PEER REVIEW REPORT

ENVIRONMENTAL PEER REVIEW OF THE EVALUATION PERFORMANCE MEASURES AND INDICATORS FOR THE KISSIMMEE BASIN MODELING AND OPERATIONS STUDY (KBMOS)

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EXECUTIVE SUMMARY: OVERALL ASSESSMENT OF REPORT

The task of the panel is to "judge the quality and credibility of the science and assumptions used to develop the evaluation performance measures and indicators[4], particularly in their applicability to provide a link between the ecology and hydrology of the system." Evaluation performance measures were selected by the District and its consultants as a result of numerous technical and stakeholder meetings. The ultimate goal of the program is to evaluate existing and alternative operating criteria for the water control structures in the Kissimmee Basin. Eventually, the operating criteria selected under this program are to be used to achieve a more acceptable balance among flood control, water supply, aquatic plant management, and natural resources requirements of the Kissimmee River Restoration Project and Kissimmee Chain of Lakes Long term Management Plan, while also balancing impacts to downstream ecosystems. The development of "more acceptable" operating criteria will be accomplished using hydrologic/hydraulic models of the Kissimmee Basin.

Here we review those performance measures as they are presented in a 200+ page report hereafter referred to as the KBMOS report:

> Draft Final Evaluation Performance Measures and Indicators, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study. January 2007, Peer Review Draft. Prepared for South Florida Water Management District, West Palm Beach, FL, by PBS&J, West Palm Beach, FL. under Contract CN040899-WO06.

Three questions form the core goals for our review:

1. Is the report clear, concise, and comprehensive enough to inform the reader of the decisionmaking that went into the selection of measures and indicators?
2. How robust are the underling links for measures and indicators between the hydrology and ecology of the lakes or river?
3. Are the proposed measures and indicators for evaluating regulation schedules appropriate and scientifically sound?

The front materials describe very well the development of the KBMOS project and the EPMs. The panel agrees that using historical flow and stage data for the system to set future targets is a conceptually sound approach. The introductory sections of the report do a good job describing the bureaucratic process of EPM development, but they are much less successful at explaining the hypothesized mechanisms linking the EPMs to the natural resources.

[4] Throughout the text here we uses "measures" or EPM(s) to refer to the collective set of "measures and indicators."

Although the linkages between hydrology and ecology were discussed in stakeholder meetings, especially for the lakes, it is not clear whether the EPMs will achieve these ecological targets in many cases and significant improvements appear unlikely in others (e.g., lakes where stage cannot be changed significantly). The KBMOS document operates under the general assumption that restoring pre-channelization or pre-regulation hydrology to the largest degree possible will create suitable ecological conditions for all plant and animal species. This assumption should be clear in the introductory text.

We concur with the judgment that the potential to restore the system to near pre-channelization conditions appears possible for the Kissimmee River. Given the constraints to the system, especially flood control, restoring pre-regulation hydrologic conditions is not possible for all the lakes. Due to these constraints, restoring pre-regulation hydrology is not an objective for the entire Upper Basin. The number of lakes in the Upper Basin, their connectivity, and differing histories and amounts of human activity provide an opportunity to manage water levels in individual lakes or sets of lakes to consider a range of stakeholder goals from more natural systems with pre-regulation amplitudes in inter-annual water level fluctuations to highly controlled systems with more restricted amplitudes. These changes should be influenced by stakeholder goals (recreational boating, fishing, and so on), but they could also be implemented to provide contrasting scenarios within the basin, which would increase the information gained in the upcoming long-term management plan (LTMP) and associated monitoring and assessment program. Given the aforementioned constraints for the lakes, we urge the agencies to consider such contrasting scenarios among sets of lakes to improve the knowledge gained from the LTMP.

Neither the front materials nor the measure and indicator discussions provide a cohesive organizational or conceptual framework of the relationships among the EPMs. This is a serious weakness with many potentially significant consequences (see Sections 2 and 3 for more details and examples.). We offer suggestions on how to develop that framework; we urge the District to adopt or improve on our suggestions and incorporate their final framework into the introductory material of the KBMOS report. Specifically, the KBMOS report fails to recognize that the various measures and indicators proposed are not all equivalent. They include descriptors of environmental drivers of lake and river ecosystems, system responses to hydrologic drivers, external (e.g., legal) constraints on hydrology, and management issues. Of these, those that set targets for environmental drivers are the most important because they will determine the condition of the lakes and the river.

We propose creation of three primary driver EPMs that focus on target (1) inter-annual water level amplitudes for the lakes in Upper Basin, (2) discharges to the Kissimmee River from the S65 structure that are sufficient to connect the river and its floodplain, and (3) discharges from the Kissimmee River at S-65E because of their influence downstream on Lake Okeechobee and the Everglades. This will yield three driver EPMs from the following combinations: E-10, E-11, E-12, and E-13 for the chain of lakes; E-01, E-02, and E-08 for the Kissimmee River; and E-18 for downstream areas.

Because of the importance water level management for both downstream ecosystems and for achieving the target hydrology of the restored section of the River, E-18 may need to be replaced with one or two evaluation performance measures that focus on those two goals. A number of EPMs should be deleted (E-14, E-15, and E-19) or placed more peripherally, such as in an appendix (E-06). We suggest refining and simplifying (e.g., reduce the number of evaluation components in E-03 to a more tractable number than 16), but retaining several response EPMs (E-03, E-04, E-05) that are checks on the degree to which river and floodplain integrity are being restored. Four remaining measures (E-07, E-09, E-16, and E-17) relate more to specific management goals that are not directly associated with the integrity or health goals. Thus, they should not be seen as integral to decisionmaking about attainment of those goals. They are of course not unimportant to the management of the Kissimmee Basin.

Another issue of significance is the assumption that changing basin hydrologic conditions will restore substantial portions of the lost natural resource values. Although this is likely to be true to some degree, it should not allow the program to ignore the real influences of other factors on the condition of water resources. We urge the District to incorporate the potential effects of other factors (nutrient and toxic chemical inputs, alien taxa introduction and spread, changes in the distribution of human activity in the basin in future decades) into their evaluations. Adherence to narrowly framed hydrologic criteria will almost certainly make it difficult for managers in the future to respond to these and other changing pressures.

Finally, the panel is not able to discern from the report the precise goal for the KBMOS document and, more important, the audience to whom the document is directed. Report revisions should clearly articulate the uses to be made of the report and the primary audiences.

Specific Recommendations for the Front Material

We recommend several additions to the front materials to put the KBMOS project into context, to briefly describe the environmental and other drivers of aquatic ecosystems, and to describe and organize the proposed EPMs.

(1) Although related projects like the Kissimmee River Restoration Project, Kissimmee River Headwaters Revitalization Project, the Kissimmee Chain of Lakes Long-Term Management Plan, and the development of hydrologic models that will be used in the alternative evaluation system are briefly described in the front materials, how these various projects are related to one another is often not clear. A diagram that illustrates how these projects are linked to each other would be very useful.

(2) A diagram and associated text should be developed to identify the drivers (and their interactions) that influence the state or condition of an aquatic ecosystem. These include hydrology, water chemistry, toxins, invasive species, structure of physical environment, and many others. Figure 1 in Section 3 would be a good starting point for such a figure. Without this background and context outlining the full range of system drivers, readers or

managers might be lulled into believing that EPMs based in hydrological models will be adequate to ensure attainment of project goals. With this background, the larger context in which KBMOS is embedded will be clear to all. Both past and future changes in the drivers will influence streams, wetlands, and lakes and their responses to changing drivers.

(3) Finally, we urge the inclusion of a section to classify and describe the kinds of EPMs developed by KBMOS. Some are external driver EPMs that will define when certain amounts of water will enter the river or a lake. Others are response EPMs that will be used to check if the river or lakes have the internal hydrological characteristics (e.g., water velocity or depth) predicted to occur and required to support local and regional living systems. Other EPMs are designed to accomplish management or legal requirements or constraints. In addition to descriptive text, a table similar to Table 2 (Section 4) should be included to illustrate the District's perception of relationships among the EPMS and various program goals.

SECTION 2

OVERALL ASSESSMENT OF THE EVALUATION PERFORMANCE MEASURES AND INDICATORS

ABSTRACT

Emulating the historical flow and stage conditions to the largest degree possible is a sound approach for the EPMs. The KBMOS report should be combined with other program components to more clearly define the expected biotic responses to the changed hydrology defined by the EPMs. It should also acknowledge that unexpected events and interactions make it difficult at best to define accurately how implementation of alternative plans will alter current conditions. Potential natural resource responses to the EPMs could include 1) no significant change in biota, 2) improvements in biota, or 3) degradation of the biota. All three potential responses should be considered when evaluating effects of the final selected EPMs, including specific statements whenever that is possible, about the biological components (both parts and processes) that are likely to be influenced and how.

INTRODUCTION

In this section we address in general terms the EPMs and their appropriateness for natural resource requirements. Because specific EPMs and suggested revisions to those EPMs are discussed in detail in section 4, we focus section 2 on the general approach to the EPMs and their expected outcomes for aquatic biota.

The panel agrees that using historical flow and stage data for the system to set future targets is a conceptually sound approach. The potential to restore the system to approximate pre-channelization conditions appears possible for the Kissimmee River. Given the constraints to the system, especially flood control, restoring hydrologic conditions at the lakes is not possible for all the lakes, nor is it an objective for the entire Upper Basin.

The panel did not identify any key hydrologic variables that were missing from the EPMs, but we believe the EPMs contained some redundancy and could be simplified without compromising the key hydrologic drivers for the system. Examples of ways to combine and simplify the EPMs are described in Section 4. One such simplification might involve focusing on and reporting inter-annual variation in water levels as a hydrologic descriptor of ecological significance. Other examples of ecologically important descriptors are provided throughout this report. These examples illustrate ways to decompose EPMs into evaluation components that more directly connected to ecological metrics.

