APPENDIX 1
Public and Peer Review Panel Comments

Appendix 1-1
Peer Review Panel Comments

Appendix 1-1b

Final Report of the Peer Review Panel Concerning the 2001 Everglades Consolidated Report, October 23, 2000

Videotapes of the October 3rd-6th Peer Review Public Workshops are available by contacting the South Florida Water Management District

F I N A L

R E P O R T

of the ***Peer Review Panel*** Concerning the

2001 Everglades Consolidated Report

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Submitted October 23, 2000

INTRODUCTION

The responsibility of this panel was to review and prepare questions for the SFWMD staff, on the draft for peer and public comment version of the 2001 Everglades Consolidation Report (the Report), dated September 1, 2000. In addition, the panels' responsibilities include the consideration and inclusion of input from the public workshop conducted October 3-6, 2000, where relevant. This report summarizes the panels findings regarding the key facts presented during the workshop and conclusions and recommendations on the subjects raised by the SFWMD staff and public participants.

The Report and this peer review are part of an open panel review and public hearing to ensure that all involved are given an opportunity to be part of an open deliberation before a panel of objective experts.

Constructive criticism of the District's programs and projects were sought from the panel. However, this review by its very nature and constraints is not designed to evaluate detailed aspects of District research and monitoring. The panel's task was to determine if the appropriate scientific models and application were employed, if all relevant data was used, and if the Report's findings were a logical consequence of the science and the data.

In reviewing the Draft Report, the general questions that the panel addressed included:

1. Does the draft document present a defensible scientific account of data and findings for the areas being addressed? Is the synthesis of this information presented in a logical and complete manner?

2. Are the findings and conclusions supported by "best available information" or are there gaps or flaws in the information presented in the main body of the document? What additions, deletions or changes are recommended by the panel to enhance the validity and utility of the document?

3. Are there other interpretations of the data and findings that should be considered and presented to decision-makers? Is there available information that has not been considered by the authors?

4. Are there data summaries and analyses that should be included in future, annual peer reviewed reports to the Governor and Legislature?

General Panel Response to the Draft Report

The draft 2001 Everglades Consolidated Report is generally well written and well considered. Almost without exception the text is clear and understandable. It is clear that the panel's review of the 2000 Report was considered and incorporated into this year's work. The 2001 Report is a much improved document.

Report Organization

The *2001 Everglades Consolidated Report* is designed to meet a number of reporting purposes associated with the following requirements:

1. Everglades Forever Act
2. Everglades Construction Project
3. Joint Legislative Committee on Everglades Oversight
4. Non-Everglades Construction Project
5. US Army Corps of Engineers 404 Permit

The above laws, projects, oversight and permits involve a broad range, from basic scientific research to construction projects.

In last years' review, the panel commented on the organization of the Report. While the 2001 Report maintains its previous organizational structure, the combination of chapters 1 and 15 provide a clearer and more immediate picture of the overall program. Also, while the Report remains as before, the public workshop conducted between October 3 and 6, 2000 was organized substantially as suggested by last years panel. Consequently, this peer review will be organized as follows:

Part I. The Everglades Forever Act: Programs, Planning and Resources (Chapters 1, 5, 6, 8, 9, 10, 11, 12, 13).

Part II. Everglades Ecology: Responses to Phosphorus Enrichment and Altered Hydrology (Chapters 2, 3, 14).

Part III. Water Quality and Mercury in the Everglades Protection Area (Chapters 4, 7).

Regarding the material in the chapters, the panel noted that a number of issues are common among many chapters. For example, there are two to four major issues with mercury in the Everglades that are also seen in other chapters. It would be useful to organize the introductory material to address these issues, with the appendices grouped to reflect these themes. The panel feels a better job could be done to coordinate inter-chapter and appendix material. Rather than treat each chapter as an individual document, the coordinator of the whole Report should be given more authority to integrate the document. Basically, each year's report would begin with a brief status report of the subject area. The authors of each chapter would then identify the most important issues for that year and spend the bulk of the report focusing on those. In this way, each year's report is both a continual status report and a tracking of central issues and responses. The public workshops could also be organized around these issue themes with fewer status report presentations.

Further, while the panel recognizes a need to keep the length of the Report under a manageable size, it may be useful to rethink the use of previous reports. Critical information was spread across a number of sources, making review difficult.

Finally, regarding the review process, for complicated topics such as mercury, secondary reviewers should be assigned specific issues (such as atmosphere cycling, internal cycling, fate and biological effects, and modeling), rather than serve as a reviewer of a whole chapter.

District and Public Responses to Review Process

The Panel would like to specifically commend the District Staff for their responses to the first round of comments submitted by the panel. The Panel would also like to commend those who participated in the public workshop. At both the workshop in written material submitted to the web board, representatives of various groups interested in the Everglades provided thoughtful and useful information. The Panel was impressed by the level of scientific information added to the process by public participants. Of special note, the Panel would like to acknowledge the input of all of the scientists brought forth by the Sugar Cain Growers Cooperative of Florida.

Finally, the Panel would like to note that the open and public process undertaken in this review aided in the scientific review of the Consolidated Report. States across the U.S. would benefit from looking closely at the peer review process pioneered by the SFWMD.

"Peer Reviewing" the Report

When 'peer reviewing' a report, written in part as an annual summary of water quality standard compliance, there is a question as to the exact purpose of the review. Is the review to simply determine the appropriateness of the methods selected to conduct the standard compliance assessment? Or is the review to seek consistency in use of methods to insure that managers receive information that is comparable from year to year?

To further elaborate on this point, Martin (2000), after conducting a survey of the data analysis methods employed to determine standard compliance, water quality trends, and comparison of populations, notes that the peer reviewed literature does not appear to be developing de facto 'standard' data analysis methods. In other words, there are many alternative data analysis methods that are producing the same water quality information being reported in the refereed literature. Thus, there is no one way, in the peer reviewed literature, to compute standard compliance. The resulting application of a variety of 'appropriate' data analysis methods has the potential to produce conflicting and inconsistent information over time and space. In fact, after using a number of common methods to compute trends, Martin notes that the selection of the data analysis method can influence the comparability of the information produced.

Knowing that the information in the Report is often the third assessment, and that there will be more assessments, causes the panel to wonder, over time, if consistent and management-relevant information will result from the 'peer reviewed' process. Or, will the authors of each report feel that the peer review process obligates them to not be consistent from year to year in their choice of data analysis methods and reporting formats. There seems to be a conflict between the freedom peer review brings to the scientific process, for the scientist doing an assessment, and the need for consistency in production of management-oriented information.

With the data analysts being free to choose any scientifically appropriate data analysis method for analyzing water quality data each year, and the peer review process available to deem their choices appropriate, the application of the peer review may be occurring at the wrong time in the cycle. Perhaps it would be more appropriate for a 'data analysis protocol' to be prepared and peer reviewed *before* data are collected. In this way, the protocol could be implemented each year, in a consistent manner, and the information would be deemed produced by a peer reviewed data analysis method. The results would not be peer reviewed each year, but the process employed to produce the management information would be peer reviewed.

As noted on the panel's review of Chapter 4, the dissolved oxygen site-specific alternative criterion development description in the appendix contains a well-documented definition of compliance. This material provides a good example of an appropriate system for data analysis and compliance.

Defining Standard Compliance

As the science behind future criterion development unfolds, it would be extremely helpful to future monitoring, data analysis and management decision making to have scientifically defined violation definitions of standards built into the criteria. A 'template' for developing a peer reviewed definition of P criterion compliance may be that used in the dissolved oxygen criterion evaluation. We view the dissolved oxygen violation definition in the criterion evaluation a critical component for connecting monitoring results to management decision-making.

