation in and on the water, (2) fish and wildlife habitat and the passage of fish, and (3) estuarine resources. These WRVs were selected because they are most relevant to the River Rise spring run, have the potential to be affected by spring flow reductions, and have sufficient data for assessment.

4.3.1 Recreation in and on the Water

The District assessed recreation in and on the water in terms of activities such as boating, canoeing, and fishing, which occur from the River Rise to the confluence with the Wakulla River. The District considered metrics including water depths for safe boat passage (power boats and canoes/kayaks) and the safe use of boat launches. Each metric is described below. The Panel agrees with the use of recreation in and on the water, but has comments for future consideration of the metrics.

Access to the SMR Spring Run is limited to public ramps at Newport Landing (adjacent to U.S. Highway 98) and near the city of St. Marks. Boats going upstream must navigate several shoals and the shoals were considered to be obstacles to small boat passage during periods of low water.

The Panel is familiar with the use of the minimum safe boating passage depth over a certain width of the river, which can be a percentage of the channel width or an absolute width. The SMR Minimum Flow Report uses a minimum depth of 3 feet across a continuous 30-foot channel width. The Panel has not seen this depth and width combination used before in other minimum flows but has seen a minimum 2-foot depth across a continuous 30-foot channel width used (Amec Foster Wheeler 2016). The District may wish to include a rationale for its more stringent minimum boat passage criteria.

The metric used for safe boat launching was the critical water depth of at least 3 feet at the toe of the St. Marks public boat ramp. Tidal fluctuation ranges drove the analysis at the Newport Landing boat launch. The Panel did a cursory check of literature supporting standards for minimum depths for construction and operation of boat ramps and found 3 feet to be typical and the range of 2 to 4 feet common based on ramp uses. The District may wish to provide a defensible rationale for its selection of 3 feet and include it in the SMR Minimum Flow Report. Finally, boat ramps are built structures and can be changed, so the Panel wonders if the depth of a constructed ramp should be used as a flow metric when the toe of the ramp can be changed. This is in contrast to the natural shoals in the river. Because the safe boat launching metric did not become part of the basis of the recommended minimum flows (Table 5-1), this point may be moot.

4.3.2 Fish and Wildlife Habitat and Passage of Fish

Floodplain Plant Community Characterization

The Panel believes that the study approach, methods, data analyses, and data sources used by the District in the floodplain characterization studies were generally scientifically reasonable and based on the best available data.

Appendix C of the SMR Minimum Flow Report, "MFLs for Sally Ward, Wakulla, and St. Marks River Rise Springs Systems for the Northwest Florida Water Management District: Floodplain Forest and Instream Woody Habitat Data Analysis," summarizes floodplain forest data collection, which involved identification of ecological community data based on overstory vegetation and soils along nine river floodplain transects.

The methods for conducting the Floodplain Plant Community Characterization were described as follows: To establish the basis for protection of floodplain habitats and communities, the District completed a study that included fieldwork to characterize the SMR floodplain communities and analysis to determine an allowable 15 percent change in the duration of inundation. The SMR floodplain was examined using a light detecting and ranging (LiDAR)-derived digital elevation model of the floodplain, field studies contracted by the District to support the minimum flow studies including surveys of ground elevations along transects, a HEC-RAS hydraulic simulation model (Appendix A), and a study of floodplain plant communities (Appendix C).

The Panel believes that the general approach is appropriate and similar in concept to approaches that have been used by other water management districts for minimum flow establishment. The Panel has, however, identified several issues in the specific data collection and analyses that should be addressed to ensure that the data collection, analyses, and report are defensible and consistent with known and well documented aspects of floodplain ecology.

Floodplain Hydrology

The assessment of hydrological conditions for the SMR (Appendix B, Development of Baseline Time Series for the SMR Rise Minimum Flows) concluded that there has been no recent measurable shift from historical conditions. That is, the baseline hydrological condition for the SMR is consistent with presumed historical conditions and current conditions. Because plant communities are found in settings where the environmental conditions (e.g., hydrology, elevation, soils) are consistent with the requirements of the species that compose them (Kozlowski 2002), it is appropriate to assume that the plant communities along the SMR should consist of species that can survive in the hydrological conditions found along the river.

The HEC-RAS model (Appendix A) development and parameterization identified three major components to wetland hydrology along the SMR: (1) flows from the River Rise for which a minimum flow is to be set, (2) flows from seepage (ungauged inflow) along the river, and (3) tidal effects, which have the effect of adding a daily water level fluctuation to the lower SMR. Effects of major coastal storms were not evaluated, but the data presented in the baseline study (Appendix B) suggest that they may exist and may at least briefly affect floodplain inundation in much of the river. The Panel believes that major aspects of floodplain hydrology important to floodplain forest ecology were evaluated and that the results are appropriate for use in setting the SMR minimum flow.

What species occur in floodplain forests are also affected by current and past land uses. In a setting like the floodplains along the SMR, past logging and land uses in adjacent uplands likely have an effect on the species composition and importance of individual species in extant plant communities. The floodplain studies focused on plant communities and attempted to relate those to flows in a series of statistical analyses critiqued below.

The Panel agrees that PCQ sampling can be used for this purpose. However, deficiencies were identified in the sample size, which were explained previously in Section 2.

The Panel suggests that the use of the Wilcoxon Signed Rank test be dropped. Based on the statistics that were provided from R, it appears to have been from a form of the Wilcoxon Signed Rank test. Appropriate repeated measures on the same “two data samples are matched if they come from repeated observations of the same subject.” The observations appear to come from independent samples, which would imply a Mann-Whitney test as appropriate (sometimes called a Wilcoxon Signed Rank test for independent samples, which has a different R printout than the one used in the report). The test would be likely to report significant differences due to historical timbering and current land management and not necessarily differences in the importance of species in the plant communities. Appropriate analyses to address differences in plant community structure would be multivariate. Other studies of this type use various forms of “ordination” or “clustering.”

The Panel also has concerns about the discriminant analysis resulting from the inadequacy of the IVs data and suggested omission or reclassification of some of the data points based on the Wilcoxon Signed Rank test. Discriminant analysis with more justifiable IVs data would be appropriate but is not necessary for characterizing the floodplain communities.

The Panel does not believe that an extensive sampling of the floodplain communities is needed. Nor are Wilcoxon Signed Rank and Discriminant Analysis necessary. The Panel suggests removing any statistics that rely upon other statistics, and simply retaining the descriptive tables. The floodplain elevations associated with these communities are also not dependent on the statistical analyses.

The Panel recommends conducting additional floodplain forest composition assessments as part of future MFL studies, but we recommend simplification and using methods where larger samples can be gathered more quickly. We also recommend focusing on species rooted at ground level. Plants rooted on hummocks and stumps experience a different hydrological regime that has less flooding than the regime experienced by plants rooted at ground level, and can confuse interpretation of the species composition relative to hydrology.

The District might consider prism sampling, which is a forestry sampling technique used for rapidly tallying trees and estimating basal area. This is a plotless sampling technique where an observer stands at a selected location holding a prism at arms length looking to see if the prism "splits" the tree versus shifting the tree to be completely disjunct. Measuring distances to trees is not needed and measuring diameter of trees that are "in" the plot is recommended (Avery, et. al., 2002).

Hydrological Assessment of the Floodplain

The floodplain inundation evaluation was based on a primary assumption: 15 percent reduction in the time that the SMR meets or exceeds the mean elevations of the floodplain plant communities will result in a no-greater-than 15 percent impact on the associated functions that are supported by the river achieving those elevations. The specific approach used was based on the evaluation of each plant community at the most restrictive location.

This approach is based on some critical conditions, which may or may not have been met. The primary conditions are as follows:

1. The floodplain plant communities have been adequately mapped
2. River water reliably reaches the plant communities
3. Average elevations have been adequately determined
4. Lateral inflows are adequately addressed
5. The determination of inundation frequency was done correctly

Each of these conditions is explained in detail below.