The goal of the EPMs, to increase inter- and intra-annual fluctuations in water levels and/or flows, were not explicitly tied to their target ranges. We believe that each EPM dealing with river and lake hydrology should show the proposed changes in interand intra-annual water levels or flows (whichever is appropriate) relative to the period of pre-channelization or pre-regulation. It was not easily evident how the EPM's would change conditions from the status quo.

Although hydrologic aspects are described well by the EPMs, the panel felt that other important drivers of biological change were largely ignored (see section 3 for more expansive discussion of this point). Nutrient levels are a primary example, but other drivers could include exotic species (discussed below). The report should better acknowledge that the KBMOS project relates only to hydrologic drivers which may or may not be the only critical driver that must be dealt with in order to restore integrity to the Kissimmee River or health of the chain of lakes. Moreover, eventually the District will have to factor the effects of future development into the analysis of water management strategies formulated to restore or maintain health or integrity.

POTENTIAL IMPACTS ON NATURAL RESOURCE REQUIREMENTS

Question 6 of the Statement of Work asks the panel to comment on the suitability of the target levels for natural resource requirements. The KBMOS document acknowledges the substantial uncertainty about whether and how the biota will respond to the hydrology changes. The panel understands this uncertainty and agrees that mimicking the historical flows and stages to the largest degree possible is a reasonable approach.

However, due to the uncertainty in biotic responses to the hydrology defined by the EPMs, it is important to consider the full range of potential natural resource responses to the alternative plans that maybe implemented. These could include:

1) No divergence in biological condition from the present condition. This is most likely at lakes where the feasible stage changes are relatively minor (described in Section 4).

2) Biological condition improves. Improvement is most likely for the Kissimmee River system because the restoration program is likely to substantially change key dimensions of system dynamics. Evidence that the restored sections of the river are moving toward pre-channelization conditions for wetland plants and animals is already available.

3) Biological condition declines. Whenever management programs are initiated, unexpected consequences are likely to emerge. These may range from the relatively minor to substantial effects on key regional species (e.g., harvested species, T and E species, keystone species). The KBMOS makes no mention of potential unintended consequences of the EPMs, or the consequences of other activities in the Kissimmee Basin.

Scenarios 1 and 2 are acknowledged in the KBMOS and associated documents; scenario 3 should also be anticipated in a program as complex as this effort. For example, torpedograss, a potentially devastating exotic plant not found at the system prior to channelization, is now distributed throughout the system. Increasing inter- and intra-annual fluctuations in lake stages could cause this plant to expand at a rapid rate. Field surveys have demonstrated that torpedograss occurs more frequently at sample sites with the shallower water depths (40 cm) that undergo periodic drying (Richardson et al. 1995). At Lake Okeechobee where lake stage is highly variable, torpedograss is present in a relatively wide depth range. This plant dominates some areas of the Lake Okeechobee littoral zone at the expense of native macrophytes (Johnson et al. 2007). Richardson et al. (1995) implied that torpedograss in higher-elevation areas of the littoral zone will expand if hydroperiods are shortened due to water-level manipulation. Thus, more extreme variation in lake stages at the KCOL could be favorable for torpedograss expansion.

Torpedograss illustrates the uncertainty in natural resource responses to the changes in hydrology proposed in the EPMs. The real potential of unintended consequences as a response to increasing variation in inter- and intra-annual water levels and flows should be acknowledged in the KBMOS report. Mechanisms to both identify as early as possible and alleviate any unintended negative consequences should be considered in the report.

Because we recognize that research is not a goal of the KBMOS, we do not call for endless research efforts. Our comments are intended to specify the bounds of uncertainty in natural resource responses, so that all potential responses are considered. We also note that insightful management of the dynamics of natural systems must consider that the effects of variation—hydrological or otherwise—will depend on managers that clearly understand the diversity of factors that will influence project success.

SECTION 3

BACKGROUND MATERIALS FOR AND PROCESS USED TO DEVELOP EPMs

ABSTRACT

The front materials describe very well the development of the KBMOS project and the EPMs. Nevertheless, several topics are not adequately addressed. We suggest the following improvements: provide an explicit discussion of the relevant external drivers of the Kissimmee River and upper basin lakes, evaluate the relative importance of the hydrological variables that affect the state of aquatic ecosystems, describe the relative importance of the proposed EPMs, and discuss the possible significance of cyclical changes in annual rainfall on the evaluation of alternative regulation scenarios. The relationship between the Kissimmee River Restoration Project expectations and the comparable EPMs for the river needs to be described and any discrepancies between them explained and justified.

INTRODUCTION

The overall goal of the KBMOS projects is clearly stated (page 4), "KBMOS will determine how existing operating criteria for the Kissimmee Basin water control structures can be modified to achieve a more acceptable balance among flood control, water supply, aquatic plant management, and natural resources requirements of the Kissimmee River Restoration Project and Kissimmee Chain of Lakes, while also balancing impacts to downstream ecosystems." The development of "more acceptable" operating criteria will be accomplished using hydrologic/hydraulic models of the Kissimmee Basin to evaluate various alternative structure operating criteria. The question to be explored is "How well do the various operating criteria meet a series of evaluation performance measure (EPM) targets?" The EPM targets have all been formulated using hydrological criteria like water levels and water flow volume.

The process (and its underlying strategy) used to develop EPMs is described in reasonable detail (KBMOS Figure 2), including the input of stakeholders into their development. In general, the front materials do a good job describing the bureaucratic process of EPM development. They are much less successful at explaining the science underlying them. Descriptions of how the EPMs will be used are provided in the KBMOS report (pages 17–19, Fig. 3). We believe the approach suggested is problematic because all EPMs appear to be treated as if they were of equal significance. We do not consider them to be equivalent (see **Relative Importance of EPMs,** pages 16 and 34). Likewise, the unqualified use of utility indices to weigh the EPMs is worrisome. Many stakeholders involved in developing the utility indices may not grasp the full significance of some of the EPMs. Also, some of the river EPMs were derived from Kissimmee River Restoration expectations and, thus, are developed with different contexts and goals in mind than for the lake EPMs (e.g., integrity vs. health).

Considerable uncertainty exists about the relationship or linkages between EPM targets and ecosystem characteristics, especially for the lakes. Although it may be literally true no data support the hypothesized relationship between the EPMs and restoring the ecological integrity of the Kissimmee River, data from other restored river systems and even recent data from the Kissimmee River Restoration Project suggest that meeting properly defined EPMs will greatly increase the chances of success of the restoration of the Kissimmee River and its floodplain. In fact, if the river EPMs or their close equivalents are not met, it is certain that the Kissimmee River Restoration Project will be significantly compromised. Because considerable uncertainty remains about how the river and associated floodplain or a given lake will respond to a new hydrological regime, development of an adaptive management (Walters 1986) and restoration evaluation program (Karr et al. 1991) should be an integral component in the implementation of new regulation schedules. Currently, adaptive management is mentioned only with regard to the Kissimmee River Restoration Project. Because we could find no clear statement of the incorporation of this activity in Kissimmee Basin lake management, we urge the District to incorporate an adaptive approach into lake management planning and implementation under the Kissimmee Chain of Lakes Long Term Management Plan (KCOL LTMP).

The front material in the KBMOS report is generally well written, organized, and informative including a good overview of the project and its organization. It does, however, have some shortcomings. These fall into five general categories: (1) questionable assumptions, (2) failure to discuss the relative importance of various hydrologic descriptors and to identify which are the most important for the river and lakes, (3) failure to recognize the relative importance of the different EPMs, (4) implications for the use of EPMs, and (5) lack of adequate background information. Because of their multiple implications, the two most serious shortcomings are the failure to recognize the most important hydrologic descriptors and the lack of an explicit hierarchy that arrays the EPMs in terms of their importance to various program goals.

QUESTIONABLE ASSUMPTIONS

Use of the historic, pre-channelization hydrology as the target for the restored section of the river and its floodplain makes sense for the Kissimmee River Restoration. For the lakes, however, using their pre-regulation hydrology to define their “healthy” condition is questionable; the plan does not include restoring the lakes of the Upper Basin to their pre-regulatory hydrology. In fact, the constraints imposed by (1) maintaining the existing level of flood control, (2) not modifying existing structures, and (3) not acquiring additional land around the lakes will probably make it impossible to restore the pre-regulation hydrology for most of the lakes. We suggest that it will be impossible to improve, enhance, or sustain the “health” of all these lakes, although much depends on how one defines health (and how that definition might vary from lake to lake). Improving the hydrologic management of the lakes is certainly possible, but more precise goals than having “healthy lakes” is needed to guide that effort. In addition to the three factors just mentioned, stakeholder goals will no doubt vary among the lakes. Finally, the nature of each lake (basin size and shape, extent of lake-margin wetlands, history of land use and human disturbance in the drainage area, and so on) will also impose constraints and create opportunities to be creative about the context of "health" in a specific water body.

The front materials do not provide any discussion of environmental drivers, other than hydrology, that control the features of aquatic ecosystems. The implicit assumption seems to be that other factors (drivers) are not important influences on river or lake condition. But that assumption is clearly false as is demonstrated by a substantial literature on this subject. At least five major classes of drivers are known to influence the biological condition of water bodies (Fig. 1; Karr 1991, 2006, Karr and Yoder 1994). Many questions emerge when one considers this array of issues important in restoring integrity or health. Are there differences in water quality—e.g., nutrient inputs—among the lakes that could alter their responses to new regulation schedules? Likewise, how will expected changes in land use around the various lakes alter future nutrient inputs? We recommend that serious thought be given to the other factors in the basin that might influence restoration success. Defining hydrologic (regulation) rules in the absence of those considerations will inevitably lead to unexpected and often negative consequences.