PART I. THE EVERGLADES FOREVER ACT: PROGRAMS, PLANNING AND RESOURCES

Major Findings & Preliminary Implications of the 2001 Everglades Consolidated Report

While not easily peer reviewed, in evaluating a “findings and implications” chapter of any report, the goal is to determine whether the findings highlighted are documented in the body of the report and whether the implications follow the findings. In the case of the draft consolidated report it is clear that both criteria are met. As an introduction to the whole report, the section *Major Findings of the 2001 Everglades Consolidated Report* provides a useful and concise guide to the results.

CHAPTER 1: Introduction to the 2001 Everglades Consolidated Report

Overall, this is an excellent chapter, well organized and logically presented, taking into account the recommendations to incorporate chapter 15 from the 2000 consolidated draft report into this chapter in the 2001 report.

Chapter 1 provides a good description of the geographic setting of the Everglades and the history of the area. It describes the protected area, Florida Bay, the WCAs and the surrounding areas as well as the major environmental problems of concern, including disrupted hydrology, water quality, and reduction in size of the ecosystem. It also describes legislation pertaining to the Everglades, and presents the government setting and roles of SFWMD and Florida DEP. It does what an introduction ought to do in providing both an overview of the content of the report as well as the process utilized in its preparation.

The short summary statements under the “Geographic Setting” section should provide the general public with sufficient information to follow the debate in the public hearing process as well as pose relevant questions. This chapter has also apparently been used by the print media to prepare several articles that were carried by national and international news services.

Conclusions

1. As the entire restoration process is science-based, a clear understanding of the project framework is vital for public understanding and effective public participation. This chapter has measurably improved public understanding of the process particularly in employing the interim milestones and the planning activities. The “ultimate solutions” are but a point in the process, which is placed in a justifiable context in the section titled “Risks of Premature Selection of Long-Term Solutions.” Discussion of the “Critical Areas” also helped focus the discussion in terms of water quality and the relationship between investments and potential outputs.

2. A statement placing the Everglades planning process in national and global contexts may be important. Noting that other efforts to manage wetlands are benefitting from the Everglades process should be considered. It is obvious that scientists and managers from other parts of the world have a great interest in the work of the District and that District personnel have an interest in research being conducted and the resultant management strategies (integrated air, land and water management) and policies being developed as a result of this work (for example, New Zealand, Brazil, and South Africa efforts to develop integrated intergrated natural resource management policies and strategies).
3. It is not clear in reading the section on the Everglades Stormwater Program that the referred-to eight basins (not included in the Everglades Construction Project) are also subject to the default P limits noted on page 1-18 "Rulemaking". This should be clarified as many members of the public may study this chapter in more detail then other parts of the report.

Recommendations

1. A summary of this chapter should continue to be provided as part of the public hearing process as a means of orienting the public to the region under consideration.
2. Page 1-6, Florida Bay. It might help reader understanding if an approximate extension of the Bay was indicated in a dashed line.
3. Page 1-9, paragraph 2, last sentence, "A general goal of the Everglades Consolidated Report is to improve public understanding of these programs and the science that supports decisions derived from the programs" should be slightly revised and be the lead statement in the report. "A general goal of the Everglades Consolidated Report is to improve public understanding of management actions and projects and the science that supports decisions derived from the approved planning process."
4. Page 1-13, paragraph 1, last two sentences, "To meet this deadline… potential remedies" is so fundamental to public understanding of the complexity of the planning process that it should be highlighted. In fact, the entire paragraph is fundamental to engendering broad public understanding and support.

CHAPTER 5: Effectiveness of Best Management Practices

Chapter 5 documents the effectiveness of Best Management Practices (BMPs) at three spatial scales in the Everglades Agricultural Area (EAA). The effectiveness is demonstrated by exceeding the 25% annual total phosphorus (TP) load from the EAA for five consecutive years. The reduction is measured against a "with BMP" or "without BMP" baseline which varies annually. As in last year's report, the chapter concludes that BMPs are continuing to reduce phosphorus loads at rates far exceeding the required 25% annual reduction. The Panel is impressed with the effectiveness of the BMPs, but would like to have the following points clarified.

While it is apparent that the EAA is a major source of TP, it is not clear whether most of the phosphorus originates from subsidence and mineralization of organic matter or from application of inorganic fertilizers. It would be useful to quantify the source of phosphorus as optimization of BMPs based on water or nutrient management requires this information.

Another questions centers around the issue of nutrient budgets and flows with the EAA. It would be useful in the long run to maintain a phosphorus budget for the EAA. This budget should include the amount of phosphorus entering the area as fertilizer and the amount leaving the area in the harvested crop. A large net gain of phosphorus in the area now may have serious consequences in later years.

A new and emerging issue is the biogeochemical relationship between mercury and sulfur. The Panel has learned that sulfur is applied as a soil amendment to increase the availability of other essential micronutrients when soil pH is high. Given this situation, the District may need to think seriously about whether sulfur should be considered in the BMPs.

In 1998, hurricane Georges produced large phosphorus spikes (figure 5-6, page 5-18) and may have contributed to the highest annual TP load in the 1996-2000 period. The spikes were primarily due to large increases in particulate P concentration (presumably caused by turbulence). Since hurricanes are not anthropogenic events, the Panel wonders whether effects of hurricanes are taken into account in computing the annual baseline TP load.

This chapter makes it clear that phosphorus load rather than phosphorus concentration is the parameter that matters. Why is phosphorus load rather than phosphorus concentration not used as the measure of the restoration goal? Readers might wonder how concentration variability caused by very dry or wet years would be handled.

Conclusions

1. Everglades BMPs continue to produce good results and show evidence that this high performance will continue in the future.
2. If further reductions in phosphorus load are to be achieved, lowering of particulate phosphorus appears to hold the highest potential.

Recommendations

1. Agricultural practices such as conservation tillage should be considered as potential BMPs to sequester atmospheric CO2 to counter soil subsidence, mineralization, and phosphorus release.
2. Growers in the EAA should be informed of the role of sulfate-sulfur in the biogeochemical production of methyl mercury, and that they should begin to think of BMPs in the use of sulfur-bearing fertilizers and soil amendments.

CHAPTER 6: Optimization Research for the Stormwater Treatment Areas

The STA investigators are to be commended for collecting an enormous quantity of data that will be very useful in deciding the best treatment options available to the state of Florida in restoring the Everglades. However, Chapter 6 is sketchy and could be improved greatly if more detail about the experiments were provided. It is understood that most of this information is available in other documents, but that does not help the reader with only the current chapter.

Unfortunately, a lack of attached biological growth data and hydraulic data has limited the authors in interpreting the chemical data, but this should be rectified during the coming water year. With the completion of the planned hydraulic and biological studies, significant conclusions about the expected performance of the STAs should be possible. The STA studies are a monumental effort, and it is recognized that collection and analysis of performance data are extremely complex activities.

Hydraulics and Performance Comparisons: Researchers familiar with hydraulic characteristics in large basins have known for a long time that the nominal hydraulic residence time (NHRT) is far from the actual HRT (AHRT). Short-circuiting of 51% of the flow is not surprising. Laboratory and pilot plant scale studies have shown that regardless of the degree of baffling in a tank, the ratio of the AHRT to the NHRT (AHRT/NHRT) will not exceed 0.8. In a large area such as Cell 4 with open water, as well as channels and dense vegetation in spots, one would expect considerable short-circuiting. Future dye studies should look for dead spots in the Cell where dye may be trapped and give a false AHRT. Aerial surveillance and photography during the dye study also would yield useful information.

It would be helpful to anyone reviewing Chapter 6 to have more details about the dye study, particular plot of the dye concentration in the Cell effluent versus time, percent dye recovery, time of first appearance of the dye in the effluent, mean HRT, median HRT, and observance of dead spots in the Cell. A plot similar to that shown in Figure 1 would be very helpful in interpreting the data from the dye study.