Condition 1: The Floodplain Plant Communities Have Been Adequately Mapped

With the caveats discussed above, we believe this to be mostly true. The Panel has concerns about the "ash swamp" given that its elevation approximates that of the lowest uplands and there is a distinct possibility of misidentification of some of the ash trees. The site description suggests that this plant community may be on an alluvial or geological feature. If it is indeed characterized by *Fraxinus pensylvanica*, a species strongly associated with disturbance and not inundation (the regional National Wetlands Inventory [NWI] classification is FAC, meaning it is anticipated to occur in both uplands and wetlands), what may be critical to this plant community is not reduction in the number of days of inundation, but rather that flood flows continue to occur at frequencies and durations adequate to maintain adequate particle deposition to the substrate. Major floods on many rivers have been shown not to be significantly affected by water withdrawals from nearby wells, but rather on major rainfall events that tend to cause downstream flooding irrespective of water withdrawals. If this is the case, then it would be appropriate not to include the ash swamp (Transect 43000.4) as a limiting WRV.

Condition 2: Water Reliably Reaches the Plant Community

Based on the floodplain profiles, this appears to be generally true, and currently data are not available to evaluate this condition. Several transects show what may be natural levees near the channel, which could act as dams at some water levels, preventing river water from reaching the swamps farther from the river until the river tops the levee. The effects can be substantial and complex (Adams et al. 2004). What appears to be a major levee with upland vegetation was mapped on SM3 (east bank), and minor raised features appear along SM1 (west bank), SM4, SM8, and SM11. Many such levees have natural breaks that allow water to readily reach the swamps, but these were not assessed. When river water levels drop, the levees can increase the period of inundation. If the levees do not extend from one HEC-RAS transect to another, this would be evidence that the levees are discontinuous and alleviate any concerns. From a wildlife perspective, the extent of the time the floodplain wetlands are connected by water to the river can be very important because it affects movement of some species (fish, insect larvae, etc.) between the river and the floodplain swamps (Munson 2008).

Given the profiles available to the Panel, we suspect that water reliably reaches all parts of the floodplain, but when the minimum flow is updated in the future, the Panel recommends there be an assessment of levee features to evaluate the condition.

Condition 3: Average Elevations Have Been Adequately Determined

The Panel notes that depressions are shown on some of the profiles. Because there were no sample points within these, there is no way to know if they are depressions within a consistent plant community, depressions not occupied by the same plant community, or side channels. For example, in SM4 a depression with multiple survey points appears to be about 5 feet deep. If not already done, it would be appropriate to eliminate the elevations associated with the depression because it does not appear to represent characteristic elevation variation for the hardwood hammock plant community. When the minimum flow is updated in the future, we suggest that there be some evaluation of each point to determine if it should be included in the elevation computation.

Condition 4: Lateral Inflows Are Adequately Addressed by the HEC-RAS Model

Lateral ungauged flows along the River Rise spring run between the River Rise and the city of St. Marks were estimated by subtracting St. Marks River flux measurements (acoustic Doppler current profiler [ADCP]) taken near the city of St. Marks (Transect 3011.35) on August 25, 2017, from flow at the St. Marks River near Newport station, resulting in an estimated total lateral inflow of 127 cubic feet per second (cfs).

To the extent that the floodplain communities are dependent on actual flooding from the river, these are addressed by the HEC-RAS modeling. However, the importance of lateral inflow in the form of seepage to the floodplain communities, especially the floodplain forest communities, was not addressed. This seepage could easily result in the hardwood hammock and tupelo-hardwood mix communities having a greater upward extent than would be likely based on river inundation alone and/or having longer periods of saturation than assumed by the modeling. It would also suggest that the communities could be impacted by water withdrawals near the river, independent of flows at the River Rise.

Given that the current hydrology and baseline condition appear to be the same, and an absence of data from which to assess the lateral flows, especially seepage, the existing analysis appears to be based on best available data.

To improve future minimum flow updates, the Panel suggests that the District install at least one series of relatively shallow monitoring wells along a transect from the uplands to the river edge and monitor it over drought and high rainfall periods to better determine the importance of inflows to the plant communities.

Condition 5: The Determination of Inundation Duration Was Done Correctly

The Panel believes that the computations of characteristic inundation duration were done correctly, and that the methodology is generally appropriate to the purpose. It is also in an area where there is little to no tidal influence. The ironwood hammock and hardwood hammock and tupelo bay plant communities are generally in areas where they would likely receive more water from lateral seepage. The hardwood tupelo and tupelo bay communities are in more downstream areas where they would have less reliance on stream flows and more reliance on tidal influences. The ash swamp community appears to occupy an alluvial feature at one of the shoals and it probably relies primarily on rare floods to replenish the substrate rather than on reliable hydration from the stream.

Frequency That Water Levels Met or Exceeded the Mean Elevation

The Panel notes that the frequency of time water levels met or exceeded the mean elevation (North American Vertical Datum of 1988 [NAVD88]) of dead woody debris, live roots along the channel edge, and each floodplain community type (ash swamp, cypress hardwood mix, hardwood hammock, ironwood hammock, tupelo bay swamp, and tupelo hardwood swamp) were used as metrics for the fish and wildlife habitat and passage of fish WRVs. The rationale for using mean elevation (versus minimum, maximum, or other statistic) is not provided. If this is a practice from other MFL studies, it would be helpful for this to be mentioned and the rationale to be provided.

Implications of Submerged Aquatic Vegetation

An important characteristic of the SMR is its dense and pervasive coverage by submerged aquatic vegetation (SAV). In areas of the SMR, SAV and some nuisance exotic species are so extensive that typical instream flow habitat methods (i.e., fish and invertebrate habitat modeling using PHASBIM or SEFA) could not be used. The SMR Minimum Flow Report states that “Less information is available concerning the submerged and emergent aquatic vegetation communities of the St. Marks River” and “In recent years, the amount of submerged aquatic vegetation has been reported to be increasing in and downstream of the River Rise spring pool (USGS personal communication). Currently, vegetation covers much of the spring pool (Figure 1-20).” The Panel is curious if the District believes the potential exists for SAV to interact with flows and water quality to reach nuisance levels and impair other WRVs such as water quality, recreation, aesthetics, or aquatic habitat. The Panel recommends that this situation be explicitly discussed and monitored and addressed in future refinements of the SMR minimum flow.

4.3.3 Estuarine Resources

Appendix D of the SMR Minimum Flow Report explains the development and application of the EFDC model of the SMR, particularly the downstream tidally influenced freshwater and estuarine reaches of the SMR and Wakulla 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.

4.4 Adaptive Management

In two places in the SMR Minimum Flow Report the District invokes adaptive management, stating that implementation of the minimum flow will follow 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 SMR Minimum Flow Report as to what this means in terms of areas of uncertainty in the SMR minimum flow analysis, thresholds that may drive the reconsideration of the minimum flow, and any data needs or gaps identified in this review or the District’s own review.

4.5 Appendix A. HEC-RAS Modeling

The following is the Panel’s evaluation of the application of the HEC-RAS model for the development of a minimum flow for the SMR.

4.5.1 Introduction

The HEC-RAS model development portions of the report, titled “Construction, Refinement and Calibration of the Hydrologic Engineering Centers River Analysis System (HEC-RAS) Model and MFL Analysis” (Applied Technology and Management [ATM] 2018) (Chapters 1–10) use a HEC-RAS model, a well-accepted and broadly used tool for modeling water flowing through systems of open channels and computing water surface profiles. Generally, the model seems to have been appropriately applied in the context of simulating flows and river stage for the SMR. The significant shortcomings of the report are its lack of documentation for model calibration and predictive accuracy, performance of model validation, and lack of support for many assumptions and changes made to the model. The lack of these critical elements of documentation makes it difficult for the Panel to confirm the quality and likely range of predictive accuracy of the model’s estimates of water surface elevations over the range of flows simulated.