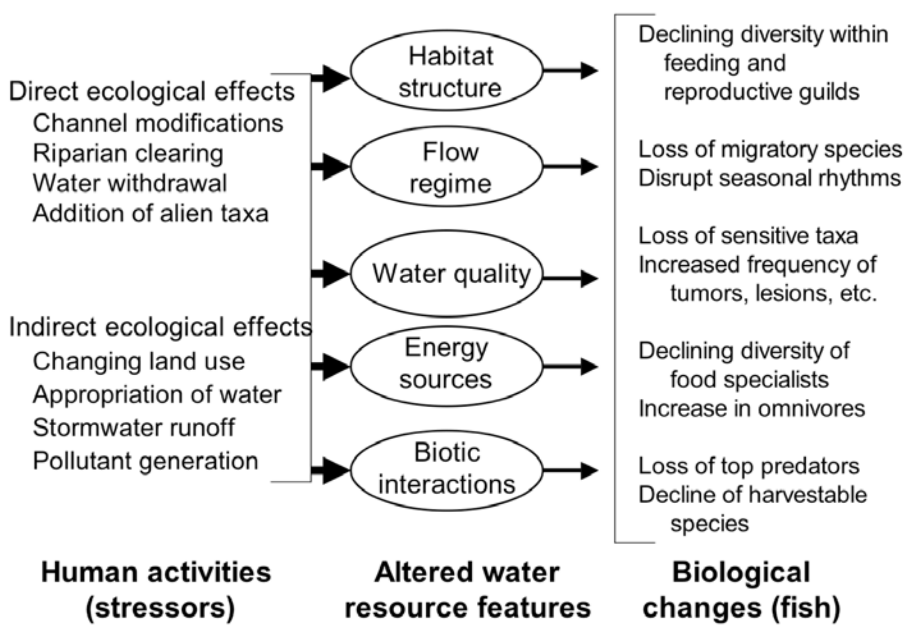

Figure 1. Human activities alter five water resource features, resulting in specific changes in fish assemblages. More expansive lists of changes in fish, plants, invertebrates and other organisms can also be specified with considerable precision (Modified from Karr and Yoder 2004 and Karr 2006.)

The authors of the report assume in the front material that restoring the "pre-regulated system will provide maximum opportunity for achieving the natural resource water management objectives of the KBMOS." No explanation was provided, however, on how these “natural resources requirements” were derived and how they relate to the proposed EPMs. Listings of abiotic and biotic indicators in KBMOS Table 3, Preliminary EPMs in KBMOS Table 4, and more detailed data on how the EPMs are related to “natural resource requirements” are provided in Appendices C and D, but no documentation or justification of how these disparate “natural resources requirements” will be met by the proposed EPMs.

Although linkages between hydrology and ecology are assumed, the bases for these linkages are not adequately described or explained. Hydrology influences the distribution and abundance of organisms by influencing recruitment, growth rates, chances of survival, and many other biological attributes. Many publications deal with ecologically-relevant hydrological descriptors: Richter et al. (1996), Nestler and Long (1997), Morley and Karr 2002, Booth et al. 2004, and van der Valk (2005). A review that incorporated the ideas from these and other published papers would provide a more convincing foundation for the development of the EPMs outlined in this report.

HYDROLOGIC DESCRIPTORS

The composition and structure of all ecosystems are the result of the history of forces or drivers that operate from regional to local scales. Local, internal environmental drivers control the distribution, size and growth rate of populations of component species in ecosystems (Levin 1998). Consequently, local differences in internal drivers are largely responsible for the spatial and temporal patterns, for the state of these ecosystems. Internal drivers can be altered by a change in external drivers such as a change in the hydrology of a wetland. When this occurs, internal drivers change, resulting in local changes in the distribution, abundance, and growth rates of species. If these internal changes result in a noticeable shift in the overall composition or structure of the ecosystem, it has changed its state. The importance of drivers is recognized in passing in the KBMOS report on page 11: “the biological and ecological attributes of the Kissimmee Basin ecosystem results from a complex set of drivers including hydrology.” Unfortunately, the paramount importance of external drivers rather than internal drivers for developing suitable EPMs was not fully recognized.

The background materials fail to identify the key hydrologic features of wetlands or other aquatic systems that determine their characteristics (e.g., the abundance and distribution of their flora and fauna). A brief section (p. 14) of hydrologic descriptors is provided, but no discussion explores their relative importance and why. The assumption is that EPMs should be based on “historical hydrology data.” This discussion and the choice of the most important metrics would be enriched and strengthened by previously published works. One review paper (Keddy and Fraser 2000), cited in the text describing an EPM for lake stages (E-11), contains a figure that clearly illustrates the overriding importance of inter-annual water level fluctuations (Fig. 2) on wetland structure (zonation) and species diversity.

The importance of inter-annual water level fluctuations for rivers and lakes, and their associated wetlands, is never explicitly identified as the key feature of their hydrology. A range of inter-annual water level fluctuations comparable those prior to river channelization or lake regulation will be needed to restore their integrity or health. Although the general significance of water level fluctuations in rivers and lakes is recognized in the KBMOS report, the description of water level fluctuations and how targets are set for them should be improved. A clearer distinction needs to be made between intra-annual or seasonal water level fluctuations and inter-annual water level fluctuations, including recognition that inter-annual water level fluctuations are much more important than intra-annual fluctuations.

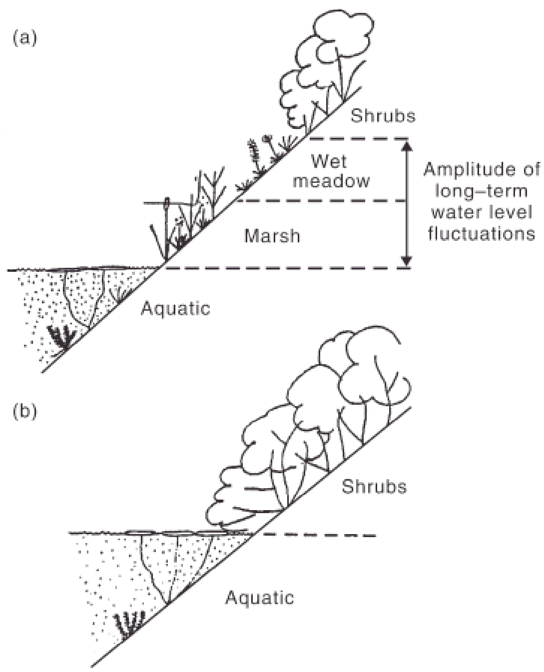

Figure 2. Impact of the constriction of the amplitude (range) of long-term (inter-annual) water level fluctuations on the number of vegetation zones in lacustrine wetlands. From Fraser and Keddy (2000).

RELATIVE IMPORTANCE OF EPMS

The EPMs and EPIs are a very diverse assemblage. They include descriptors of hydrologic drivers, legal constraints on water levels, desired physical or biological ecosystem states, and management objectives. See section 4 for a suggested classification and organization of EPMs and EPIs. An explicit discussion of the nature, significance, and relative importance of the various EPMs and EPIs should be incorporated into the front material. The most important measures relate to the drivers of these ecosystems; they define the targets for the hydrology of the river and lakes. Additionally, many other measures are of little to no direct relevance for restoring the river or improving the health of the lakes.

IMPLICATIONS FOR USE OF EPMs

The use of the EPMs in evaluating alternative scenarios is described briefly on pages 17-19. An important feature of the alternative evaluation system is the "utility index" used to weigh an EPM's components and locations. Utility indices can range in value from 0 to 1. Any EPM can be made irrelevant by giving it a utility index value of 0. This approach ignores the fact that not all EPMs are equally important. A distinction between evaluation performance measures and indicators is framed, but this distinction is solely whether their targets are quantitative or quantitative. The implication in this dichotomy is that quantitative is more important than qualitative, but that may not always be true in a decision making context. As noted in KBMOS (Fig. 3, page 18), they will be treated the same way in the alternative evaluation system.

Because the first five river EPMs are linked directly to hydrologic expectations for the Kissimmee River Restoration (Anderson et al. 2005), they are associated with a more specific goal (restoring integrity) than is true for the lake EPMs. In the alternative evaluation system, these river EPMs should not be weighted using a utility index proposed by the stakeholders because these five river EPMs must be met regardless of how the lakes are managed. In contrast, the lake EPMs evidently include input from stakeholders, but the stakeholder views were not evident in the KBMOS and thus we were not able to discuss weights given to stakeholder concerns.

One report assumption (p. 9) is that "multiple evaluation components … will ensure that the results from alternative plan simulations can be differentiated." We do not agree with that assessment. Too many EPMs and EPM components may make it harder to evaluate alternative regulation scenarios because the more EPMs considered, the greater the chances that some of the EPMs or their components will be met by any given scenario. A better strategy would be to reduce the number of EPMs and EPM components to a minimum that capture the key hydrologic drivers. For example, many of the EPM targets differ by miniscule amounts that are not likely to be biologically significant. An example of how the EPM's could be reduced and targets simplified is shown in the Appendix.

In the Upper Basin, various lakes or groups of lakes have water control structures (KBMOS Figure 1), and six lakes or groups of lakes seem to be the focus of some of the proposed lake EPMs. The hydrology of different lakes or groups of lakes can be managed to some extent independently. This makes it possible for different lakes to be managed for different purposes. The possibility of establishing different targets for each lake or groups of lakes so that they could be managed for different "natural resource requirements" is not discussed. In fact, the evaluation locations are only briefly described on page 18. A more detailed description and justification of the evaluation locations need to be added to the front materials.

Although we recognize that for some lakes their maximum attainable range of inter-annual water-level fluctuations will be considerably smaller than their pre-regulation ranges, the alternative evaluation system should examine each lake or group of lakes separately with the view to maximize their inter-annual range of water level fluctuations within the broader set of constraints for that water body.