Comparisons of the phosphorus removal in the various cells are meaningless without knowledge of the hydraulic characteristics of all of the Cells. The aspect ratio of each Cell is very different, the plant cover and location are different, channeling is different and biological activity on the various plants is probably different, among many other variables. Without some reasonable estimate of the hydraulic characteristics and the variation in the attached biological growth on the plants, little can be made of the data reported. The need for the biological and hydraulic data is acute, and little can be said about the reasons for the variations in performance between the various Cells until these data are incorporated into the report.

It is recognized that the characteristics of the various Cells change with time, and dye studies may not fully describe the hydraulic characteristics, but a reasonable estimate of the characteristics of each cell would certainly help in interpreting differences in phosphorous removal between the Cells. The earlier regression analyses by Chimney showing negative relationships between HRT and phosphorus removal are probably meaningless because of the lack of knowledge of the true hydraulic characteristics of the Cells.

The comments above apply equally to the ENRP test cells. These cells are relatively small and dye studies would be much easier to conduct and would yield invaluable data in interpreting phosphorus removal results.

Observations of large pond wastewater treatment systems and constructed wetlands have shown that the hydraulic characteristics of these systems are one of the controlling factors, if not the critical one. It is likely that the same is true in the Everglades.

Phosphorus Removal Comparisons: It would be convenient for the reader of the Chapter if concentrations of phosphorus in the effluents from the various Cells were shown along with the retention rates. A plot of the influent phosphorus concentration versus the effluent concentration would be useful, even if not conclusive. It is well known that the performance of a biological system can vary with the concentrations of the influent material. As the influent concentration decreases, it becomes more difficult for the system to remove the constituent. Were the influent concentrations of phosphorus to each Cell equivalent? Was there a relationship between the performance of Cells and the influent concentrations of phosphorus? Did Cell 3 retain less TP because it was less efficient or because it received a lower TP load? Can the variability in TP retention rates for treatment wetlands in STA-1W be related to other factors such as vegetation, precipitation, etc.? Discerning open water from Submerge Aquatic Vegetation (SAV) may be necessary to optimize STA performance.

Vegetation in Cell 2 has shifted from cattails to open water/SAV in the last few years, but TP retention does not appear to have changed substantially. Is performance of this cell independent of vegetation type? If so, how do we reconcile this with the apparent performance of SAV-dominated Cell 4?

The conclusion states that the performance of Cell 4 is increasing over time, but the results in Figure 6-2 do not clearly support this statement. The conclusions that emergent marsh performs well initially but declines over time, and that the SAV and open water system improves with time, appear to be premature.

Chemical precipitation of phosphorus could be a significant mechanism in the STAs. Very high pH values during high algae growth can have a significant impact on the carbonate balance in a wetland or lagoon system. Have attempts been made to determine the influence of chemical precipitation?

ENRP Test Cells: These experiments will be useful in interpreting the performance of full-scale units and in design modifications for the STAs and future treatment areas. It is recognized that there are budget constraints on the number of samples that can be collected and the number of analyses that can be performed; however, two areas that might need attention are discussed below.

It is important that the hydraulic characteristics of the Test Cells be determined. This should be a much easier and less expensive task than that experienced in the STA Cell 4. Simple tests such as introducing dye into the tanks and taking aerial views of dye studies (obtainable from a tall ladder) would reveal valuable information about dead spots, channeling, etc.

Were periphyton and microinvertebrates experiments conducted in the Test Cells as well as the STAs? Was diurnal sampling of the pH value done, or was the pH value measured during the collection of samples? Both growth and pH may or may not be factors in the performance of the Test Cells. It probably was assumed that these two factors would not be an issue with all of the cells receiving the same influent water and being in the same location; however, it would be prudent to occasionally sample for biological activity and measure the pH value. What was the vegetation in the ENRP test cells? Was it similar in each? The description of the decomposition studies indicates that there were both emergent (*Typha*) and SAV vegetation types in the cells. Did vegetation affect cell performance?

One very interesting result from the Test Cells experiments is the performance of the South Test Cell when receiving a TP input of approximately 0.030 mg/L and putting out the same concentration. This indicates that the minimum TP concentration from a wetland probably is limited to this value. It is possible that this is the minimum sustainable concentration of TP, even with additional treatment such as that described in Chapter 8, once the treated water is reintroduced to natural wetlands. This hypothesis is supported to some degree by the decomposition studies in that decaying material will aid in reestablishing the minimum TP concentration.

Test cell HLR and water depth research uses controls with a mean HLR of 2.7 cm/d and nominal depth of 0.6 m to reflect average design conditions for the STAs. In practice how much do HLR and depth vary from design conditions in operating STAs? At the south site only the low HLR cell had a positive TP mass retention. Given that the low HLR is considerably less than average design conditions, does this suggest that the south parts of the STAs are superfluous? Does TP in the outflow of the south cells equal TP generated within the cells?

Ongoing Research: A more detailed description of the ongoing research would be helpful. The description of continuing research on the Test Cells needs expanding, and some indication of what is planned for the STAs would be helpful. A separate section at the end of the Chapter summarizing the plans for the future would be helpful.

Marsh Dryout Study: The marsh dryout studies will contribute greatly in predicting the impact of a drought. The results suggest that dryout should be avoided at all costs. Have the short- and long-term impacts to downstream systems been considered if dryout cannot be avoided?

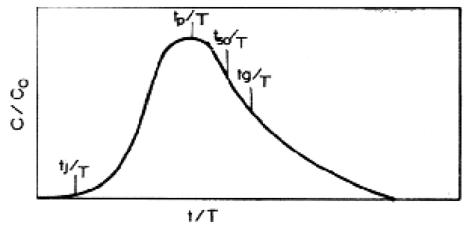
It would be interesting to know how the reapplication of water to the Test Cells was handled after dry out. Was the water added in one immediate application, or was it proportioned according to expected rainfall? Would a slow application have any affect on the reintroduction of phosphorus to the water?

On page A6-9, the treatments are not clearly identified. It is necessary to review Figure 6-14 to determine what 1-4 represent.

Recommendations

1. It is highly recommended that hydraulic studies of the other STA Cells and the ENRP Test Cells be conducted. This is particularly critical for the STA Cells because of the significantly different physical characteristics of the Cells. Hydraulic studies in the Test Cells should be relatively simple compared to the studies in the STA Cells.
2. Time of sampling should be mentioned along with the possible influence that this might have on the interpretation of the results. Sampling time has a profound impact on results obtained in biological systems such as the STAs. It would be convenient to the readers if mention were made of the sampling frequency, time of day samples were collected, and weather conditions along with a brief explanation of the difficulties of sampling such complex systems as the STAs.
3. More detail on the future research activities would be helpful. Future studies are mentioned in various places, but it would add to the chapter if a final summary of future activities were added.

Figure 1. Plot of Data to Obtain Dispersion Curve



T	=	V/Q (theoretical detention time)
t_i	=	time for tracer to initially appear at the tank outlet
t_p	=	time for tracer at outlet to reach peak concentration
t_{10}, t_{50}, t_{90}	=	time for 10, 50, and 90% of the tracer to pass at the outlet of the tank
t_g	=	time to reach the centroid of the effluent curve
t_i/T	=	index of short-circuiting
t_p/T	=	index of modal detention time
t_{50}/T	=	index of mean detention time
t_g/T	=	index of average detention time
t_{90}/t_{10}	=	Morrill dispersion index—indication of degree of mixing

CHAPTER 8: Advanced Treatment Technologies for Treating Stormwater Discharges into the Everglades Protection Area

As with Chapter 6, ATT investigators are to be commended for collecting an enormous quantity of data. However, dimensions of experimental units, influent flow rates, and hydraulic residence times are frequently omitted. It is understood that most of this information is available in other documents. It is disappointing that analysis of the various unit processes investigated was not done more along the lines of the way an Environmental Engineer would analyze the situation: model the reactor using basic mass balance and reaction kinetics/stoichiometry principles.