It may be that the shortcomings of the report are easily rectified by addressing the above points and adding the necessary descriptions and basis for assumptions and modifications of the model and providing the necessary calibration and verification data in appendices. What is unclear is whether the data are available for model validation; this would require a data set that was not used in the calibration to provide an independent test of the model predictive ability. This may be particularly important for the upper river, where unvalidated adjustments were made to the model.

Like any model, a HEC-RAS model is subject to uncertainties associated with model inputs, assumptions, parametrizations, and extrapolations. The Panel believes that the ATM (2018) report should be revised to explicitly address the issues above and the relevance of model performance to the MFLs established using it, as well as any uncertainty that may be inherent in their use, and any improvements that could be made.

4.5.2 Review of HEC-RAS Modeling Report

The ATM (2018) Report documents the construction, refinement, and calibration of a HEC-RAS model of the St. Marks and Wakulla rivers, and the model's use to support minimum flows development for the SMR. The report indicates that two separate, existing HEC-RAS models developed for the Federal Emergency Management Agency (FEMA) for floodplain assessments for the Wakulla and St. Marks rivers were combined and lists additional geometry modifications that were made to the combined model. The ATM report also describes the input flow files, model calibration, and conversion of the unsteady-flow (transient) HEC-RAS model to a steady-state HEC-RAS model, and provides scenario runs of the steady-state HEC-RAS model to support the development of minimum flows for the SMR.

Chapter 11 of the report includes the supporting analysis for minimum flow development. This chapter provides the evaluation of two WRVs and their associated metrics:

- WRV1 Recreation in and on the Water
- WRV2 Fish and Wildlife Habitat - Fish Passage
- WRV2 Fish and Wildlife Habitat - Manatee Passage
- WRV2 Fish and Wildlife Habitat - Floodplain Habitat Inundation
- WRV2 Fish and Wildlife Habitat - Instream Woody Habitat

The chapter does not provide a rationale for the WRV metrics used but does state that the WRV metrics detailed in this chapter were evaluated following numerous discussions between ATM and District staff.

Regarding the HEC-RAS modeling portion of the report, the model appears to have been appropriately applied in this case and used in the context of simulating flows and river stage for the SMR. The procedures used to apply the HEC-RAS model were generally appropriate.

A significant weakness of the ATM report is its lack of appropriate documentation for model calibration and predictive accuracy, performance of model validation, and lack of support for many assumptions and changes made to the model. The lack of these critical elements of documentation makes it difficult for a reviewer to confirm the quality and likely range of predictive accuracy of the model's estimates of water surface elevations over the range of flows simulated. This would also make it difficult for the procedures and analyses to be independently repeatable without further documentation because many modifications of the model were described generally but not documented. Based on a qualitative evaluation of the ATM model simulations and accuracy using the limited documentation provided, it does *appear* that the model *may* be performing well for certain flow ranges, but without the necessary documentation, a firm judgment simply cannot be made. It may be that the necessary modeling documentation is available, and this significant report weakness could be relatively easily rectified. The following points address the more significant issues:

- The ATM report generally does not provide quantitative evidence of data checking/validation and model predictive capability. Statements made in the report such as "…sufficient job of describing river geometry…", "…were improved...", "…had been verified as most reliable…", "…model performed quite well…", and "…does a very good job of predicting…" are essentially unsupported assertions that a reviewer cannot check without the supporting data or evidence. Therefore, the quality of the predictive simulations remains unclear.
- The HEC-RAS model appears to have been parameterized and calibrated, but no quantitative data on calibration and model predictive performance results were provided. Very little documentation of model parameterization was provided. Typically, modeling reports contain considerable appendices dedicated to providing the documentation necessary for reviewers to assess the model calibration, validation, and changes to the model to achieve satisfactory performance. The report cites several electronic file names where certain model boundary conditions, time series, and inputs are stored, but these were not provided.
- The HEC-RAS model performance does not appear to have been validated with an independent data set; model validation is an important and standard practice in modeling. Model validation provides an assessment of the model's ability to accurately reproduce known results, generally by simulating different flow conditions and reaches from those used in model calibration. This may well be possible with the data described in the report as being available but does not appear to have been done.
- No assessment of the model performance and applicability was completed for the two underlying FEMA models, one from the Wakulla River and one from the SMR. These two HEC-RAS models were merged into one model to create the ATM (2018) HEC-RAS model. The extent of documentation of the two underlying HEC-RAS models is limited to the statement that "Both models were found to have been

appropriately configured." This is inadequate. No reports on the development and testing of the underlying FEMA models were provided, and no citations were included.

- No rationale is provided for why certain model development and calibration choices were made, or for why model calibration for the non-tidal portion of the river was limited to the location near the Newport gage, especially given that much of the SMR is well upstream and outside of the primary areas of tidal influence. Support for the model calibration approach on page 9, "Model calibration by means of unsteady-state forcing," is suitable for both steady- and unsteady-state scenario analysis but is not supported in the description or by literature citation.
- The calibration of the model using the unsteady-flow approach was performed with a very limited period of record: May 13 through July 20, 2017 (page 9). This flow range corresponds to river stages at USGS gauge 02326900 (very near the River Rise) from about 9.3 to 10.9 feet NAVD88, or about a 1.6-foot stage range (ATM, Figure 18e), and about 80 percent of the simulated stages in the calibration were within 0.8 foot of stage (NAVD88). The ATM report does not provide the corresponding range of flows that this represents (though it should have), but reference to the USGS data online for 02326900 shows that the flow range was approximately 400 to 800 cfs. Flows at this gauge are frequently higher than this range and sometimes but less frequently lower than this range. Based on this range of calibration flows, the ATM report provides steady-state river stage predictions for a much broader range of flows/stages, ranging from 8.6 to 13.01 feet NAVD88, a range of about 4 feet. The ATM report provides no assessment of the predictive accuracy of the model for this broader range of river flows/stages.
- Section 8.1, Steady-State Model Development, provides a very brief description of how the unsteady-flow HEC-RAS model (calibrated to the May 12 through July 20, 2017, period) was translated into a steady-state model. This section was not entirely clear and left much undescribed and not justified. No source, description, or justification is provided as to how the flows were developed in Table 5 (page 36), which are important upstream boundary conditions for the steady-state model runs.
- Calibration of the model was apparently problematic in particular areas and typical procedures for calibrating a HEC-RAS model by adjusting n-values was not adequate to produce a model that matched the observed river stage values, indicating an issue with the model geometry in the upper reach of the model (page 27). The model was calibrated by considerably increasing Manning's n value (to potentially unreasonable values) and by the addition to the model of a "hypothesized" channel obstruction of 5.35 feet height. While these modifications "…greatly improved the model predictions," they were not validated in the field though a survey. The authors did recommend that an additional survey be performed of this part of the river to better define the river geometry, for incorporation into the HEC-RAS model as a model refinement. However, the authors

were silent on the issue of how these model adjustments potentially affected model stage predictions for flow outside of the range of the calibration flow. Stated another way, while these model adjustments improved model performance in one flow range, it is unclear if they improved or degraded stage predictions outside of that range.

- The graphics in the ATM report are poorly developed and often not legible. The report lacks a clear map showing the rivers, USGS gauges, monitoring sites (HD-1, HD-2), shoal locations, and transect locations. This was compounded by poor labeling of graphics as to whether they are for the Wakulla River or SMR.

4.6 **Appendix B. Baseline Time Series**

The SMR Minimum Flow Report states that a baseline period during which evidence of impacts of groundwater levels are absent or not discernible in the spring flow time series is needed for minimum flow determination. The development of an unimpacted baseline flow record for the River Rise is described in Appendix B (Janicki Environmental 2018). Multiple analyses were performed to assess changes in the spring flow time series that could be indicative of groundwater withdrawals or climatic impacts. Analyses included examination and identification of trends in rainfall, evapotranspiration, river flows, baseflow, spring flow, and groundwater levels; comparisons of spring flow and rainfall statistics among multiple time periods; review of water budgets; double mass curve analysis; and analysis of rainfall residuals. A more detailed review of this work by the Panel is provided later in this section.