ADDITIONAL BACKGROUND INFORMATION

The models to be used to evaluate the alternative regulation schedules will use rainfall data as a primary input. Annual rainfall is known to vary cyclically in Florida as elsewhere (Enfield et al. 2001). Have cyclical rainfall patterns affected the development of EPM targets? Could they affect the evaluation of alternative regulation scenarios? A discussion of annual rainfall patterns should be added to the front materials.

The major goals of the Kissimmee River Restoration Project are described in a series of expectations (Anderson et al. 2005). The first five EPMs are very similar to those first 5 Expectations but they are not identical in their formulations. Text describing the reasons for those differences should be added to the report.

SECTION 4

ASSESSMENT OF INDIVIDUAL EVALUATION PERFORMANCE MEASURES AND INDICATORS

ABSTRACT

Evaluation performance measures (EPM) and evaluation performance indicators (EPI) (collectively "measures") form the foundation of the program to restore the ecological integrity of the Kissimmee River and maintain the health of the Upper Chain of Lakes region. Properly selected measures are essential to program success. Our review of the presentation of those measures leads us to three conclusions: (1) an excellent job has been done to define pre-regulation hydrology from historical records, (2) a solid program is actively working to identify alternative operating criteria for water control structures within the Kissimmee Basin, and (3) a broad range of important issues are captured in the measures selected to define the best operating criteria. Here we present a number of recommendations that range from suggestions about rethinking the organization of those key measures to the manner of presentation in a report that will be important for District managers, citizens, and other agency personnel. We emphasize the following recommendations: First, the report needs to do a better job of outlining the conceptual framework, content, and relationships among the measurement tools as well as how they relate to dimensions of the program not captured in this largely hydrologic analysis. Second, an effort to combine selected measures will simplify and clarify to everyone's benefit. Third, the connections between the measures selected and programmatic ecological goals need to be made more explicit. Fourth, the report should acknowledge that the interactions of biology and hydrology are often not as well known as one might prefer. But enough is known to conclude that, without efforts to restore pre-regulation hydrologic regimes, program integrity and health goals cannot be attained. Finally, any effort to fine tune the hydrology must also be mindful of the effects of and interactions with other factors that influence natural resource condition in central Florida.

INTRODUCTION

The evaluation performance measures (EPM) and evaluation performance indicators (EPI) form the core of the KBMOS report. Following a few introductory comments, we provide comments on each of the EPMs and EPIs before outlining our views on the strengths and weaknesses of the current approach to development and application of those measures and indicators. We close with suggestions on how those measures (inclusive of measures and indicators) might be organized to yield a shorter list of stronger measures.

Nearly twenty years ago a symposium and associated reports (Loftin et al 1990a, b) on the Kissimmee River identified altered hydrology as the primary factor responsible for the loss of natural resource values in the post-channelization Kissimmee River.

Restoration of a more natural hydrology, including connectivity between the river and its historical floodplain, was identified as the keystone goal for any program to restore biological or ecological integrity of the Kissimmee River. Leaders in the restoration effort also recognized that connectivity between the river and upstream segments of the Kissimmee Basin (the chain-of-lakes region) made careful integration of the upper and lower segments of the Kissimmee Basin essential to program success.

As a result, an effort was initiated to compile pre-regulation data on flows in the Kissimmee Basin. From those data, it was reasoned, one can infer many of the most important characteristics of flow as a driver of natural resource values in the river and its floodplain. The performance measures (and indicators) proposed in the report were developed to mimic the historical trends for the Kissimmee Basin prior to channelization. The program is fortunate to have comprehensive historical hydrological data to guide its planning process, and it is clear that those data were thoughtfully analyzed to develop the EPMs.

GENERAL COMMENTS ON EPMs AND EPIs

The descriptions of each measure or indicator are reasonable in light of program goals. A few suggestions seem appropriate to speed the readers understanding of the content of those descriptions. For simplicity, we present our suggestions as bullets.

- Change labeling of EPMs and EPI to reflect whether they are for the river or lakes, e.g., EMR-01 for EPM 1 for the river and EIL-01 for EPI 1 for the lakes.

- Clarify labeling of columns in the “Target” tables.

- Specify the expected range for both inter-annual and intra-annual flow and/or stage for each EPM, and how the proposed ranges will vary from current conditions.

- Be sure that all tables have complete descriptive captions.

- Number target tables (and all other illustrative material) for quick reference throughout this and other documents.

- Ensure that the hydrologic rationales are clear for all target components. To the greatest extent possible, the report should explicitly connect hydrologic rationales to biological and ecological rationales.

- Clarify that, although “meeting the targets does not guarantee that restoration expectations. . . will be met,” a substantial body of empirical evidence from other rivers and even from the Kissimmee provide evidence that meeting these EPMs will greatly increase the chances of success of the restoration of the Kissimmee River and its floodplain. In fact, if these EPMs or their close equivalents are not met, it is certain that the Kissimmee River Restoration Project will be compromised.

- Reduce the number of significant digits in target tables to reasonable levels in both ecological context and the realities of operational practice.

- Clarify how available hydrologic data summaries are integrated with ecological and operational realities to produce target hydrologic conditions.

- Organize operating objectives with some conceptual framework rather than just listing in alphabetic order.

COMMENTS ON EVALUATION PERFORMANCE MEASURES (EPMs)

Our evaluations of EPMs are guided by four general criteria: (1) Need for and justification of each EPM and EPM component; (2) Clarity of the description of EPMs and EPM components; (3) Consistency among EPMs and EPM components; and (4) Relative importance of each EPM for the lakes, river, or downstream ecosystems.

E-01 Kissimmee River Continuous Flow

Combine E-01 with E-02 and E-08 to create a new EPM that describes the target discharge from the S65 to the river. This new EPM should be formulated in terms of target inter-annual and intra-annual ranges in flow volumes (or stage elevations). This new discharge EPM should be described using a hydrograph to illustrate desired seasonal and inter-annual discharge volumes. Later in this report, we illustrate this suggestion with a draft proposal to combine E-11 and E-12.

Currently, proposed discharges from the restored section of the Kissimmee River to downstream ecosystems are described in an evaluation indicator, E-18. We believe that setting discharge targets at the S65 D or E structures will be essential for achieving the desired flows and stages (E-03, E-04, E-05) in the restored section of the River. Targets and evaluation components comparable and complementary to those for the S65 structure should be developed for the S65D or E structures. By setting discharge targets at the S65D or E structures, target flows and stages for the restored section of the river and its floodplain can be more reliably achieved than by just setting inputs at the S65 structure. See E-18 for more details.

Mimicking the historical flows in the lower river is a reasonable goal, but this text is written as if very low flows and low dissolved oxygen did not occur prior to the hydrologic modifications. But relatively pristine Florida rivers and associated wetlands (and floodplain rivers in other regions) have periods of low dissolved oxygen (DO), even fish kills; many fish and other organisms are highly adapted to withstand low DO events (Kushlan 1974, 1976). Low DO events are common in the upper St. Johns and Withlacoochee Rivers today (Michael S. Allen, personal observations), and both of these systems lack large-scale modifications of their hydrology. Moreover, high water events are also associated with low oxygen in these systems. We suggest that arguments to sustain flow in the lower river and associated wetlands need to acknowledge that periods of low or no DO are a natural occurrence. During the historical record, the river had very low flows for extended durations (e.g., 1956), which probably resulted in low DO and fish kills. This EPM will allow low flows to occur, but we suggest the text should not be written as if the goal is to prevent low DO.

This and other Kissimmee River EPMs contain evaluation components that are simply restatements of the data from the pre-channelization period of record (Table E-01.1). Giving both seems needlessly redundant.

Please justify the inclusion of two sets of dates for low flow events: January–December in evaluation components A, C, and E is presumably the entire year. What is the point then of the June-October dates in B, D and F? The average low flow criterion are nearly the same for both sets of dates, >215 (E) and >210 (F) cfs, respectively, at S-65. Perhaps there is some logic to beginning the analysis in this broader context but when the results are so similar, it seems sensible to take that opportunity to simplify.

The evaluation components (here and for other EPMs as well) could be shortened and simplified by giving the acceptable range of low flow for each period. For example A, C and E could be combined into something like "Low flows from January to December should not fall below 250 cfs for more than 28 days." Simple sentences to summarize the goal will be crucial to engage the broader public, even if a case can be made to provide a more technical framework in segments of the document.

The issue of low flows and DO above could be better understood if the tabulation of extremes did not just use long term averages, but also included the extremes, such as the extreme low flows over the period of record. For example, the mean low flow for a period of years may not reflect an actual minimum flow that occurs with some regularity. That minimum flow may be necessary to dewater some areas and thus allow accumulated organic material to decompose. Similar consideration should be given to high flow events as extremes rather than long term average high flows. Such descriptors provide more direct ecological context to guide EPM development than average extreme events.

E-02. Seasonality and Variability of Kissimmee River Flow

This EPM should be combined with E-01. E-02, a complement to the low flow criteria for E-01, defines the desired seasonal high flows into the Kissimmee River at S-65. Unfortunately, the evaluation components for the two EPMs are not the same. E-01 and E-02 together determine the range of flows that will be discharged into the Kissimmee River from the Upper Basin. The E-02 evaluation components are designed to ensure inter-annual as well as intra-annual variation in river flows. This makes the E-02 EPM arguably the most important of the river-related EPMs.

The first four evaluation components specify what percentage of the years in the simulation the maximum flow should occur during certain periods of the year. The measures and contexts of this EPM are incomplete, however, without some indication of what the minimum high flow (cfs) should be (or how they were defined). Also, what should the minimum annual range between low and high flows be? How is that defined?