It is significant that some of the ATTs can reduce TP to less than 0.010 mg/L, but it is critical that cost estimates be made so that the screening process can begin. Preliminary cost estimates will provide data that can be used to eliminate some of the options being considered and allow more resource to be devoted to the evaluation of the viable options.

Advanced treatment technologies under investigation: The introductory paragraphs provide an excellent summary of the activities, descriptions of the forms of phosphorus and problems facing the District. Were any of the effluents introduced into an environment similar to that expected after treatment? Is it possible that the treated effluent will return to a minimum sustainable concentration of TP (perhaps 0.030 mg/L)? What was the influent TP fractionation in Phase I studies? It is indicated that phosphorus was analyzed for PP, TDP, and SRP, but these data were not shown. How did the fractionation change seasonally and was performance of the reactors affected? Why were the results from Phase II not shown in Figure 8-3 or in a separate graph?

One of the important aspects of these treatment processes is how they will behave in response to events such as storm flows. Are experiments planned or have any been conducted in mesocosms or test cells where the systems are subjected to transients in inflow rate or phosphorus concentrations and types?

It would be helpful to see the results of individual treatments as a minimum in terms of percent phosphorus removal. With this information readers could draw their own conclusions, and it would facilitate analysis of the removal efficiency under different treatment conditions. A simple mass balance model including processes involving water-substrate interactions of phosphorus could be produced that would be useful for evaluation and design purposes.

There apparently was some replication of some treatments in the PSTAS mesocosms, and it would be helpful to see the variability. This is very important in evaluating the reliability of the process.

In the peat based system it is possible that shading of the attached algae reduced growth rates and consequently reduced phosphorus removal. It would be interesting to know what impact the macrophyte growth had on the hydraulic characteristics of the systems. The hydraulic characteristics of the PSTAs will vary with the amount of plant cover, and as plant cover increases light penetration decreases having a significant effect on algae growth.

Mesocosm tanks producing lower mean TP outflow concentrations than the test cells is probably attributable to all of the factors mentioned on page 8-11, but another factor is the possibility for greater short circuiting in the test cells. A careful analysis of the hydraulic characteristics of the two types of tanks may yield significant results.

It would be interesting to have an explanation of how the mesocosms were operated to obtain the different velocity in Phase 2. The velocity is a function of flow rate entering the mesocosm and the cross sectional area of the mesocosm; therefore, if recycle is used to control the velocity through the system, the HLR will increase and there will be an increase in the mass of TP entering the system. If the influent flow rate is decreased to compensate for the recycle, there is a corresponding decrease in the concentration of TP entering the mesocosm. In mathematical terms:

$$Velocity = \frac{Flow\ Rate}{Cross-\sec tional\ Area} = \frac{cm^3/day}{cm^2} = cm/d$$

$$\mathrm{HLR}_1 = \frac{\mathrm{Flow\ Rate}}{\mathrm{Surface\ Area}} = \frac{\mathrm{cm}^3/\mathrm{day}}{\mathrm{cm}^2} = \mathrm{cm/d}$$

$$\mathrm{HLR}_1 + \mathrm{HLR}_R = \frac{\mathrm{Flow\ Rate}}{\mathrm{Surface\ Area}} + \frac{\mathrm{Re\,cycle}}{\mathrm{Surface\ Area}}$$

The overall HLR cannot be constant without varying the flow rate or the surface area. How was the experiment conducted?

Another factor that will affect the velocity in the mesocosms (as well as the Test Cells) is the volume of plants in the cross-sectional area. Are the studies designed to account for the effects of plant growth on the hydraulics of the systems?

The field-scale PSTA experiments should yield interesting and useful results. It is good to see the third-point sampling stations. Too many wetland experiments and evaluations without intermediate data have been conducted and have yielded data subject to misinterpretation. Examples of this error are many of the early constructed wetlands systems and multiple cell wastewater treatment lagoon systems. Data from the influent and effluent to these systems have been used to design systems that have resulted in over-designs.

We suggest that one of the two unbaffled field scale units be constructed with a baffle covering about 2/3 of the cross-sectional area of the basin at the 1/3 points (at the sampling boardwalks) beginning on opposite sides. Research on large models have shown significant improvement in the hydraulic performance with such a simple modification in a straight-through flow pattern. Such a modification could be accomplished by attaching a baffle to the first sampling boardwalk and repositioning the second boardwalk to start on the opposite side from the first boardwalk and attach a baffle. A simple plastic sheet or boards would accomplish the desired effect. A copy of the material in the fourth reference is being sent, and other results of the research on baffling can be found in the following:

1. Mangelson, K. A. 1971. Hydraulics of Waste Stabilization Ponds and Its Influence on Treatment Efficiency. Ph.D. dissertation. Utah State University, Logan, Utah.

2. George, R. L. 1973. Two-dimensional Wind-generated Flow Patterns. Diffusion and Mixing in a Shallow Stratified Pond. Ph.D. dissertation. Utah State University, Logan, Utah.

3. Mangelson, K. A. and G. Z. Watters. 1972. Treatment Efficiency of Waste Stabilization Ponds. ASCE San. Eng. J., 98 (SA2), April.

4. Middlebrooks, E. J., et al. 1982. Wastewater Stabilization Lagoon Design, Performance and Upgrading. Macmillan Publishing Co., Inc. New York, NY.

Submerged Aquatic Vegetation/Limerock: Were the volumes or masses of vegetation the same in the reactors operating at HRT of 1.5, 3.5, and 7.0 days? It is very likely that one of the dominant factors in the performance of the SAV/LR is the growth attached to the vegetation.

The SAV/LR were analyzed only in terms of HRT. This assumes that the P removal process is a volumetric removal within the water column rather than an interfacial mass transfer to the bottom substrate. Has this been confirmed? An educated guess would be that the latter is more significant; therefore, overflow rate is the controlling parameter. If depth is the same in all reactors, then the same relationship between percent removal and HRT would exist for the percent removal and HLR, assuming that you know the actual HRT.

It is interesting that TP removal did not increase when the HRT was increased from 3.5 to 7.0 days, particularly since the concentration of TP appeared to be adequate to sustain the growth of attached algae. Were the actual hydraulic characteristics of the mesocosms essentially the same or were there sidewall effects or differences in vegetation that could account for the lack of an increase? There are similarities between the biological components of the PSTA and the SAV/LR. Were the HRTs in the PSTAs similar to the HRTs in the SAV/LRs? One significant difference was the influent TP concentration. It would be interesting to see a comparison of the two biological components taking into account differences in influent TP concentrations, HRT, and vegetation.

Were statistical comparisons of the mean effluent TP concentrations conducted to determine if they differed?

Were dye studies conducted to determine the actual HRT in the mesocosms? (See the discussion of hydraulics in the review of Chapter 6.) There are large differences in the nominal HRT and actual HRT (AHRT), and it is likely that many of the differences observed can be better explained if the AHRT were known.

Were the first year results from varying water depth less because of greater plant growth resulting in less light penetration, reducing the attached growth contribution to TP removal? It would be desirable to show the influent TP concentrations on Figure 8-8.

Harvesting of the plants in the SAV probably reduced the surface area available for attached microorganisms to grow. Long term effects without harvesting and allowing biomass to accumulate might increase TP concentrations by feedback to the water. It would be good to show pre- and post-harvesting and recovery data in Figure 8-8. Identifying dates when changes in operating procedures occurred would make it easier to understand Figure 8-8.

In the Effects of Substrate Types experiments the more vigorous growth of plants was an obvious factor in TP removal, but it is equally likely that the increase in plant growth also provided a home for the attached organisms resulting in additional TP removal.