The Panel reviewed the report titled “Wakulla Spring, Sally Ward Spring, and St. Marks River Rise Minimum Flows and Levels, Preliminary Conceptual Groundwater Model (Interflow Engineering 2015). The report concludes that the primary anthropogenic stressors on the River Rise are pumping and irrigation. These components are a relatively small portion of the water budget for the River Rise groundwater contribution area. Appendix B concludes that there is no evidence of persistent groundwater withdrawal impacts on the flow at the River Rise. In addition, the baseline is not affected by climatic impacts (short- or long-term reductions or increases in rainfall) because analysis of the rainfall data from 1990 to present showed no evidence of trends. The Panel agrees with this analysis and concludes that the baseline time series analysis of flow at the River Rise in Appendix B and the supporting report (Interflow Engineering 2015) were appropriate and reasonable and based on the best information available, all necessary factors were incorporated and correctly applied, and the conclusions were supported by the data.

4.7 **Trend Tests of Data to Be Used for Spring Flow Time Series Development**

The Panel finds that the use of the non-parametric Seasonal Kendall test (SKT) for trends is appropriate for flow data, which tend to be non-normal. And the use of the correlogram to examine auto-correlation is appropriate. The use of median values rather than means is also reasonable and consistent with other trend analyses in flow data.

4.7.1 Flows

The SMR Newport gauge was the only station with sufficient record to analyze trends, although no trends were indicated and serial correlation was observable for up to 6 months. The Panel notes that this is encouraging because this gauge necessarily has captured any change in the upstream conditions measured at SMR Swallet near Woodville. The long-term average of the Newport gauge is 690 cfs and, by the District's estimate, the long-term average spring contribution is 452 cfs. The average of the SMR Swallet near Woodville has been observed to be 123 cfs during the short period of record but the long-term average has been calculated to be 238 cfs.

The District notes that the period of record (POR) for the Woodville gauge occurs over a relatively low flow period. During the period of overlap in the flow records of the Newport and Woodville gauges, high flows are not well represented in either record. Furthermore, the high flows at the Woodville gauge have not been accurately captured. The District has acknowledged this and is committed to improving the accuracy of the high flow data at the Woodville gauge. The Panel encourages the District to pursue its active management goal and revisit the relationship between the gauges when the overlapping periods of record better represent a wider range of flow conditions. Currently, these data appear to be the best available for the District to use for the development of the minimum flow.

4.7.2 Long-Term Time Series of Discharge at St. Marks River Rise

This section details the development of the long-term River Rise flow estimates, which are essentially the difference between the SMR Swallet gauge and Newport gauge. The difficulty is that the SMR Swallet gauge has a short flow record and thus a long-term record needed to be generated from relationships that were developed using a record that began in June 2015. The Panel notes that the District was open to many possible empirical models and provided lake, aquifer, and rainfall records in addition to the flow data. Statistical modeling strategies included:

- OLS regression
- GLS regression
- Nonparametric and nonlinear locally weighted regression (LOESS)
- ARIMA modeling

The data filling technique for the Woodville gauge time series (generation of the days of missing data within the POR for the Woodville gauge) was reasonable. The use of LOESS-predicted values is a valid means of filling the relatively brief periods of missing data (maximum of 8 days).

The relationship between the Woodville and Newport gauges is very strong ($R^2 = 0.97$ for simple linear regression). Additional covariates mentioned above were examined using ARIMA models (to account for the autocorrelation). In all, 48 additional variables were tested (mostly lags) and only 2 were found to add any explanatory power. This resulted in three final candidates for modeling flow at the Woodville gauge: a LOESS model using only Newport flow, a univariate ARIMA using only Woodville flow, and an ARIMA with covariant (first two then one). The discussion presented in Appendix B regarding the advantages and disadvantages of each is well written and accurate.

The Panel concludes that the statistical approach in Appendix B to develop a long-term flow record for the Woodville gauge was technically sound and well documented. Various models were tested and the District in consultation with the consultant was reasonable when selecting the LOESS model. The advantages of data parsimony, the creation of the longer record, and the fact that the LOESS model did not yield negative flows were reasonable considerations. The Panel encourages the District to revisit the creation of the historical Woodville flow record in the future when the actual POR is longer and additional higher-flow observations exist.

4.8 Flow Record Subset Selection

Appendix B, Section 6 describes the selection of a subset of the unimpacted River Rise flow record to be used in the modeling evaluation. This is reasonable considering the computational complexity that would be necessary to utilize the entire flow period. Further, the boundary conditions were derived from the Gulf Coastal Shelf Model, which covered only the period from 1995 to 2002. The comparison of the distribution of baseline daily flows and various segments of the shorter period for which the Gulf Coast Shelf Model output exists resulted in the selection of May 1, 1997, to May 31, 1999. While not all possible alternatives are provided in the report (this could be voluminous) the hydrographs of the selected period and the POR show strong similarity, especially between the 5 and 95 percent exceedances.

The Panel has noted in Section 4.5.2 that in the HEC-RAS model the limited POR was used for calibration of the model. It was then used for a broader range of flows without validation and subsequently used to create the steady-state HEC-RAS stage-discharge relationships for the full range of flow observed over the entire POR. While all of these differences are discernible to the careful observer, the Panel recommends that the difference in records being used in the models be emphasized for clarity in the SMR Minimum Flow Report. The Panel’s recommendation concerning the lack of validation and discussion of the uncertainty associated with its absence is provided in Section 4.4.2 of this report.

4.9 Flow Seasonality and Return Intervals of High and Low Flows

The District’s approach to establishment of a minimum flow for the SMR does not explicitly address seasonality. Nor does it address return intervals or lengths of specific events needed to maintain the river and floodplain structure and the habitat values that those provide. As shown in the flow graphs, major flood and low flow events do not occur on an annual basis. It is well established in the literature that seasonality of flow events and return intervals for floods of specific magnitudes are important to maintenance of the floodplain communities.

For future updates of the minimum flow, the District should consider adding some event-based analyses. For reference, the St. Johns River Water Management District (SJRWMD) has used an event-based concept that considers the importance of both return intervals and durations of flows (typical, low, and high) to be important (Neubauer et al. 2008). This concept can be difficult to implement, especially when hydrological data are unavailable. The concept, however, points out the importance of seasonality and flood events to the maintenance of the floodplain plant communities, especially in relation to forest regeneration and maintenance of the upland/wetland boundary.

4.10 Appendix D: Part A: Hydrodynamic Model Development and Calibration in Support of St. Marks River Rise MFL Evaluation and Part B: Hydrodynamic Model Evaluation of Minimum Flow Scenarios for the St. Marks River Rise

The following is a review of (1) the development and application of the hydrodynamic model based on the EFDC model for the downstream tidally influenced freshwater and estuarine reaches of the SMR and Wakulla River (Janicki 2018a) and (2) the use of the SMR and Wakulla River hydrodynamic model to examine the potential effects of reduced spring flow scenarios on metrics assumed to affect estuarine communities (Janicki 2018b). The results were analyzed to determine the allowable withdrawals that would be protective of the estuarine resources WRV.

The models, methods, and impact analysis approaches used in the two hydrodynamic model reports were scientifically reasonable, effectively used the best available data, and have been used before in similar ways to support development of minimum flows for other Florida riverine/estuarine systems. The model calibration, testing, and sensitivity analysis were clear and well documented. The EFDC 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) habitat as the WRV metric. The Panel commends the District for developing the hydrodynamic model of the lower SMR and Wakulla River and collecting the necessary supporting data to provide the analyses needed now and in the future. The following are a few points of clarification and general comments on these reports that should increase their clarity and defensibility.