Presumably, the goal is to have high flows occur primarily in the late summer and fall as they did historically. These evaluation components could be simplified by combining them into one. For example, “Maximum mean monthly flows from January to March, April to June, July to September and October to December should occur 30, 30, 35 and 50%, respectively, of the years during the evaluation period.” Given this statement, does it make ecological sense to distinguish between the first and second quarters and the third quarter with a difference of only 5%?

The second group of evaluation components specifies the coefficient of variation around mean water flow during three-month intervals. Such a coefficient of variation is a measure of year-to-year or inter-annual variation in flows during a given month, but it is of little relevance ecologically. The important measure is the maximum inter-annual range (amplitude) between low and high flows and the mean annual range of low and high flows. We recommend that coefficients of variation be replaced with target inter-annual and intra-annual ranges in flow rates. Doing this should make it possible to combine E-01 and E-02 into one EPM.

Another example of the interaction of biota and hydrology comes from recent studies of the effect of urbanization on the biota of streams in the Pacific Northwest (Konrad 2000; Morley and Karr 2002). Flow data from continuously recording gauging stations were used to calculate two measures of “flashiness” (e.g., increase in frequency and magnitude of peak flows relative to base flow) and two measures of the magnitude of peak flow. Flashiness measures were (1) fraction of year that the daily mean discharge rate exceeds the annual mean discharge rate (T_{Qmean}) and (2) ratio of the annual maximum daily flow to maximum instantaneous flow (Q_{max}:Q_{inst}). Both measures of hydrologic flashiness were correlated with river biological condition (divergence from integrity). Peak flow was measured as (1) maximum instantaneous flow divided by drainage area (Q_{inst}: DA) and (2) ratio of maximum daily flow to minimum daily flow (Q_{max}:$Q_{\mathrm{min.}}$). To account for variation in drainage area, peak flow measures were divided by either drainage area or minimum daily flow. Neither measure of peak flow was related to biological condition.

Please define “floodplain fish” and “river channel fish” as used in this document.

How will implementation of the performance measure influence the KCOL segment of the Basin?

E-03 Kissimmee River Stage Hydrograph/Floodplain Hydroperiod

EPM E-03 is designed to restore the pre-channelization hydrology to reconnect the river and its floodplain. Success in accomplishing this goal is directly dependent on the magnitude of seasonal flows from the Upper Basin into the Lower Basin. Those flows are largely defined by the operation schedule developed from E-01 and E-02.

The 16 evaluation components of this EPM seems excessive in light of the relatively simple reconnection goal. This EPM is dependent on E-01 and E-02 and it is directly tied to the much simpler and easier to grasp Expectation 3 (Anderson et al. 2005): "River channel stage will exceed the average ground elevation for 180 d per year and stages will fluctuate by 3.75 ft." Here again (see our comments on E-02), the range of water level fluctuations on the floodplain intra-annually and inter-annually are the key considerations. Evaluation components H (Average "river channel stage fluctuation range per water year.") and I (Standard deviation of "river channel stage fluctuation per water year") provide comparable targets to those given in Expectation 3. We recommend revising this as the target inter-annual range in water-level fluctuation.

Why is the standard deviation used as a measure of variation in this EPM and the coefficient of variation in E-02? The amount of the floodplain covered with water at any time is a function of the stage of the river and the amount of the floodplain at a given elevation. Thus, evaluation components O and P are redundant and are not needed.

The point is made in the rationale section that "floodplain inundation is needed for wetland plants and for the exchange of organisms and materials between the river channel and floodplain." The same could be said for animals so why not include both plants and animals in this sentence?

The relationship between small fish density and duration of inundation (positive) is mentioned but surely this relationship is complicated by other factors such as submergent, floating, and emergent plant densities.

E-04 Kissimmee River Stage Recession/Ascension

Here again, we note that periods of low DO were probably a natural occurrence in the Kissimmee River. Establishing a schedule to prevent the occurrence of low DO is not necessarily an appropriate objective. Timing of ascension and recession also likely varied widely pre-regulation resulting in conditions that were periodically unsuitable for snail kites, many fishes, alligators, and wading birds; the report recognizes this point for these groups on page 62. Thus, we urge care in placing too much emphasis on preventing low DO. That said, it is also important to ensure that such events are relatively rare. Local and regional ecosystems are no doubt resilient to occasional low DO events; chronic exposure to low DO is likely to substantially alter the composition of animal assemblages.

Recession rate may not be as significant a driver of system condition as are intra-annual and inter-annual water level fluctuation. Therefore, recession rate may not be significant as an EPM target. A simper formulation of the target should be adequate to judge whether recession rates are comparable to pre-channelization conditions: “Percent of years in which **average** recession events (change from maximum to minimum flows) will last more than 170 days” with a target of 100%. This would bring this EPM more in line with Expectation 4. The stage reversal evaluation component (B) is fine as is.

E-05 Kissimmee River Channel Velocity

Both evaluation components for this EPM are framed as per cent of mean daily velocity when flow velocity is less than 2000 cfs, the level below which flow is constrained to the channel. The current organization of this text is not clear that there are three classes of flow condition and two are being evaluated under this EPM. Please revise to make the full situation clear. Finally, we understand that the decision has been made since the first draft of this report was prepared to make the target for E-05 equivalent to the pre-channelization data.

We also have concerns about the use of average flow velocities because two river conditions could produce the same mean under very different hydrologic regimes. Does this text refer to restored river segments or the channelized areas of the river below the lakes?

Specific flow requirements for fishes (e.g., redbreast sunfish) should be removed from the KBMOS because the main channel river flow rates may not adequately index habitat suitability. Page 74 specifies flows for various life stages of sunfish. In reality changes in flow will influence stage, and high flows in the river could increase fish habitat through inundation of the floodplain. We believe the specific flows mentioned for each life stage are too simplistic to capture the dynamics influencing the fish populations. Moreover, a narrow focus on select habitat requirements for a single species can foster management “rules” that are too narrow for that species and not in the best interest of the broader range of species implicit in the integrity goal.

E-06 Kissimmee River Energy Grade Line

Although this very esoteric EPM on protection of the backfilled sections of the C-38 canal from erosion is an important consideration for USACE and SFWMD engineers, it will be very difficult for most stakeholders to grasp. This management issue is better addressed outside the KBMOS framework by those technically competent to deal with it. This issue should be mentioned in the front materials and explained in detail in an Appendix. Some adaptive management and reformulation of the S65 discharge EPM may be necessary in the future if problems develop due to the adopted regulation schedule.

E-07 Kissimmee River Probable Flood Events

This EPM seems to be a priority because of the legal context of the federally authorized flood control project. We have some concern that very rigid adherence to this EPM might make it impossible (or nearly impossible) to attain the ecological objective of restoration of biological or ecological integrity. If feasible, this EPM should be made an EPI to reduce its impact on the alternative evaluation process.

E-08 Flow Duration

This EPM should be combined with E-01 and E-02 to create an S65 discharge EPM. Please clarify what "temporal" refers to, intra-annual, inter-annual, or both. This EPM deals with desired flow duration curves for the S-65 structure with components expressed as the probability of a certain flow rate occurring. In essence, this is a version of EPMs E-01 and E-02, except in this formulation of flow data, season is ignored. We suggest that this EPM be dropped unless a clear case for its importance is developed. Intra-annual and inter-annual flow patterns as described (or potentially described) in E-01 and E-02 are more relevant and useful because they constrain any operational criteria more than this EPM would. NOTE: Why is there no target table for this EPM?

E-10 Probable High Lake Stages

E-10, E-11, E-12, and E-13 should be combined into a new lake water level EPM formulated as target inter-annual and intra-annual water level fluctuations. An example of how this could be approached is presented in the Appendix. This new EPM should be formulated as a hydrograph that shows seasonal water levels during periods with high and low water levels along the lines of the illustrated for the evaluation of E-11 in Figure E-11.15 (page 117).

Maintenance of appropriate high lake stages is crucial to attainment of the flood control mandates for the project area. Thus, the goals embodied in formulation of E-10 are clearly essential to project success.

At our kick-off meeting the point was made that opportunities to substantially raise water levels with minimal flood impacts may be present in the lower lakes (Kissimmee, Hatchineha, Cypress).

To what extent are the four components of this EPM bureaucratic necessities? Because some seem to be redundant, could they be dropped from consideration?

What exactly is meant in the description of component A by "above peak annual stage for the base condition"? This is not defined in Table E-10.1. The text for this issue should be revised to avoid ambiguity.

Base condition is somehow linked to "flood protection required by the current federally authorized flood control projects" (page 104). What exactly are these requirements? Have they been presented in this document for clarification? Presenting them explicitly may help the reader to understand what component A actually is.

Flood protection must be maintained under any operating system but, as Table E-10.1 indicates, data are not available for defining Critical Lake Stage for these systems.

Perhaps lake stages higher than full pool can be obtained with minimal impact, at least in some lakes. Please discuss.

E-11 Seasonality and Variability of Lake Stages

E-10 thru E-13 should be combined into a lake EPM that specifies inter- and intra-annual fluctuations in lake stages. Because lake levels in many of the lakes cannot fluctuate substantially enough to change conditions from what is the norm today, the panel believes that the targets for those should be simplified. The example in the Appendix combines E-12 and E-13 to yield an EPM for the lakes with two components, inter- and intra-annual fluctuations.

E-11, the lake equivalent of E-02, establishes important criteria for the seasons during which maximum water levels should occur (components A, B, C and D) as well as criteria for intra-annual (E) and inter-annual (F) water level fluctuations (lake stage variation). Can the number of components be reduced by combining A, B, C and D into one component for each evaluation location?

Evaluation components E and F are the two most important components of this lake-focused EPM. The desired annual fluctuation in water levels is given as a range. The inter-annual lake stage variation referred to in this EPM is the standard deviation around the annual mean. We recommend changing this to the inter-annual range (in feet) in water levels over the period of record, making intra-annual and inter-annual evaluation components directly comparable.