Is it possible that the wide variation in the influent TP concentrations had an effect on the *Chara spp*. in the Sequential SAV/LR treatment system? About the time that TP concentrations became erratic there was a significant drop in influent TP followed by a significant increase that was followed by a rapid decline and then rather erratic input after that. Is it known why the senescence of *Chara spp.* occurred?

It would be helpful in interpreting the results of the Shallow Raceway (SR) experiments if the velocity, HRT and complete dimensions of the system were provided. It is difficult to compare the size of the SR that would be required to accomplish the same results as those obtained with the other ATTs. If the size of a SR system is not prohibitive, it appears to offer great promise as a biological solution to the phosphorus problem in the Everglades. Initial results after doubling the velocity and HLR indicate that the optimum velocity and HLR were selected during the first experiments.

The evaluation of STA 1-West Cell 4 is conducted in both Chapter 6 and Chapter 8. Are the same results presented in both chapters? Although somewhat redundant, it would be convenient to readers to have the results in both chapters.

Results in Table 8-6 appear to support lowering the HLR to 0.11 cm/day; however, additional information is needed to reach such a conclusion. It would be helpful to include the influent TP concentration in Table 8-6.

More detail about the dynamic simulation model would be interesting such as the basic form of the equation and variables to be considered.

Are hydraulic characterization studies planned for the future? Many of the results of the extensive research effort being conducted in the Everglades will be subject to considerable question if hydraulic characterization studies are not conducted. Very few variables are as critical as the hydraulics of an engineered system.

Are efforts being made to assess the "sustainability of long-term treatment?" Will there come a point when P buildup in the bottom substrate is enough to provide a P recycle feedback that will effectively reduce the efficiency of the treatment system, requiring some form of maintenance to restore its utility?

Chemical Treatment-Solids Separation: The pH value and alkalinity can have a pronounced effect on algae growth. Bioassay result will give some indication of what impact might occur, but has any thought been given to what impact the discharge of the treated water to a natural environment might have on periphyton, plants, etc.? With increases in sulfur concentrations is there a potential for blooms of sulfur bacteria and an impact on the production of methyl mercury from the deposits of particulate mercury?

Low Intensity Chemical Dosing: Figure 8-14 would be improved by adding the influent TP concentration. The decision to discontinue the LICD appears to be appropriate.

Managed Wetlands: What were the statistical relationships between the control test cells and the treatment test cells during Phase 1 Test Cells studies?

It is doubtful that the attempt to simulate sludge contact by recirculating sludge to the top of the flow stream in the test cells was a very realistic simulation. If the ability of the Managed Wetlands to remove TP is to be adequately evaluated, a typical system should be utilized as it appears will be the case at the Big Cypress Reservation. What operational adjustments were made to overcome the episodic floc overflow? On page 8-38 it is stated that TP and TPP concentrations in wetland outflow are lower when compared to the control. How much lower?

Conclusions

As mentioned in the opening paragraph, enormous quantities of data have been collected in the ATT studies, and the investigators are to be commended for their efforts. The Findings section is a good summary of the results from the various ATT studies, and it may be more appropriate that this section appear at the beginning of the chapter in the summary section and change the title to Summary and Findings. Such a rearrangement would make it much easier for the reader seeking the bottom line without wading through the detail.

Recommendations

1. It is strongly recommended that the analysis of the various unit processes investigated be done more along the lines of the way an Environmental Engineer would analyze the situation: model the reactor using basic mass balance and reaction kinetics/stoichiometry principles.
2. It is strongly recommended that the hydraulic characteristics of all of the ATTs be evaluated. Design information is not complete without good hydraulic information.
3. Cost estimates should be made as soon as possible so that the screening process for the ATTs can begin.
4. Analyses of the data should be conducted to determine the influence of the influent TP fractionation on performance of the ATTs.
5. Experiments should be conducted in mesocosms or test cells where the systems are subjected to transients in inflow rate or phosphorus concentrations and types.
6. Efforts should be made to assess the "sustainability of long-term treatment."

CHAPTER 9: Summary of the Lower East Coast Regional Water Supply Plan

The introduction, purpose, and process sections are all well written and provide the reader with a summary of issues and proposed action framework. It helped clarify a number of general questions related to how the overall planning of the region attempts to integrate the management of water and land resources for the benefit of established land-use goals. The chapter notes that the LEC Plan was set to meet water supply needs of the environment as well as urban and agricultural needs. The report notes that while the water needs of urban and agricultural consumers are largely met, portions of the Everglades and important estuaries do not receive adequate quantity, timing or distribution of water. However, the report clearly notes that meeting long-term environmental needs is as important as other demands being placed on the system.

Conclusions

1. The final report of the review panel for the 2000 draft report (page 28) noted that the lack of water for the "environmental sector" would be dealt with through the installation of a number of storage and water conveyance systems. The 2001 report did not note the status of these proposals. The panel suggests that it may be helpful if the District provided an update on provision of water to this sector.

Recommendations

1. Page 9-8, paragraphs 1, 2 are not clear. Paragraph 2 notes four areas that "did not fully meet their respective planning targets…", yet there are five noted under year 2005 in table 9-2. A more detailed explanation of why WCA 2B will not meet the planning target even by year 2020is needed.

2. The model used to determine future urban water needs should be reviewed (perhaps in a footnote or annex).
3. It is clear that certain management parameters had greater weight in determining whether future water needs could be met. Controlling salt water intrusion and meeting the goals of the CERP could be seen as high priority as compared to meeting all stated needs of the urban and industrial (including agriculture) sectors. The report should provide some context for understanding these parameters and/or other factors that might influence future management decisions for assigning water.
4. The ASR water management technology should be more clearly defined in either the List of Acronyms or in chapter 9 (page 9-6).

CHAPTER 10: Comprehensive Everglades Restoration Plan

As is noted in this chapter, the feasibility report recommended a comprehensive plan for the restoration and preservation of the south Florida ecosystem, while meeting other water needs of the region. The Restudy Bill authorizes the District to undertake three primary activities: to function as local sponsor for projects included in the CERP; to continue with ongoing monitoring, research and pre-construction engineering and design for projects included in the CERP; and the implementation of pilot projects. Some 68 major "components" involving either structural or operational changes to the existing Central and Southern Florida project are included in the CERP.

It is important that the public clearly understand that the Restudy Bill authorized the District to construct pilot projects to help *determine the feasibility* of technologies included in the comprehensive plan (page 10-1, summary, paragraph 2). It should be clearly stated that testing these technologies does not imply that they are proven. The District runs the risk of bad press and misunderstanding on the part of the public if pilot efforts prove not to be economically or technologically feasible in this region within the context of the overall plan. This last point is critical. A technology may be locally feasible, but not viable within a different context or larger region. Some effort should be made to explain this context if only in a footnote.

The important concept of a "program" cannot be overemphasized as a means of avoid misunderstanding as to both process of developing and sequencing of investments as well as anticipated results. Also it must be clearly understood that a "Master Program Management Plan" does not imply finality, but rather provides a framework for adjusting investments to new scientific data and the results of the pilot projects.

Conclusions

1. There is no clear statement as to which agency (Corps or District) is responsible for ensuring that the goals of the CERP are met, nor is there any discussion as to how differences of opinion are to be resolved.

2. Public outreach plans seem well thought-out. The public should be involved from the outset in planning efforts for this aspect of the comprehensive planning process. It is not clear if this is the case. It might help to note that the principles of the Inter-American Strategy for Public Participation in Environmental Decision-Making, as approved by all 34 member states in December, 1999 (including the U.S.) will help “guide this planning effort to establish a transparent role for civil society input”. A copy of the ISP was provided to the District in 1999.
3. Figure 10-2 presents a logical framework for restoration activities by the interdisciplinary task teams. What is not clearly stated is how they will interact. This may lead to misunderstanding by the general public as the restoration process is not linear or time constrained in nature.