The metrics used in the analysis as indicators of the estuarine resources WRV were volume, bottom surface area, and shoreline length of waters less than 0.5 part per thousand (ppt), 1 ppt, 2 ppt, 3 ppt, and 4 ppt salinity within the SMR spring run, which extends from the confluence of the Wakulla and St. Marks rivers upstream to the River Rise. The Panel agrees with the importance of low-salinity (oligohaline) habitat and using it as a metric for the estuarine resources WRV, but also believes that a stronger biological/ecological linkage can and should be made in the Janicki reports and/or the SMR Minimum Flow Report between the low-salinity dependent habitats and the results of the hydrodynamic simulations. For example, the mapping of riverine wetlands as shown in Research Planning, Inc (RPI) (2016) Figure 5 and other resource mapping sources provided in the St. Marks River and Apalachee Bay SWIM Plan (District 2017) could be cited and the resources could be mapped together with the simulated salinity regime from the hydrodynamic model to increase understanding of the linkage of the low-salinity habitats with the estuarine resources being protected (freshwater marsh). Better linkage with the ecological importance of the species and habitats with freshwater dependence as discussed in Lewis et al. (2009) may be beneficial here as well. The District may also want to review the recent work of Celik (2016), which investigated plant communities and salinity regimes in a river also named the St. Marks that is located in the Apalachicola River watershed.

The Panel notes that the reduction in WRV metrics within the spring run (confluence upstream to the U.S. Highway 98 bridge) for a 30 percent spring flow reduction never reaches 15 percent, indicating that estuarine resource metrics are relatively insensitive to reductions in flow from the River Rise (Janicki 2018b, page 4-1). That is, none of the metrics associated with the estuarine resources WRV (volume, bottom surface area, and shoreline length of waters with less than 0.5 ppt, 1 ppt, 2 ppt, 3 ppt, and 4 ppt salinities) were determined to be reduced less than 15 percent with River Rise flow reductions of up to 30 percent (District 2018). The Panel is curious about this result, but neither of these reports attempts to explain this apparent insensitivity. This result may be due to the inherent characteristics of the SMR and SMR estuary, but that was not explored. The Panel suggests that the SMR Minimum Flow Report include some insights or explanation of the insensitive response of the low-salinity zone metrics to a 30 percent change in the spring flow component. It may be helpful to compare and contrast the results with what has been found in similar minimum flow studies in other Florida tidal rivers and estuaries cited by the District.

On page 52 of the District (2018) report, numerous studies are cited regarding other studies for Florida MFLs that use a similar approach that could be used for comparative purposes. Understanding the possible explanations for the lack of sensitivity of low-salinity zones in the SMR to reductions in flow from the River Rise would increase the confidence in the results and reduce uncertainty about the modeling results. In doing this, the District may wish to also review the results of Xiao (2014) on the effects of sea level rise on salinity intrusion in the St. Marks River Estuary, Florida, which included hydrodynamic modeling, assessment of the potential effects of sea level rise, and salinity intrusion.

Finally, Figure 2-2 showing average monthly salinities during 2016–17 seems to indicate unusually high average monthly salinities at Stations SM15 and SM16 during December 2016. Average salinities at these stations seem to be typically less than 1 ppt, but during December 2016 are at levels over 4 ppt salinity. The SMR Minimum Flow Report does not explain the reason for these atypically high salinities, but the Panel notes that based on USGS records for USGS gauge 02326900 St. Marks River Near Newport, December 2016 was a sustained period of relatively low flows, less than 400 cfs for most of the month. Has the District investigated this result and found an explanation? Does this result comport with the lack of sensitivity of the salinity regime with reductions in spring flow contribution?

5 Proposed Methods Used in the Minimum Flow Report That Are Not Scientifically Reasonable

Deficiencies: List and Describe Scientific Deficiencies and Proposed Remedies
Remedies: Determine if the Identified Deficiencies Can Be Remedied and Provide Suggested Remedies

5.1 Introduction

The following is a compilation of all deficiencies identified by the Panel and their specific remedies.

5.2 Supporting Data and Interpretation (Chapter 2)

Floodplain Plant Communities

Deficiency: Page 2-2, Section 2.2.2. Appendix C of the SMR Minimum Flow Report, "MFLs for Sally Ward, Wakulla, and St. Marks River Rise Springs Systems for the Northwest Florida Water Management District: Floodplain Forest and Instream Woody Habitat Data Analysis," summarizes floodplain forest data collection, which involved identification of ecological community data based on overstory vegetation and soils along 11 river floodplain transects.

The Panel questions the presumption that trees and soils should be the only indicators of floodplain plant communities. It is clear from the results of the tree sampling that there is considerable overlap in tree composition between the various identified wetland forest communities. Herbaceous plants and shrubs could have been, and likely were, informally used in identifying the plant communities.

Remedy: The Panel believes that recording those plants at a general level might have assisted in the identification of the plant communities. Despite the assumption that the trees integrate the communities better (Appendix C, p. 12), many herbaceous species and shrubs are long-lived and highly diagnostic of environmental conditions. While Appendix C-2 of the SMR Minimum Flow Report) has general photographs at each transect, the Panel suggests that in future MFL studies, a sampling plan that includes rigorous use of photography would provide a rapid and cost-effective way of sampling the entire plant community. For this purpose, we suggest that photographs be taken at surveyed locations, and at enough locations to show consistency within sampled communities and show contrasts between adjacent communities. Photographs could also document microhabitats and channels that are not consistent with the overall plant communities.

Deficiency: Page 2-2, Section 2.2.2 Issues with Point Center Quarter Sampling. The Panel agrees that PCQ sampling can be used for this purpose and that it is simple to apply. However, like all sampling methods, PCQ needs to meet basic sample size requirements. In this case, the sampling was used to create IVs for each species in each identified plant community. The computed IVs were then used as observations in other statistical analyses.

To use it this way, an adequate sample size would be needed for each species in each community, with an adequate number of points available for all or at least most species in all communities. The number of samples needed could have been estimated based on a preliminary survey, with a preliminary survey needed for each vegetation community. This was not done.

The environmental literature has numerous examples of PCQ sample sizes for different forested community types. Each was a single community, and the goal was to compute a single value (generally total basal area or tree density). The number of points needed varies, but recommendations, based on field conditions and in the absence of using a preliminary sample to calculate the needed sample size, are on the order of 15 to 20 points (for 60 to 80 trees). That is for a single statistic in a single plant community. See Bonham (1989). Ellenberg and Dombois (1974) recommended a minimum of 20 points. Not mentioned (Bonham 1989) is that this sample size is for estimating single statistics, without regard to multiple forest community types or estimating the statistic for individual species. A minimum of 3 points per plant community per transect (12 trees) is highly unlikely to ever be adequate for a natural, moderate- to high-diversity plant community.

The actual number of points per plant community (summed over all transects) along the St. Marks River was limited. A minimum of 3 points per plant community per transect (12 trees) is highly unlikely to ever be adequate for a natural, moderate- to high-diversity plant community. In at least four of the plant communities, sample sizes were inadequate to estimate the percent occurrence or IVs of individual species, resulting in a lack of robustness that dilutes any statistical analysis that is reliant on the data.

Remedy: The Panel concedes that if a suitable number of observations to characterize each species in each community were collected, PCQ sampling would be inefficient and expensive. The Panel is aware of other districts using PCQ sampling in MFL studies. However, sample size adequacy was evaluated and in at least one case an attempt at getting adequate sample size at a community level (a single statistic for an identified floodplain plant community) was difficult and time-consuming.

The Panel suggests minor updates to the SMR Minimum Flow Report:

- Verify that the identification of the species *Acer saccharum* (sugar maple) is correct. We suspect a good identification because sugar maple is highly recognizable. However, it is the first entry in Table 7 Appendix C, where it is called OBL (wetland obligate) and it is discussed as an obligate in the text. In fact, FDEP does not list *Acer saccharum* as a wetland species (62-340.450 F.A.C., effective July 1, 1994). The species listed in 62-340.450 F.A.C. as an obligate is *Acer saccharinum*, the silver maple. It is possible that *Acer saccharinum* was the species actually present, or that both *A. saccharum* and *A. saccharinum* could be present. If both are present, we suspect they would be in hydrologically different parts of the floodplain.