An important test of the suitability of various water management scenarios is to determine how much compression or constriction of the inter-annual range of water levels will occur. Table 1 provides an example to illustrate this point, although the numbers should not be taken as precise. A precise table should be developed and included in the document. Because of the limited data on long-term water level fluctuations, estimates of inter-annual ranges will have to be based on a minimal amount of data. Known fluctuations in rainfall patterns should be evaluated to see how they may have affected estimated pre-regulation inter-annual water level fluctuations.

Please define or illustrate where each water control structure is and which lakes are regulated by each structure in the description of this EPM. Although this can be inferred from KBMOS Figure 1 (page 3), including this information in the EPM would make it easier for stakeholders to see its implications.

Effective use of this EPM depends on availability of meaningful data, but the text does not do a good job of summarizing the issues. Effects of water levels on fish metrics at these lakes, for example, are unknown and likely complex due to interactions with aquatic plants and other factors. Recent research (Allen et al. 2003; Bonvechio and Bonvechio 2006) has not demonstrated simple effects of water levels on fish recruitment in the KCOL. The long-term effects of channelization and relatively stable water levels, perhaps due to channelization and management for similar hydrographs each year over the past 30+ years. For systems that fluctuate more naturally, the literature shows that fish population dynamics are closely tied to water level fluctuations and the changes in habitat that result (Bonvechio and Allen 2005; Miranda et al. 1984; Ozen and Noble 2005).

Table 1. Mean pre-regulation and post-regulation intra-annual and inter-annual ranges in water-level fluctuations in selected lakes based on data figures in E-11 and E-12

Lake (Structure)	Intra-annual Range (ft)[1]		Inter-annual Range (ft)[2]	
	Pre	Post	Pre	Post
East Tohopekaliga (S59)	3.0ft	2.0ft	9ft	4ft
Alligator etc. (S-60)	2.0ft	1.3ft	5ft	3ft
Tohopekaliga (S61)	2.5ft	2.3ft	8ft	3ft
Hart and May Jane (S-62)	2.5ft	1.0ft	NA	NA
Gentry (S63)	1.2ft	1.5ft	NA	NA
Kissimmee (S-65)	2.7ft	2.2ft	10ft	4.5ft
Mean	2.3ft	1.7ft	8ft	3.6ft

[1] The maximum elevation for post-regulation annual high water levels is at lower absolute elevations. There has been a shift in the time of the year at which the highest water levels occurred from October-November to February-March.

[2] Post-regulation ranges estimated from targets in E-12. If potential navigation targets in E-9 are used, the inter-annual ranges would be even smaller. Most of the constriction of inter-annual ranges is due to the elimination of annual maximum peaks in water levels.

The hypothesis that more extreme fluctuations in lake water level would prevent or reduce the accumulation of tussocks and loss of littoral habitat for fishes seems likely to be true. However, the magnitude of intra- and inter-annual water level fluctuations needed to accomplish this is uncertain, although Table 1 provides some relevant guidance. That table is a rough interpretation of historical records; a more rigorous examination of those records should be a product of the next round of project activity.

Knowledge of how native and non-native plants will respond to changes in the lake hydrographs is limited. The only way to elucidate the patterns is to implement a cycle of water level fluctuations (preferably with an experimental design behind it) while aquatic plant, fish, and wildlife responses are tracked in a thoughtful monitoring and assessment program, a recommendation that is consistent with the recommendations of a 1991 report on the design of a restoration evaluation program (Karr et al. 1991).

It appears that only the lower three lakes regulated by S-65 can be managed for water-level fluctuations roughly similar to pre-regulation conditions. As shown above, inter-annual variation in stage for most of the other lakes in the basin cannot mirror the pre-regulation condition. The proposed EPM's for S-58 and S-60 have less than three feet of fluctuation between the high pool and normal low elevations, and East Lake Toho (S-59) has only slightly more than three feet. The panel believes that these fluctuations are unlikely to cause substantial changes in lake ecology over conditions that exist today. We also heard evidence that the stakeholders at some of those lakes prefer stable water levels and minimal inter-annual fluctuation.

Thus, it seems that there are three scenarios for the lakes: 1) lakes controlled by S-65 could have the largest inter-annual fluctuations in lake stage and the potential for biological condition that is a closer approximation to ecological integrity, 2) lakes controlled by S-58, S-59, and S-60 can have only minor fluctuations unless they are managed with extreme lows, lower than those considered in the KBMOS, and 3) the unique West Lake Toho could be managed individually to provide substantial fluctuations at lower elevations because of S-61.

The lake EPM's could potentially be simplified by separating the targets according to these three scenarios (Appendix). Lakes where substantial fluctuation is not considered feasible should have simple targets to avoid the perception that these lakes are going to be "changed". Separating the lakes into groups with different levels of inter-annual water level fluctuation would also accomplish some contrast in the shape of the basins, which could help reveal how the biota of individual lakes responds to changing hydroperiods.

Figure E-11.6 stimulates several questions. Plots of pre- and post-regulation mean daily stages are given for six sites. The patterns show some differences between the pre- and post-regulation patterns as well as differences among the sites. Are any of these differences significant in any important way (e.g., statistically, biologically, hydrologically)? How, why, and is that important?

A sentence on page 112 implies that "maximum plant diversity" may be the primary or a primary goal. The concept should be employed with caution as plant diversity can be increased through the spread of non-indigenous species in the region. Perhaps it would be better to specify diversity of native or indigenous plants.

The uncertainty section (page 115), begins with the statement that "Evaluating this performance measure using different months will likely produce difference performance results." This seems to be a problem that requires thoughtful exploration and decision making beyond a casual mention of the issue.

E-12 Frequency, Duration, and Timing of High and Low Lake Stages

This EPM should be combined with E-10, E-11 and E-13. This important Upper Basin EPM is closely related to E-11. Both recognize the importance of water-level fluctuations for maintaining the full range of wetland vegetation types and their associated animal communities. As with earlier EPMs, we conclude that they lack explicit acknowledgement of the importance of the range of both inter-annual and intra-annual water levels.

The upper water level (high pool stage) is set by flood control considerations (see E-10). An examination of Figures E-12.1 to E-12.8 indicates that the proposed EPM will not allow water levels in any lake to have the range of water level fluctuation that existed historically (pre-regulation). This means that the range of water level fluctuations will be significantly reduced, a point that is acknowledged on page 125. Thus historic water level fluctuation data cannot be used to derive this EPM. In Table E-12.2, definitions of wet low, normal low, extreme low, and so on are given based on how much and how long the "current" vegetation of the lakes is covered with water. The data in Table E-12.3 that summarize the frequency and duration of pre-regulation flooding in various lakes or groups of lakes do not match the targets for various components. For example, Lake Tohopekaliga (S-61)) in the pre-regulation period was flooded above the Extreme High stage from September to January for 60% of years. In component A, which is equivalent, it is set at 30% of years. Although it varied from lake to lake historically (35 to 75%), why has component A been made the same (30%) for all the lakes? In fact, all the components have been given the same target for every location.

In effect, all the lakes will now be managed in the same way, arguably leading to the loss of important differences among the lakes (see Appendix). Because a variety of factors vary among lakes (e.g., basin size and shape, proportion of shallow water, and others), an ecologically sound management program tasked to protect health cannot look only at stage as a factor governing insightful water management for attainment of the "health" goal. This issue should be considered across the final range of EPMs with a focus on lake environments.

One component of this EPM seems to be at variance with one in E-10. In E-10, the percent of years with a "peak annual stage above the High Pool Stage AND above the peak annual stage for base conditions" is set as 0%. Extreme High Pool Stage in E-12 involves water levels higher than the High Pool Stage (Table E-12.1). Component A of this EPM allows water levels to exceed Extreme High stages for 30 or more days in September to January 30% of the years. Please clarify.

As with E-11, we have concerns about the lack of data on effects. The recommendation calls for an increase in KCOL water level fluctuations; the seasonal and inter-annual sequences appear to mimic the natural regime in pattern. But they are seriously lacking in the very important magnitude of fluctuations. Although it will be impossible to mimic historical water level fluctuations (Figures 12.5-12.8) in some lakes and difficult in others, why not make an effort to restore the natural level of fluctuations in some of the lakes? The extreme high at the S-65 structure seems to be set at 54-ft, apparently the regular full pool under the previous system. Why not explore if higher stages for the extreme high lake levels are possible for this system? Another and perhaps more rational approach would be to lower the minimum pool allowed to provide a total range of fluctuation that is consistent with historical records, but at slightly lower absolute levels (instead of 56 ft high pool and 47 ft low pool use 54 and 45 to accomplish the same 9 ft range). Without that restored range of fluctuation, we expect project goals may not be attainable. As we noted before, some presentation of the presumed constraints for the lower three lakes should be included in this document so that the reader can interpret the analysis and conclusions with greater insight.

Lake drawdowns have mixed effects on largemouth bass (or other species) populations. They do not always result in increases in bass abundance at the KCOL, because plant, invertebrate, and fish responses to extreme water events may vary for diverse reasons. An extreme low water in one year, for example, may produce very different effects than the same low lake levels in another year. Understanding what contributes (both antecedent and current conditions) to this variation is a key need at the KCOL.

Finally, to what do the text boxes in Figures 12.1-12.4 refer. All figures and tables should have clear and complete captions up to the standards of peer-reviewed journals, including clear definitions of all codes, abbreviations, line types, and so on.

E-13 Lake Stage Recession/Ascension

This EPM should be combined with E-10, E-11, and E-12. Issues of importance here are similar to those already outlined in discussion of E-12, although the rates here seem less important than the magnitude and duration of the stage changes (E-11, E-12). Recession and ascension rates will vary depending on seasonal precipitation patterns and the current water level in a lake or group of lakes. Expressing recession/ascension rates would be clearer if they were expressed on the basis of lake levels or simply as acceptable rates of water level change like <1 ft/month for recessions and < 1.6 ft/month for ascensions. Recession rates < 1.3 ft per month should not be a constraint to nesting and nursery areas for fishes.