Recommendations

1. A clear statement should be made as to how the CERP should be adapted as new information is forthcoming in the implementation process.
2. A clear statement must be made as to the water quality monitoring process that will be employed as implementation proceeds.
3. The report should attempt to define "restoration" or "recovery" in a way that relates specific management goals or legislative mandates of P or Hg thresholds and levels to the more general goals of the CERP and the long-term health of the Everglades system. Perhaps some attempt should also be made to distinguish between the potential impact of P and Hg in the overall management scenario.
4. It seems logical that as investments are initiated, a summary, perhaps in a tabular format, be included at the outset of this chapter. This table should also include some statement as the projects relate to issues such as management of TP, site specific P. Hg, etc.

CHAPTER 11: The Everglades Stormwater Program

The purpose of the Everglades Stormwater Program is to ensure that water quality standards will be met for areas of the Everglades Protection Area that are not directly involved in the Everglades Construction Project (ECP). The ECP covers seven of the 15 major basins that discharge into the Everglades Protection Area. The Stormwater Program is responsible for implementing water quality strategies for the eight remaining basins and interior waters of the Everglades. The aim of the Stormwater Program is to complete basin-specific feasibility studies and engineering designs to determine the optimal combination of water quality measures required to achieve the long-term goal of the Everglades Foreever Act.

Two key words in this program are strategy and schedules. The strategy is defined by the Regulatory Action Strategy (RAS) and involves developing a basin-specific regulatory program to ensure compliance with all water quality standards, and the schedule is to meet these standards by December 31, 2006. There is also an earlier deadline to complete the basin-specific feasibility studies and engineering designs by December 31, 2003. There are seven steps in the development of the basin-specific feasibility studies and engineering designs. These steps are outlined on page 22 of Chapter 1, and progress towards their completion is provided on pages 7 to 12 in Chapter 11. It is not clear from the content of these pages whether the program will complete the feasibility studies and designs by the December 31, 2003 deadline. It might be useful in the next report to include a time chart showing where each step resides with respect to the December 31, 2003 completion date.

Included in this section is a description of the on-going work in the Everglades Agricultural Area (EAA). It is not clear why this is included in Chapter 11, given that the results of the Best Management Practices now being implemented in the EAA have been adequately covered in Chapter 5.

A basin-by-basin update of activities along with a summary of findings is provided. The report concludes that water discharging into the EPA from non-ECP basins is generally acceptable with the exception of phosphorus concentrations discharging from three of the eight basins. This comes as surprise because in the basin-by-basin descriptions, only one basin is cited for discharging high phosphorus concentration water. But the high phosphorus concentration in the discharge waters of the three basins is confirmed by data in the appendices.

Conclusions

1. The water quality monitoring data for all non-ECP basins show remarkably few excursions except for total phosphorus and dissolved oxygen.
2. In reviewing the water quality data, it appears that too much effort is being expended on measuring dissolved oxygen, and that more work should be directed toward establishing site specific alternative criteria (SSAC) for dissolved oxygen.
3. The Stormwater Program's effort to measure both flow volume and phosphorus concentration indicates that it considers phosphorus load rather than phosphorus concentration to be the critical water quality parameter.

Recommendations

1. In the next report a chart showing a time-line relative to the December 31, 2003 deadline should be provided for all seven steps of the basin-specific feasibility studies and engineering designs.
2. Since sulfate-sulfur is involved in production of methyl-mercury, the Program should follow the sulfur and mercury projects to determine whether discharge waters need to be monitored for sulfur.

CHAPTER 12: Land Acquisition Projects in the Everglades Region

This chapter discusses land acquisition and a summary of projects. It appears all acquisitions are consistent with project goals. The chapter was logically and clearly presented.

Recommendations

1. It may be useful if mention of the legal tools and processes available for resolving conflicts over land acquisition disputes were noted.
2. The material in Chapter 12 could be included in Chapter 1 and not exist as a separate chapter.

CHAPTER 13: Managing Fiscal Resources

It appears this chapter fully meets the requirements for the 1997 Everglades Oversight Act for submission of an annual report. The chapter discusses the funding sources to carry out projects costing an estimated $827 million (up $20 million from last year) over 20 years. The chapter also notes spending of $367 million for restoration activities for Florida Bay through year 2004. While presenting a complete financial system, the procedures appear appropriate for the project.

Recommendations

1. More explanation on the unfunded mandates and the relation to reaching the overall goals of the CERP would help reader understanding. For example, reaching the water quality goals by 2006 will require funding some of the currently unfunded activities. Without such funding the District may be in non-compliance with mandates of the Board or forced to take management decisions without complete information.
2. The summary presentation of this chapter in year 2001 public hearing process could be included with the chapter 1 presentation.

PART II: EVERGLADES ECOLOGY: RESPONSES TO PHOSPHORUS ENRICHMENT AND ALTERED HYDROLOGY

Chapter 2: Hydrologic Needs: Effects of Hydrology on the Everglades

This chapter is vital in setting the stage for following sections of the report. It describes hydrologic patterns in relation to natural processes and water system management, and the effects of altered hydrology on biological processes. Rather than repeating data on hydrologic patterns given in the previous reports, it focuses on water year 2000 and compares patterns of precipitation, inflow, and water levels with the 30-year average. It describes patterns brought about by Hurricane Irene, and by operations of the Interim Structural and Operational Plan (ISOP) designed to provide water levels to maximize potential for nesting of the Cape Sable Seaside Sparrow. This chapter also includes more information on probable historic water flows in the Everglades system, and on the importance of these flows in maintaining the ridge and slough microtopography that influences biotic communities. One section addresses the health of seagrass beds in Florida Bay and the potential effects of increased freshwater flow to the Bay. The final part of the chapter gives an update on tools for hydrologic management, including the Everglades Landscape Model, and describes the Applied Science Strategy process of the Comprehensive Everglades Restoration Plan (CERP) and the use of regional conceptual models for developing and evaluating restoration performance.

The influence of Hurricane Irene on water volumes and flows in the Water Conservation Areas (WCAs) and Everglades National Park (ENP) shows the very dominant effect that pulsed climatic events can have on the Everglades. This storm resulted in a high water peak during an otherwise dry year, contributed to above-average inflows into the WCAs, and may have prevented drought-related events such as fires. As an editorial comment, it would be most helpful to the readers of this report who are not completely familiar with the engineered aspects of the Everglades system to describe the locations of various control structures (pumps, levees, canals) when they are mentioned in the text.

The section on pre-drainage hydrology builds a compelling case for the importance of the historical flows in maintaining the peat-based ridge and slough microtopography that supports the sawgrass and slough communities in much of the Everglades. Understanding these historic flows and their effects on carbon transport, to the extent possible, is critical to evaluating restoration options that will maintain this landscape. So far the evidence, based largely on interpretation of aerial photography and on historical accounts, sounds convincing, but there are no experimental data or field studies to support these assumptions. This research should continue, and the District is to be commended for initiating a new ridge and slough research program in the next year to examine hypotheses associated with these carbon and nutrient transport processes. This will allow for better prediction of long term effects of hydrological alteration, nutrient control, invasive species, and mercury contamination abatement. These data form the basic abiotic background needed to understand the functioning of the Everglades system. Similarly, paleobotanical research should be continued to further establish the historical trends of vegetation, and peat accretion should be addressed more closely in an historical perspective.

These hydrologic data raise issues about their application in future management and restoration. The report hypothesizes that the ridge and slough landscape can be restored and preserved only by establishing unimpeded flows consistent with pre-drainage patterns. This conjecture could significantly affect plans for restoration, and itiraises the question of whether such flows can reasonably be established? If not, what will be the short- and long-term impacts to the ridge and slough landscape? Literature on the effects of structures on sedimentation and erosion and on accepted techniques for analysis of theses phenomena should be reviewed. Documentation from historic accounts of the earlier occurrence of sawgrass marsh on the southwestern rim of Lake Okeechobee (rather than a forested rim) is significant to the understanding of historic outflows from the Lake into the Everglades. This raises questions of whether the assumptions that Lake Okeechobee outflow occurred throughout the year, and that more outflow passed through the western portion of the southern shoreline, have implications for proposed management or restoration?