- Verify the identification of the species *Fraxinus profunda*. It is reported to be very abundant in the sampled communities. According to ash experts, and in recent studies of the distribution of *Fraxinus profunda*, it was considered to be extinct in Florida and rare throughout its range and reported by IUCN as likely to be extinct in Florida (Westwood et al. 2017). It is difficult to distinguish from *Fraxinus pensylvanica* (green ash) (Nesom 2010), which occurs frequently in floodplain plant communities from central Florida to southern Canada. The ecology of these two species is notably different, with *F. profunda* typically being found in wetter sites than *F. pensylvanica*. The sites where *F. profunda* is being reported in this study appear to be predominantly short hydroperiod sites, especially the ash swamp, whose elevation approximates that of the nearest upland. The Panel also has no way to verify if pop ash (*F. caroliniana*) was correctly identified, especially in the ash swamp, but it is generally associated with long hydroperiods and often deep water.

5.3 Technical Assumptions (Section 3)

The Panel did not identify deficiencies with any of the technical assumptions.

5.4 Procedures and Analyses (Section 4)

Deficiency: Page 4-2, Section 4.2. The SMR Minimum Flow Report is for the establishment of the “spring flow component” of the water discharged from the River Rise based on allowable reductions in the spring flow component. The minimum flow is therefore intended to be set for allowable reductions to the spring flow only.

Remedy: This concept and how analyses based on the total flow of the river are then related back to the spring flow component should be more clearly described in this section.

Deficiency: Page 4-2, Section 4.3.1. Recreation in and on the Water. The SMR Minimum Flow Report uses a minimum depth of 3 feet across a continuous 30-foot channel width. The Panel has not seen this depth and width combination but has recommended a minimum 2-foot depth across a continuous 30-foot channel width.

Remedy: The District may wish to include a rationale for its more stringent minimum boat passage criteria.

Deficiency: Page 4-2, Section 4.3.1. Recreation in and on the Water. The metric used for safe boat launching was the critical water depth of at least 3 feet at the toe of the St. Marks public boat ramp. Tidal fluctuation ranges drove the analysis at the Newport Landing boat launch. The Panel did a cursory check of literature supporting standards for minimum depths for construction and operation of boat ramps and found 3 feet to be typical and the range of 2 to 4 feet common based on ramp uses.

Remedy: The District may wish to provide a defensible rationale for its selection of 3 feet and include it in the SMR Minimum Flow Report.

Deficiency: Page 4-2, Section 4.3.1. Recreation in and on the Water. Boat ramps are built structures and can be changed. This is in contrast to the natural shoals in the river. The Panel wonders if the depth of a constructed ramp should be used as a flow metric when the toe of the ramp can be changed.

Remedy: Because the safe boat launching metric did not become part of the basis of the Recommended Minimum Flows (Table 5-1), this point may be moot.

Deficiency: Page 4-4, Section 4.3.2. Plant Communities and Floodplain Inundation. The floodplain studies focused on plant communities and attempted to relate those to flows in a series of statistical analyses critiqued below.

Remedy: The Panel suggests that the use of the Wilcoxon Signed Rank test be dropped. Based on the statistics that were provided from R, it appears to have been from a form of the Wilcoxon Signed Rank test. Appropriate repeated measures on the same two data samples are matched if they come from repeated observations of the same subject.

The observations appear to come from independent samples, which would imply a Mann-Whitney test (sometimes called a Wilcoxon Signed Rank test for independent samples, which has a different R printout than the one used in the report). The test would be likely to report significant differences due to historical timbering and current land management and not necessarily differences in the importance of species in the plant communities. Appropriate analyses to address differences in plant community structure would be multivariate. Other studies of this type use various forms of "ordination" or "clustering."

The Panel also has concerns about the discriminant analysis resulting from the inadequacy of the IV data and suggested omission or reclassification of some of the data points based on the Wilcoxon Signed Rank test. Discriminant analysis with more justifiable IV data would be appropriate, but is not necessary to characterizing the floodplain communities.

The Panel does not believe that an extensive sampling of the floodplain communities is needed. Nor are Wilcoxon Signed Rank and Discriminant Analysis necessary. The Panel suggests removing any statistics that rely upon other statistics, and simply retaining the descriptive tables. The floodplain elevations associated with these communities are also not dependent on the statistical analyses.

The Panel recommends conducting additional floodplain forest composition assessments in future MFL studies, but we recommend simplification and using methods where larger samples can be gathered more quickly. We also recommend focusing on species rooted at ground level. For example, the District might consider prism sampling, which is a forestry sampling technique used for rapidly tallying trees and estimating basal area. This is a plotless sampling technique in which an observer stands at a selected location holding a prism at arms length, looking to see if the prism "splits" the tree versus shifting the tree to be completely disjunct. Measuring distances to trees is not needed and measuring diameter of trees that are "in" the plot is recommended (Avery, et.al., 2002)

Deficiency: Page 4-5, Section 4.3.2.

The Floodplain Plant Communities Have Been Adequately Mapped

The Panel has concerns about the "ash swamp" given that its elevation approximates that of the lowest uplands and there is a distinct possibility of misidentification of some of the ash trees. The site description suggests that this plant community may be on an alluvial or geological feature. If it is indeed characterized by *Fraxinus pensylvanica*, a species strongly associated with disturbance and not inundation (the regional National Wetlands Inventory [NWI] classification is FAC, meaning it is anticipated to occur in both uplands and wetlands), what may be critical to this plant community is not reduction in the number of days of inundation, but rather that flood flows continue to occur at frequencies and durations adequate to maintain adequate particle deposition to the substrate.

Remedy: Major floods on many rivers have been shown not to be significantly affected by water withdrawals from nearby wells, but rather on major rainfall events that tend to cause downstream flooding irrespective of water withdrawals. If this is the case, then it would be appropriate not to include the ash swamp (Transect 43000.4) as a limiting WRV.

Deficiency: Page 4-5, Section 4.3.2

Water Reliably Reaches the Plant Community

Based on the floodplain profiles, this appears to be generally true, and currently data are not available to evaluate this condition. Several transects show what may be natural levees near the channel, which could act as dams at some water levels, preventing river water from reaching the swamps farther from the river until the river tops the levee. The effects can be substantial and complex (Adams et al. 2004). What appears to be a major levee with upland vegetation was mapped on SM3 (east bank), and minor raised features appear along SM1 (west bank), SM4, SM8, and SM11. Many such levees have natural breaks that allow water to readily reach the swamps, but these were not assessed. When river water levels drop, the levees can increase the period of inundation. If the levees do not extend from one HEC-RAS transect to another, this would be evidence that the levees are discontinuous and alleviate any concerns. From a wildlife perspective, the extent of the time the floodplain wetlands are connected by water to the river can be very important because it affects movement of some species (fish, insect larvae, etc.) between the river and the floodplain swamps (Munson 2008).

Remedy: Given the profiles available to the Panel, we suspect that water reliably reaches all parts of the floodplain, but when the minimum flow is updated in the future, the Panel recommends there be an assessment of levee features to evaluate the condition.

Deficiency: Page 4-6, Section 4.3.2.

Average Elevations Have Been Adequately Determined

The Panel notes that depressions are shown on some of the profiles. Because there were no sample points within these, there is no way to know if they are depressions within a consistent plant community, depressions not occupied by the same plant community, or side channels. For example, in SM4 a depression with multiple survey points appears to be about 5 feet deep.