COMMENTS ON EVALUATION PERFORMANCE INDICATORS (EPIs)

The coding system for EPMs and EPIs is at best confusing. Instead of giving them the same acronym as EPMs, it would be better to distinguish between the two by labeling EPIs something like EI-09 or better EI-01. As we noted earlier in this report (page 2), a complete revision in numbering and naming of measures is needed. Clear and concise definitions of EPMs and EPIs (including any efforts to revise the organization and structure of "measures") and any other formality used in the naming and numbering should be clearly described early in the report and then reiterated as appropriate throughout the report.

E-09 Stage Duration for Navigation and Recreation

E-09 sets the lower limit for water levels in the lakes considered by the USACE as navigable. We question this approach in light of a "healthy" lakes goal. Table E-09.1 in effect defines the lowest acceptable water level in these lakes at a level that will make it impossible to attain the range of intra-annual and inter-annual fluctuations essential to restoring and maintaining lake health. Compared to the extreme low stage in E12.3, the "Stage that may impact recreational uses" in E-09 is about 1.5 to 2 ft higher. Thus, this EPI is at variance with the low water levels specified in E-12.

E-14 Lake Littoral Zone Inundation

This EPI should be deleted. This EPI is apparently based on the incorrect assumption that the vegetation of a lake and its peripheral wetlands do not respond to inter-annual changes in water levels. Adjustments in vegetation zones lag behind changing water levels by years not months. Furthermore, changing water levels are essential to the maintenance of the diverse vegetation zones associated with undisturbed or minimally disturbed (by humans) lakes in this region. Because the targets for lake littoral zone inundation are not known, we suggest that this EPI be dropped.

E-15 Sub-watershed Runoff Volume

This EPI should be deleted. In our view the dominant factor defining sub-watershed runoff is the nature of and changes in land use within the sub-watershed. We do not understand the mechanism through which sub-watershed runoff will be affected by modifications in the operation of water control structures. Even if some slight effect could be demonstrated, compared to other hydrological targets, this should have no bearing on the operation of structures. We recommend dropping this EPI.

E-16 Water Supply for Consumptive Use

The state of development of this EPI is not adequate for comment at this time.

E-17 Lake Discharges and Stages for Hydrilla Management

The panel understands that special low lake levels may be needed for control, including use of herbicides, of *Hydrilla*. Looking for naturally occurring opportunities to implement *Hydrilla* management makes good sense. The most successful approach to *Hydrilla* management may in fact involve management of lake water levels so that every so many years, a lake would be drawn down to control *Hydrilla* rather than to deal with it on an *ad hoc* basis. In any case, we recommend definition of threshold levels of *Hydrilla* infestation that would trigger weed control for each lake.

E-18 Kissimmee River Inflows to Lake Okeechobee

Just as water management in the KCOL is crucial in defining the condition of the lower Kissimmee Basin, the outflow from the Lower Kissimmee (S-65E) to Lake Okeechobee, the Everglades, and Florida Bay. Thus, linking the Kissimmee Basin hydrologically to management of Lake Okeechobee and the Comprehensive Everglades Restoration Plan (CERP) is essential. Although it may be impossible to link the Kissimmee Basin hydrological model with Lake Okeechobee at this time, this EPI is essential for those concerned with the impacts of changes in the operation schedule for the Kissimmee Basin due to requirements for Lake Okeechobee and beyond. In the long run, this EPI is one of the most important to water management in South Florida.

The current emphasis in E-18 is solely on ensuring that discharges into Lake Okeechobee do not result in adverse impacts to the Lake. We believe that, if properly formulated, it would also important for the management of the restored section of the Kissimmee River. By combining the inputs into the Kissimmee River from the S65 structure and the outputs from the S65D or E structures, it will be possible to develop a water budget for the restored section of the River. Such a water budget will be a useful check on relative importance of inputs into the Kissimmee River downstream from the S65 structure. Meeting the proposed hydrology targets for the restored sections of the River will require taking into account both inputs from the S65 structure and those downstream from it.

We believe that the setting the discharges from the river are important not only for the well-being of downstream ecosystems but also for the management of the restored section of the River. Consequently, we recommend that E-18 be reformulated into one or two evaluation performance measures/indicators. As outlined in our discussion of E-01, we recommend that targets be set for discharges from the restored section at S65D for the Kissimmee that an EPM be developed that sets targets for discharges from the restored section of the Kissimmee River at S65. These should be comparable and complementary to those for the S65 structure. These targets should be specified so that the desired flows and stages (E-03, E-04, E-05) for the river and its floodplain will be achieved.

An expanded version of E-18 could also include discharge targets from the S65E structure into Lake Okeechobee as a second evaluation location. An alternative would be to have an EPM for discharge targets at S65D and another EPM/EPI with discharge targets at S65E.

E-19 Palustrine Wetland Hydroperiod/Surficial Aquifer Water Budget

This EPI should be deleted. One of the weakest of the EPMs/EPIs, we do not see E-19 as crucial to the considerations with the highest priority at this time. Can the existing models actually contend with the major issues associated with modeling this EPI? Can those models shed much light on the impact of changes in structure operation on palustrine wetlands in the Kissimmee watershed? We recommend this EPI be dropped.

RELATIVE IMPORTANCE OF EPMs

No systematic effort has been made in this draft report to describe or display the conceptual relationships among the EPMs and EPIs. We provide a framework (Table 2) for the District and its consultants to consider as it moves forward to revise the document.

Most proposed EPMs fall into four classes (Table 2). Some EPMs describe the hydrology of either the river or lakes essential to restore either “integrity” or “health.” These are ecosystem driver EPMs. They must be met or the river and lakes will not have the hydrology needed to meet “natural resources requirements.” Some EPMs describe expected characteristics (states) of the river or lakes with the desired hydrology. These are ecosystem response or state EPMs. Other EPMs describe legal constraints on either river or lake hydrology such as flood control and navigation requirements. These are legal constraint EPMs. Finally, some EPMs focus on lake management concerns such as aquatic weed control and water supply. These are management EPMs. (Some EPMs do not fall readily into these four classes because they are so peripheral to setting hydrological targets for the river or lakes.) Of these four types of EPMs, the driver and constraint EPMs are far more important than the response and management EPMs as guides to water management.

The alternative evaluation system must recognize that driver and legal constraint EPMs are the primary EPMs for developing and defining the operating criteria. Response and management EPMs do not necessarily have to be met. In reality, response EPMs are functions of the driver EPMs and are simply checks on whether the driver EPMs are creating the desired ecosystem states. Management EPMs are an indirect admission that, because of current conditions or constraints, proposed driver EPMs will not be adequate to produce the desired ecosystem states.

Although evaluation components of EPMs are mentioned on pages 9 and 18, the rationale for them is only briefly discussed. As with the EPMs themselves, the possibility that some components are more important than others is not addressed. In effect, many components are used to describe desired seasonal variations in flow rates or water levels. They are not independent of each other. Whenever EPMs or their components are linked or dependent on each other, it makes sense to combine them. In any case, the justification for components needs to be described in greater detail.

OTHER FACTORS FOR CONSIDERATION

1. The Kissimmee River Restoration Project is ongoing and its major goals are described in a series of Expectations (Anderson et al. 2005). The first five EPMs are very similar to the first 5 Expectations (Anderson et al. 2005) for the Kissimmee River Restoration Project. However, they are not identical in their formulations. What are the reasons for the differences in formulations of those two sets? What can and should be done to reconcile the differences.

Table 2. Classification of KBMOS EPMs and EPIs

Type of EPM*	Lakes	River	Lake Okeechobee
Driver	E-10 to E-13	E-01, E-02, E-08, E-18**	E-18**
Constraint	E-09	E-07	
Response	E-14	E-03, E-04, E-05	
Management	E-16, E-17	E-06	
Other	E-15, E19		

* **Driver**: EPM will determine the hydrology of the river or lake.
Constraint: A legal or regulatory limitation on a driver EPM.
Response: Some desired or expected abiotic or biotic feature of the river or lake.
Management: EPM describes some management goal.
Other: EPM unrelated directly to river integrity or lake health.

** As described in the text, a revised E-18 should focus on both maintenance of proper flows in the restored Kissimmee River channel and floodplain and the outlet to Lake Okeechobee.

2. Information on historic patterns of annual precipitation should be added to the front materials with an analysis of how much they might have influenced the formulation of EPM targets and how much they could influence the processes associated with the planned alternative evaluation system.

3. We recommend selection of targets within the new lake water level EPM that will be as similar as possible to natural inter-annual water level variation for each lake or lake group. If done properly, the result could serve as a natural experiment on how the amplitude of inter-annual water level fluctuations affects the flora and fauna of these

lakes. To take advantage of this natural experiment for adaptive management, rigorously defined monitoring and assessment programs will be needed.

4. Proposed EPM targets need to be linked to population dynamics of specific organisms, especially those that are legally protected or are of great recreational importance. We conclude from the report that discussion of this issue has been extensive (see Appendices C and D). The alternative evaluation system is supposed to resolve conflicts among various proposed water level regimes. Currently, there is no direct linkage of EPMs to the ecology of any organism or to the more complex multispecies assemblages (the dominant focus when integrity and health are invoked as goals) upon which these target organisms depend.

5. Finally, the panel is not able to discern from the report the precise goal for the KBMOS document and, more important, the audience to whom the document is directed. Report revisions should clearly articulate the uses to be made of the report and the primary audiences.