The section on ecological trends includes studies of cattail and sawgrass responses to hydrology and nutrients, recent findings from the tree island research program, preliminary data on seagrass responses to Everglades input into Florida Bay, and information on wading bird and macroinvertebrate responses to hydrology. New experimental results on cattail and sawgrass responses to hydrology, nutrients and fire are presented in this report. Experiments evaluating the response of cattail to muck-burned, surface-burned, and non-burned soils suggest muck burns facilitate cattail growth. Similar experiments with sawgrass, and with cattail and sawgrass together, would be relevant. Studies quantifying aspects of the life cycles of sawgrass and cattail point to differences in the timing of seed production and dispersal, and differences in germination and early seedling growth responses, that may interact with natural hydrologic patterns in the Everglades to either control or promote the spread of these species. These findings raise the questions of how this information might be used for management. Is it possible to manage hydro period to discourage cattail spread? Such management should be assessed with regard to effects on diurnal DO curves because they are important to the biogeochemistry of the system. The inclusion of more physiological data on cattail and sawgrass is appreciated, but the findings of the phytotron studies are not well integrated into the research on these emergent macrophytes. The implications of these results are not clearly placed into a management context. It would be very helpful for the District to integrate the findings presented in this section on ecological trends with prior work and provide a synthetic summary of the state of this knowledge in relation to choices about how to manage nutrients and hydrology in the Everglades. If this synthesis cannot be accomplished in the 2001 report, it should be considered as a task for the coming year.

The preliminary data from two tree islands suggest that the health of tree island vegetation is sensitive to flooding, which is related to the elevation differences between the ground, surface, and surrounding water levels. Future results from this program and from additional islands should be valuable in understanding tree island ecology, sustainability, and restoration. The section on effects of Everglades freshwater inputs to Florida Bay and growth of seagrasses is also rather preliminary. Factors associated with freshwater inputs to Florida Bay change sub-daily, daily, seasonally, and annually. There is no information on how sampling frequency was determined. Can a single freshwater inflow event have a catastrophic effect? Is there a salinity threshold level beyond which seagrass or other biological components cannot recover?

A great deal of effort and discussion is being spent on the conceptual models for the Comprehensive Everglades Restoration Plan (CERP). This report gives a general description of the strategy of developing these models for the major landscapes of South Florida, as a basis for identifying performance measures and restoration targets, and to identify critical linkages between stressors and attributes. The "Applied Science Strategy" as a process for linking science and management in the planning and evaluation of the restoration process is commended. However there are many aspects of this process that are not clear. For example, how will the models or the performance measures be handled quantitatively. The report states that "a performance measure identifies which element of each stressor must be corrected, how these elements should be measured, and how those elements must change to eliminate or reduce their adverse effects," but it is not described how this is to be accomplished. Are there numerical endpoints for the performance measures? How is it determined when a success has been achieved? The Panel understands that SFWMD is wrestling with these issues. However, the example of the marl prairie/rocky glades model included in this chapter does not reveal the science behind the proposed linkages. It would be useful to show where the relationships are understood and quantified through scientific study, and where they are hypothesized. Such information could be placed in an appendix.

Review comments on Chapter 2 provided by the USDOI Everglades Program Team (EPT) raise useful technical points and perspectives that should be given careful consideration by the District in the final revision of this report.

Conclusions

1. This chapter is important in providing the basic background needed to understand the functioning of the Everglades system, and is a critical part of the Everglades 2001 Consolidated Report.
2. Information on historical flows and their importance in maintaining the hydrology and vegetation of the system should be incorporated into the restoration plans for the Everglades. Given the importance of this information to restoration scenarios, the research needs to be developed further and carefully documents.
3. It is not clear how the conceptual ecological models or the performance measures, will be used quantitatively to identify which element of each stressor must be corrected, how these elements should be measured, and how those elements must change to eliminate or reduce their adverse effects.
4. New experimental studies on the responses of cattail and sawgrass to hydrology, nutrients and fire are presented. These findings are not integrated with prior research in this area.

Recommendations

1. Research on historical flow patterns, hydrology, and vegetation should continue. This should include a review of literature on effects of structures on sedimentation and erosion and on accepted techniques for analysis of these phenomena. Study plans should be documented, and the findings should be reviewed by peatland ecologists and geomorphologists and published in the peer-reviewed literature.

2. It would be useful to indicate how information from several of these studies, such as the information on historical flows, or on the responses of cattail and sawgrass to hydrology, might be incorporated into management and restoration plans.
3. More information needs to be given about the science supporting the conceptual ecological models, and how they will be used in evaluating restoration success.
4. The District should develop a synthetic summary of the state of knowledge of the responses of cattails and sawgrass to hydrology, nutrients and fire, in relation to choices about how to manage nutrients and hydrology in the Everglades.
5. Review comments from the EPT should be given careful consideration by the District in the final revision of this report.

CHAPTER 3: Ecological Effects of Phosphorus Enrichment in the Everglades

The Everglades Forever Act (EFA) finds that waters flowing into the Everglades Protection Area (EPA) contain excessive levels of phosphorous (P), and that a reduction in P will benefit EPA ecology. The South Florida Water Management District (SFWMD) and the Department of Environmental Protection (DEP) are required by the EFA to complete research to establish a numeric phosphorous criterion by 31 December 2001. The criterion cannot be lower than the natural conditions of the EPA, and must take into account spatial and temporal variability. Furthermore, compliance with the criterion must be based upon a long-term geometric mean of concentration levels at sampling stations representative of EPA receiving waters. Failure to adopt a P criterion by 31 December 2001 will result in establishment of a default criterion of 10 ppb P.

The 1999 Interim Report and the 2000 Consolidated Report provide information on the effects of P enrichment on the EPA, including analyses specific to Water Conservation Area 2A (WCA-2A) and Loxahatchee National Wildlife Refuge (LNWR). Chapter 3 provides an update of data collection and analyses performed in support of P criterion establishment. The update focuses on the approaches to criterion development, a summary of previously reported research efforts and findings, major research efforts including work performed by the SFWMD/DEP and the Duke University Wetland Center (DUWC), status of the WCA-2 criterion, LNWR findings, preliminary central and southern Everglades findings, and information submitted by others. To date, only data from WCA-2A and WCA-1 have been collected and evaluated.

Key findings of the research programs are described. First, the evaluation of data collected along gradients in WCA-1 and WCA-2A allow differentiation of minimally impacted sites from significantly altered sites. Second, the annual geometric mean of P concentrations at reference sites in WCA-1 and WCA-2A ranged from 5.9 to 10.5 ppb. Third, based upon the aforementioned information, the EFA default criterion of 10 ppb would be protective of the natural flora and fauna. Fourth, the DUWC study supports a P threshold in the range of 17 to 22 ppb. Fifth, the Environmental Protection Agency concluded that the Miccosukee Tribe of Indians water quality standard of 10 ppb P is scientifically defensible. And sixth, an attempt to create a localized P-enriched zone for the purpose of recreating historic vegetation is not practical, but a beneficial application may be found.

For the most part, the chapter presents a defensible scientific account of data and findings for the areas being addressed, and the information is presented in a logical and complete manner. Changes in multiple biological and chemical metrics occurred at approximately the same location along the gradient transects in WCA-1 and WCA-2, and support the robustness of the transect study design and the reference site approach. Mesocosm studies have generally confirmed the effect of P enrichment. Although the biological criteria exhibit a clear break point along the P gradient, the chapter would benefit from illustration of the variability in P concentrations at the impacted sites.