Remedy: If not already done, it would be appropriate to eliminate the elevations associated with the depression because it does not appear to represent characteristic elevation variation for the hardwood hammock plant community. When the minimum flow is updated in the future, we suggest that there be some evaluation of each point to determine if it should be included in the elevation computation.

Deficiency: Page 4-6, Section 4.3.2.

Lateral Inflows Are Adequately Addressed by the HEC-RAS Model

Lateral ungauged flows along the River Rise spring run between the River Rise and the city of St. Marks were estimated by subtracting St. Marks River flux measurements (acoustic Doppler current profiler [ADCP]) taken near the city of St. Marks (Transect 3011.35) on August 25, 2017, from flow at the St. Marks River near Newport station, resulting in an estimated total lateral inflow of 127 cubic feet per second (cfs).

To the extent that the floodplain communities are dependent on actual flooding from the river, these are addressed by the HEC-RAS modeling. However, the importance of lateral inflow in the form of seepage to the floodplain communities, especially the floodplain forest communities, was not addressed. This seepage could easily result in the hardwood hammock and tupelo-hardwood mix communities having a greater upward extent than would be likely based on river inundation alone and/or having longer periods of saturation than assumed by the modeling. It would also suggest that the communities could be impacted by water withdrawals near the river, independent of flows at the River Rise.

Given that the current hydrology and baseline condition appear to be the same, and an absence of data from which to assess the lateral flows, especially seepage, the existing analysis appears to be based on best available data.

Remedy: To improve future minimum flow updates, the Panel suggests that the District install at least one series of relatively shallow monitoring wells along a transect from the uplands to the river edge and monitor it over drought and high rainfall periods to better determine the importance of inflows to the plant communities.

Deficiency: Page 4-7. Section 4.3.2. The Panel notes that the frequency of time water levels met or exceeded the mean elevation (NAVD88) of dead woody debris, live roots along the channel edge, and each floodplain community type (ash swamp, cypress hardwood mix, hardwood hammock, ironwood hammock, tupelo bay swamp, and tupelo hardwood swamp) were used as metrics for the fish and wildlife habitat and passage of fish WRVs. The rationale for using mean elevation (versus minimum, maximum, or other statistic) is not provided.

Remedy: If this is a practice from other MFL studies, it would be helpful for this to be mentioned and the rationale to be provided.

Deficiency: Page 4-7, Section 4.3.2. Fish/Wildlife Habitat & Passage of Fish. An important characteristic of the SMR is its dense and pervasive coverage by SAV. In areas of the SMR, SAV and some nuisance exotic species are so extensive that typical instream flow habitat methods (i.e., fish and invertebrate habitat modeling using PHASBIM or SEFA) could not be used. The SMR Minimum Flow Report states that "Less information is available concerning the submerged and emergent aquatic vegetation communities of the St. Marks River" and "In recent years, the amount of submerged aquatic vegetation has been reported to be increasing in and downstream of the River Rise spring pool (USGS personal communication). Currently, vegetation covers much of the spring pool (Figure 1-20)."

Remedy: The Panel is curious if the District believes that the potential exists for underwater aquatic vegetation to interact with flows and water quality to reach nuisance levels and impair other WRVs such as water quality, recreation, aesthetics, or aquatic habitat. The Panel recommends this situation should be explicitly discussed and monitored, and the possibility should be addressed in future refinements of the SMR Minimum Flow Report.

Deficiency: Page 4-8, Section 4.4. In two places in the SMR Minimum Flow Report the District invokes adaptive management, stating that implementation of the minimum flow will follow an adaptive management approach, with MFLs periodically reviewed and revised by the District as needed, to incorporate new data and information.

Remedy: The Panel agrees with and supports an adaptive management approach. However, the Panel suggests that more information be provided in the SMR Minimum Flow Report as to what this means in terms of areas of uncertainty in the SMR minimum flow analysis, thresholds that may drive the reconsideration of the minimum flow, and any data needs or gaps identified in this review or the District's own review.

Deficiency: Page 4-8, Section 4.5. HEC-RAS Model Application. Generally, the model seems to have been appropriately applied in this case to be used in the context of simulating flows and river stage for the St. Marks River and Spring Run. The significant shortcomings of the report are its lack of documentation for model calibration and predictive accuracy, performance of model validation, and lack of support for many assumptions and changes made to the model. The lack of these critical elements of documentation makes it difficult for a reviewer to confirm the quality and likely range of predictive accuracy of the model's estimates of water surface elevations over the range of flows simulated.

Remedy: It may be that the shortcomings of the ATM (2018) report are easily rectified by adding the necessary descriptions and basis for assumptions and modifications of the model, and providing the necessary calibration and verification data in appendices. What is unclear is whether the data are available for model validation; this would require a data set that was not used in the calibration to provide and independent test of the model predictive ability. This may be particularly important for the upper river, where unvalidated adjustments were made to the model.

Deficiency: Page 4-9, Section 4.5.2. HEC-RAS Model Application. A HEC-RAS model is subject to uncertainties associated with model inputs, assumptions, parameterizations, and extrapolations.

Remedy: The Panel believes that the ATM (2018) report should be revised to explicitly address the issues in the deficiency above and the relevance of model performance to the minimum flow established using it, as well as any uncertainty that may be inherent in their use, and any improvements that could be made. The steady-state river stage predictions are the basis for supporting analysis for minimum flow development for five WRVs metrics as described in Chapter 11 of the ATM (2018) report.

Deficiency: Page 4-13, Section 4.7.1. Flows. The St. Marks River Newport gauge was the only station with sufficient record to analyze trends, although no trends were indicated and serial correlation was observable for up to 6 months. The long-term average of the Newport gauge is 690 cfs and, by the District's estimate, the long-term average spring contribution is 452 cfs. The average of the St. Marks River Swallet near Woodville has been observed to be 123 cfs during the short period of record but the long-term average has been calculated to be 238 cfs. The POR for the Woodville gauge occurs over a relatively low flow period. During the period of overlap in the flow records of the Newport and Woodville gauges, high flows are not well represented in either record. Furthermore, the high flows at the Woodville gauge have not been accurately captured.

Remedy: The District should revisit the relationship between the gauges when the overlapping periods of record better represent a wider range of flow conditions.

Deficiency: Page 4-14, Section 4.7.2. The Panel concludes that the statistical approach in Appendix B to develop a long-term flow record for the Woodville gauge was rigorous. Various models were tested and the District, in consultation with the consultant, was reasonable when selecting the LOESS model. The advantages of data parsimony, the creation of the longer record, and the fact that the LOESS model did not yield negative flows were reasonable considerations. However, the short period of record and lack of high-flow observations is an issue.

Remedy: The District should revisit the re-creation of the historical Woodville flow record in the future when the actual POR is longer and more higher-flow observations exist.

Deficiency: Page 4-14, Section 4.8. Flow Record Subset Selection HEC-RAS Model Period of Record. The Panel has noted in Section 4.5.2 that in the HEC-RAS model the limited POR was used for calibration of the model. It was then used for a broader range of flows without validation and subsequently used to create the steady-state HEC-RAS stage-discharge relationships for the full range of flow observed over the entire POR. **Remedy**: The difference in flow records being used in the models should be emphasized for clarity in the SMR Minimum Flow Report.

Deficiency: Page 4-14, Section 4.9. Flow Seasonality and Return Levels of High and Low Flows. The District's approach to establishment of a minimum flow for the SMR does not explicitly address seasonality. Nor does it address return intervals or lengths of specific events needed to maintain the river and floodplain structure and the habitat values that those provide. As shown in the flow graphs, major flood and low flow events are not annual. It is well established in the literature that seasonality of flow events and return intervals for floods of specific magnitudes are important to maintenance of the floodplain communities.

Remedy: For future updates of the minimum flow, the District should consider adding some event-based analyses. For reference, SJRWMD has used an event-based concept that considers the importance of both return intervals and durations of flows (typical, low, and high) to be important (Neubauer et al. 2008). This concept can be difficult to implement, especially when hydrological data are unavailable. The concept, however, points out the importance of seasonality and flood events to the maintenance of the floodplain plant communities especially in relation to forest regeneration and maintenance of the upland/wetland boundary.