SUMMARY

The KBMOS report is the first comprehensive description and discussion of the evaluation performance measures (EPM) and evaluation performance indicators (EPI) developed to date. Those measures (inclusive of measures and indicators) were developed as a crucial step in the program to restore the ecological integrity of the Kissimmee River and maintain the health of the Upper Chain of Lakes region. The presentation of each measure is organized around a consistent series of headings: Expectation, Target, Rationale, Operating Objectives, Evaluation Locations, Justification and Analysis, Uncertainty, Source, Evaluation Protocol, and References. Although no detailed discussion is provided for three headings, they are present in all measures as placeholders: Utility Index Functions, Performance Measure Score, and Acceptance Status.

In addition to specific comments on improvement and clarification of each of the measures, we offer three recommendations on how the measures might be classified, simplified, and connected more explicitly to the program goals.

First, the report needs to do a better job of outlining the conceptual framework, content, and relationships among the measures. The current report presents nineteen measures but virtually nothing is done to organize those measures except the division between measures and indicators. Some measures define the drivers of system condition while others, for example, might more appropriately be characterized as constraints (e.g., legal constraints). We offer one organization for the District and consultants to consider.

Second, many measures have too many “targets” for analysis and redundancy among metrics creates a diversity and complexity that may be both unnecessary and confusing. Depending on how some measures are used, they may lead to decisions that move the Basin away from rather than towards integrity and health objectives. We offer suggestions on combining metrics to simplify and focus the effort on what we consider the most important hydrologic issues.

We propose creation of three primary driver EPMs that focus on target (1) inter-annual water level amplitudes for the lakes in Upper Basin, (2) discharges to the Kissimmee River from the S65 structure that are sufficient to connect the river and its floodplain, and (3) discharges from the Kissimmee River at S-65E because of their influence downstream on Lake Okeechobee and the Everglades. This will yield three driver EPMs from the following combinations: E-10, E-11, E-12, and E-13 for the chain of lakes; E-01, E-02, E-08, and E-18 for the Kissimmee River; and E-18 for downstream areas. A number of EPMs should be deleted (E-14, E-15, and E-19) or placed more peripherally, such as in an appendix (E-06). We suggest refining and simplifying (e.g., reduce the number of evaluation components in E-03 to a more tractable number than 16), but retaining several EPMs (E-03, E-04, E-05) that are not integral to the core goal (restoring river and floodplain integrity) because they are not drivers of system condition. Four remaining measures (E-07, E-09, E-16, and E-17) relate more to specific management goals that are not directly associated with the integrity or health goals. Thus, they should not be seen as integral to decisionmaking about attainment of those goals. They are of course not unimportant to the management of the Kissimmee Basin.

Third, the connections between the measures selected and programmatic ecological goals need to be made more explicit. The report should acknowledge that the interactions of biology and hydrology are often not as well known as one might prefer. But enough is known to conclude that, without efforts to restore pre-regulation hydrologic regimes, program integrity and health goals cannot be attained.

REFERENCES CITED

Allen, M. S., K. I. Tugend, and M. Mann. 2003. Largemouth bass abundance and angler catch rates following a habitat enhancement project at Lake Kissimmee, Florida. *North American Journal of Fisheries Management* 23:845–855.

Anderson, D. H., S. G. Bosquin, G. E. Williams and D. J. Colangelo. 2005. Defining success; Expectations for restoration of the Kissimmee River. South Florida Water Management District, West Palm Beach, FL.

Bonvechio, T. F. and M. S. Allen. 2005. Relations between hydrological variables and year-class strength of sportfish in eight Florida waterbodies. *Hydrobiologia* 532:193–207.

Bonvechio, K. I., and T. Bonvechio. 2006. Relationship between habitat and sport fish populations over a 20-year period at West Lake Tohopekaliga, Florida. *North American Journal of Fisheries Management* 26:124–133.

Booth, D. B., J. R. Karr, S. Schauman, K. P. Konrad, S. A. Morley, M. G. Larson, and S. J. Burges. 2004. Reviving urban streams: land use, hydrology, biology, and human behavior. *Journal American Water Resources Association* 40: 1351–1364.

Enfield, D. B., A. M. Mestes-Nunez, and P. J. Trimble. 2001. The Atlantic Multidecadal Oscillation and its relation to rainfall and river flows in the continental US. *Geophysical Research Letters* 28:2077–2080.

Johnson, K., M. Allen, and K. Havens. 2007. A review of littoral vegetation, fisheries, and wildlife responses to hydrologic variation at Lake Okeechobee. *Wetlands* (In Press).

Karr, J. R. 2006. Seven foundations of biological monitoring and assessment. *Biologia Ambientale* 20(2): 7–18.

Karr, J. R., and C. O. Yoder. 2004. Biological assessment and criteria improve total maximum daily load decision making. *Journal of Environmental Engineering* 130: 594–604.

Karr, J. R., H. Stefan, A. C. Benke, R. E. Sparks, M. W. Weller, J. V. McArthur, and J. H. Zar. 1991. Design of a Restoration Evaluation Program for the Kissimmee River, Florida. Report to South Florida Water Management District. West Palm Beach, Florida. 46 pp.

Konrad, C.P. 2000. New metrics to characterize the influence of urban development on stream flow patterns. *Washington Water Resource* **11:** 2-6. (Also available from http://depts.washington.edu/cuwrm/.)

Kushlan, J. A. 1974. Efects of a natural fish killon the water quality, plankton, and fish population of a pond in the Big Cypress Swamp, Florida. Transactions American Fisheries Society 103: 235–243.

Kushlan, J. A. 1976. Wading bird predation in a seasonally fluctuating pond. *Auk* 93: 464–476.

Levin, S. A. 1998. Ecosystems and the biosphere as complex adaptive systems. *Ecosystems* 1:431–436.

Loftin, M. K., L.A. Toth, and J. T. B. Obeysekera. 1990a. Proceedings of the Kissimmee River Restoration Symposium. South Florida Water Management District, West Palm Beach, Florida.

Loftin, M. K., L. A. Toth, and J. T. B. Obeysekera. 1990b. Kissimmee River Restoration Alternative Plan Evaluation and Preliminary Design Report. South Florida Water Management District, West Palm Beach, Florida.

Miranda, L. E., W. L. Shelton, and T. D. Bryce. 1984. Effects of water level manipulation on abundance, mortality, and growth of young-of-year largemouth bass in West Point Reservoir, Alabama-Georgia. *North American Journal of Fisheries Management* 4:314–320.

Morley, S. A., and J. R. Karr. 2002. Assessing and restoring the health of urban streams in the Puget Sound Basin. *Conservation Biology* 16: 1498–1509.

Nestler, J. M. and K. S. Long, 1997. Development of hydrological indices to aid cumulative impact analysis of riverine wetlands. *Regulated rivers: Research and Management* 13: 317–334.

Ozen, O. and R. L. Noble. 2005. Relationship between largemouth bass recruitment and water level dynamics in a Puerto Rico reservoir. *Lake and Reservoir Management* 21:89–95.

Richardson, J. R., T. T. Harris, and K. A. Williges. 1995. Vegetation correlations with various environmental parameters in the Lake Okeechobee marsh ecosystem. *Archiv fur Hydrobiologie*, *Advances in Limnology* 45:41–61.

Richter, B. D., J. V. Baumgartner, J. Powell, & D. P. Braun, 1996. A method for assessing hydrologic alteration within ecosystems. *Conservation Biology* 10:1163–1174.

van der Valk, A. G. 2005. Water-level fluctuations in North American prairie wetlands. *Hydrobiologia* 539:171–188.

Walters, C. J. 1986. *Adaptive Management of Renewable Natural Resources.* Blackburn, New Jersey.

Appendix. An example illustrating and describing how EPM's E-12 and E-13 (lake hydrographs) could be combined and simplified.

Part 1: Inter-Annual Lake Stages

		Location		
	Evaluation Component	**S-58, S-59, S-60**	**S-61**	**S-65**
A	% Years Extreme High	20	Not modified	30
B	% Years Normal High	80		70
C	% Years Spring High	0		10
D	% Years Reduced High	0		10
E	% Years Wet Low	0		40
F	% Years Normal Low	80		40
G	% Years Extreme Low	20		10

The S-65 values are unchanged from the targets on page 121 of the KBMOS. Lake stages for Components C, D, and E for S-58, S-59, and S-60 are not sufficiently different to justify different values; we conclude that having the lakes deviate from the normal high and normal low only one in five years is appropriate. This is similar to the draft report but with fewer targets. Note that E-10 has been eliminated because it describes the maximum tolerable stages which are also included in E-11 and here.

Part 2: Intra-Annual Lake Stages

	Evaluation Component	**S-58, S-59, S-60, S-62, S-63**	**S-61**	**S-65**
A	% Years Maximum Mean Daily Stage in Sep, Oct, or Nov	75	Not modified	75
B	% Years Maximum Mean Daily Stage in Jul, Aug, Dec, or Jan	10		10
C	% Years Minimum Daily Stage Occurs in Apr, May, or June	75		55
D	% Years Minimum Daily Stage Occurs in Feb, Mar, Jul, or Aug	25		30
E	% Years with Stage Recession for 176 d over Sept-June	70		60
F	% Years with Stage Ascension event of 92 d during Dec-June	50		30
G	% years with stage reversals > 0.5 ft and < 1.5 ft in Dec-June	20		15

Again, the S-65 values for A-D above are unchanged from the targets on page 110 of the KBMOS. The values for S-58, S-59, S-60, S-62 and S-63 are simplified because the differences among them were very minor. This does not change the general idea proposed for those structures. Component E of E-12 on page 110 would need to be revised for each structure, and component F would no longer be needed because it would be controlled by Part 1 of this draft EPM.

E-12 and E-13 are combined here. Component A on page 136 is found as E above. Recession rate across structures S-58, S-59, S-60, S-62 and S-63 are simplified above, because we were unsure whether those differences were likely biologically meaningful. It's also not clear what stakeholders would think about the ascension and recession rates. Similarly, the stage reversal component was simplified.