Deficiency: Page 4-15, Section 4.10. Appendix D. Hydrodynamic Modeling. The metrics used in the analysis as indicators of the estuarine resources WRV were volume, bottom surface area, and shoreline length of waters less than 0.5 ppt, 1 ppt, 2 ppt, 3 ppt, and 4 ppt salinity within the St. Marks spring run, which extends from the confluence of the Wakulla and St. Marks rivers upstream to the River Rise.

Remedy: The Panel agrees with the importance of low-salinity (oligohaline) habitat and using them as metrics for the estuarine resources WRV, but also believes that a stronger biological/ecological linkage can and should be made in the Janicki reports and/or the SMR Minimum Flow Report between the low-salinity dependent habitats and the results of the hydrodynamic simulations. The mapping of riverine wetlands as shown in RPI (2016) Figure 5 and other resource mapping sources provided in the St. Marks River and Apalachee Bay SWIM Plan (District 2017) could be cited and the resources could be mapped together with the simulated salinity regime from the hydrodynamic model to increase understanding of the linkage of the low-salinity habitats with the estuarine resources being protected (freshwater marsh). Better linkage with the ecological importance of the species and habitats with freshwater dependence as discussed in Lewis et al. (2009) may be beneficial here as well. The District may also want to review the recent work of Celik (2016), which investigated plant communities and salinity regimes along the lower SMR.

Deficiency: Page 4-16, Section 4.10. The Panel notes the reduction in WRV metrics within the spring run (confluence upstream to the U.S. Highway 98 bridge) for a 30 percent spring flow reduction never reaches 15 percent, indicating that estuarine resource metrics are relatively insensitive to reductions in flow from the River Rise (Janicki 2018b, page 4-1). That is, none of the metrics associated with the estuarine resources WRV (volume, bottom surface area, and shoreline length of waters with less than 0.5 ppt, 1 ppt, 2 ppt, 3 ppt, and 4 ppt salinities) were determined to be limiting with River Rise spring flow reductions of up to 30 percent (District 2018). The Panel is curious about this result, but neither of these reports attempts to explain this apparent insensitivity. This may be due to the inherent characteristics of the SMR and SMR estuary, but that was not explored.

Remedy: The SMR Minimum Flow Report should include some insights or explanation of the insensitive response of the low-salinity zone metrics to a 30 percent change in the spring flow component. It may be helpful to compare and contrast the results with what has been found in similar minimum flow studies in other Florida tidal rivers and estuaries cited by the District.

On page 52 of the District (2018) report, numerous studies are cited regarding other studies for Florida MFLs that use a similar approach that could be used for comparative purposes. Understanding the possible explanations for the lack of sensitivity of low-salinity zones in the SMR to reductions in flow from the River Rise would increase the confidence in the results and reduce uncertainty about the modeling results. In doing this, the Panel may wish to also review the results of Xiao (2014) on the effects of sea level rise on salinity intrusion in the St. Marks River Estuary, Florida, which included hydrodynamic modeling, assessment of the potential effects of sea level rise, and salinity intrusion.

Deficiency: Page 4-16, Section 4. Figure 2-2 showing average monthly salinities during 2016–17 seems to indicate unusually high average monthly salinities at Stations SM15 and SM16 during December 2016. Average salinities at these stations seem to be typically less than 1 ppt, but during December 2016 were at levels over 4 ppt salinity. The SMR Minimum Flow Report does not explain the reason for these atypically high salinities, but the Panel notes that based on USGS records for USGS gauge 02326900 St. Marks River Near Newport, Florida, December 2016 was a sustained period of relatively low flows, less than 400 cfs for most or all of the month.

Remedy: The District should investigate this result and propose an explanation. The District should determine whether this result comports with the lack of sensitivity of the salinity regime with reductions in spring flow contribution.

6 Evaluation of the Minimum Flow Determination

The District's approach to determining the minimum flow for the SMR River Rise and Spring Run is summarized below.

The District conducted a screening analysis of all 10 WRVs and determined that those most relevant to the River Rise spring run, that had the potential to be affected by spring flow reductions, and had sufficient data for assessment were:

- Recreation in and on the water (recreation)
- Fish and wildlife habitats and the passage of fish (fish and wildlife resources)
- Estuarine resources

These were selected as priority WRVs for the minimum flow determination.

For each priority WRV, multiple quantitative metrics were used to relate WRVs to spring flows and to assess potential effects of reductions in spring flow from the River Rise. Recreation in and on the water was evaluated in terms of the frequency of motorized boat, canoe, and kayak passage across the river shoals, in addition to the safe use of public boat launches. Metrics for fish and wildlife habitats and the passage of fish were designed to protect sufficient water depths and frequencies for the passage of fish during low flows, manatee passage, inundation of woody habitats, and inundation of floodplain wetland communities along the spring run. Metrics for estuarine resources were designed to protect the volume, bottom surface area, and shoreline length of multiple low-salinity zones.

To determine the effects of spring flow reductions on WRV metrics, a baseline spring flow record was developed. Flows measured by USGS at the St. Marks River Near Newport gauge and St. Marks River Swallet Near Woodville gauge were used to estimate River Rise spring flow, with spring flow defined as the difference in flow between the St. Marks River Near Newport gauge and St. Marks River Swallet Near Woodville gauge. The St. Marks River Near Newport gauge has daily discharge data from 1956 to present, while the St. Marks River Swallet Near Woodville gauge has daily data from 2015 to present. A statistical relationship between discharges at the two gauges was developed and used to estimate flow at the St. Marks River Swallet Near Woodville gauge from 1956 to 2014. This time series was then used to calculate a time series of daily spring discharge at the River Rise from 1956 to 2017. Subsequent analysis determined that no quantifiable effects of consumptive uses are present in the River Rise spring discharge time series and baseline conditions were defined as the full period of record between 1956 and 2017.

Potential effects of spring flow reductions were assessed using a HEC-RAS model for metrics associated with recreation and fish and wildlife resources, while an EFDC model was used to assess estuarine resources metrics. To allow for reasonable model runtimes for the EFDC model, the period of May 1, 1997, through May 31, 1999, which is representative of the entire baseline period of record, was selected and used to evaluate potential spring flow reductions. The entire period of record was used for the HEC-RAS modeling.

The HEC-RAS and EFDC models were used to determine the flow regime needed to prevent significant harm from withdrawals. Although significant harm is not specifically defined in statute, a maximum of 15 percent reduction in WRV metrics has been implemented as the protection standard for numerous MFLs throughout Florida (SRWMD, 2016, SWFWMD, 2002, SWFWMD, 2017), accepted by more than a dozen MFL peer review panels and is used in this assessment. MFL implementation will follow an adaptive management approach, with MFLs periodically reviewed and revised by the District as needed, to incorporate new data and information.

Regarding the final determination of the minimum flow, the District used the smallest allowable reduction in spring flow corresponding to a 15 percent reduction in inundation frequency to determine the proposed minimum flow for the River Rise. The most limiting WRV metric was the frequency of inundation of the cypress hardwood mix community located at river station 53367.25. The allowable flow reduction is 34 cfs for a spring flow of 452 cfs.

After a thorough review of the SMR Minimum Flow Report, appendices, and supporting documents, the Panel supports and endorses the District's approach to determining the minimum flow and final selection of the minimum flow for the SMR River Rise and Spring Run. The Panel concludes that the District had sufficient data to conceptually address the complete range of flows likely to occur on the SMR through its consideration of various WRVs and use of several metrics to evaluate "significant harm" against a baseline period. The District focused on minimum flow requirements but did not limit its assessment to just low flows. It has explicitly addressed low flows, instream flows, and out-of-bank flows where the latter are intended to protect floodplain wildlife habitats (plant communities) from significant harm.

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