The chapter does not address at length the concept of a localized P-enriched zone in the vicinity of the stormwater treatment areas for the purpose of creating historic vegetation. The idea was deemed impractical. Bioengineering can achieve much, but creating habitat (e.g., pond apple) requiring very different soils and hydrology than presently exist would make success costly and risky. Recognition of the value of a pond apple habitat would be better addressed by restoration at the original site.

The chapter findings and conclusions are generally supported by "best available information." The DUWC threshold approach is no less scientifically valid than the reference site approach. In fact the reference site approach and the threshold approach will likely yield fairly consistent results if differences in means calculations are reconciled. And both approaches suggest a criterion consistent with the threshold (10 to 20 ppb P) above which biota in other low nutrient waters respond to nutrient enrichment. However, the panel is concerned that the CART statistical analyses used by DUWC is inappropriate for setting criterion.

Admittedly, the DUWC information would be more valuable if the interpretations were consistent with the mandate of the EFA. The SFWMD/DEP should continue working with the DUWC to extract as much value as possible from their information. Two central issues should be addressed to improve consistency with the EFA. First, the DUWC P levels are derived as mean breakpoints; i.e., there is roughly a 50 percent chance that there will be a significant shift in biological indicators. Clearly this is not a protective measure, and it would be more helpful to know what the lower confidence limits are for the indicators considered. Second, the DUWC breakpoints are based upon arithmetic means rather than the geomeans requested by the EFA. The DUWC data should be re-analyzed using geomeans. The DUWC studies do provide valuable information on the ecology of the Everglades but may not be appropriate for criterion setting.

Use of the DUWC information should also consider two other points. Mesocsom experiments can sometimes give spurious results that do not relate well to whole-system responses. For example, the enriched DUWC flumes never attained a biotic state typical of the enriched portions of the WCAs. Also, cattails occurred at the DUWC transect in WCA-2A despite P concentrations were of less than 20 ppb.

The SFWMD/DEP might also reconsider USEPA Regional Monitoring and Assessment Project (REMAP) data. Differences in sampling methodology do not necessarily negate the value of the information. In fact, the use of independent data sets can help establish the robustness of data and interpretations for a large, synoptic project like the Everglades. To facilitate future use of the REMAP information, USEPA should be encouraged to submit comments during the review period and to participate in the public sessions. The recently submitted comments were received too late to receive the full attention of the review panel.

The report should consider alternative interpretations of the data and findings. The SFWMD/DEP research correctly identifies the annual geomean P value at minimally impacted sites in WCA-1 and WCA-2 as about 10 ppb. However, the report minimizes discussion of variability about this geomean, and about the geomean at impacted sites. Explanation(s) for observed temporal variability should be considered. For example, the suggestion by the DUWC that P concentrations vary with depth should be evaluated. Alternatively, P concentrations could be evaluated with regard to photoperiod, rainfall, or any number of other variables. Understanding variability around a geomean of 10 ppb P may be fundamental to maintaining the health of the natural system. Everglade's biota may be dependent upon periodic or seasonal increases in P to fulfill life requisites. Future research should consider the possibility that Everglades biodata are influenced not only by geometric means of total P, but also the variability surrounding those means. It is possible that damping temporal variation in P loading may alter the system in ways unintended by the EFA.

Additional data summaries and analyses should be included in the future. Aside from the issue of temporal variability in water column P, sediment P should be better understood. Of critical importance is the relationship of sediment P to water column P. Generally, sediments lag the water column in their response to load changes. In systems like the Everglades where external loads are decreasing, the surface sediments may act as a buffer against a rapid response of water column P. Recommended studies include: 1) determining if an equilibrium exists between surface sediment concentrations and water column concentrations, 2) analyzing the P depth profile to determine the history of P loading to the systems, and 3) developing a mass balance model to address questions about system response time and the potential for expansion of a high P front in the WCAs.

The rate of expansion of the high P front is probably related to anoxia events evident in the diurnal oxygen curves found in the impacted areas. P mobilization is known to increase under anoxic conditions in the water column. Anoxia will increase the influence of sediment P on P content of the water column. Thus, research should continue on the relationship among community structure, P enrichment, and diurnal oxygen curves.

The rate a P plume spreads may be related to sulfur and iron dynamics in the system. Work in a Netherlands wetland system has demonstrated that introduction of sulfate-rich, iron-poor water led to an increase in phosphate mobilization. The effect occurred even when the inflow was stripped of P. The increased mobilization occurred because sulfate is reduced to sulfide, and the sulfide precipitates the iron in the anoxic sediments. Iron is crucial to keeping P precipitates in the sediments in the oxidized microzone. High sulfate water is entering the STAs and WCAs from the Everglades Agricultural Area (EAA).

The management scheme should not ignore nitrogen contamination. *Scytonema* is heterocystous and common in some parts of the wetland. The presence of a nitrogen-fixing species suggests that nitrogen is limiting in some parts of the wetland. The nutrient bioassays reported in the peer review session were laboratory-based using non-cyanobacterial species, and may not be directly applicable to the nitrogen limitation in the periphyton mats. Controlling both nitrogen and P may be necessary to maintain the system in some locales.

The relationship between EPA biota and other water quality parameters (e.g., turbidity, sulfur, etc.) was likely examined early in the research program. Nevertheless, the report would benefit from reference to these studies. If these studies were not conducted then the relationship between EPA biota and other constituents of EAA runoff should be examined. Of particular concern is the relationship between Hg and S. Preliminary evidence suggests that S in agricultural runoff has the potential for exacerbating the production of MeHg. Representatives for the Sugar Cane Growers Cooperative of Florida have suggested that P enrichment may ameliorate S effects. No credible evidence was provided to support this contention. Nevertheless, the SFWMD/DEP should increase our understanding of the relationships between P, S, and MeHg.

Finally, establishment of a P criterion would benefit from a cost benefit analysis. The stormwater treatment areas appear, in their current configuration, incapable of reducing P to 10 ppb. With the exception of chemical treatment, advanced treatment technologies may also be incapable of achieving a 10 ppb P criterion. Therefore, there should be a clear understanding of the practicality of a 10 ppb P criterion and the affect of a higher criterion on the Everglades ecosystem.

Conclusions

1. EPA sites minimally impacted by P enrichment can be differentiated from impacted sites.
2. The EFA default criterion of 10 ppb P may or may not be protective of EPA biota. However, the multiple studies cited support 10ug/L as a criteria that would be protective of natural flora and fauna.
3. The SFWMD/DEP have not fully realized the value of the DUWC information.
4. Temporal variation in water column P is common in minimally impacted sites, and is not well understood.
5. The relationship between sediment and water column P is poorly understood.
6. Presently, there is no direct evidence that P enrichment ameliorates S effects on the production of MeHg.

Recommendations

1. The SFWMD/DEP should continue efforts to reconcile DUWC and findings. Efforts should include calculation of DUWC geomeans and determination of lower confidence limits.
2. The nature and implications of water column P temporal variability should be understood. Studies might include: 1) an examination of the relationship(s) between water column P and other parameters such as photoperiod, depth, and precipitation, 2) an evaluation of the effect of a 10 ppb P geomean standard on water column P variability, and 3) potentially, experiments to determine the effects of diminished P on EPA biota.
3. The relationship between sediment P and water column P should be determined so that sediment P front movement and system response to changing P loads can be predicted.
4. The system should be evaluated for potential nitrogen limitation.

Chapter 14: Exotic Species in the Everglades

Exotic plant and animal species have become a serious problem in South Florida, and much environmental damage can be done by these invasive species. Florida is listed as one of the four states in the U.S. with the greatest number of non-indigenous species. The management and control of invasive species has been an issue since the beginning of the Everglades restoration effort, and is one of the priorities established by the South Florida Ecosystem Restoration Task Force (SFERTF) in 1993 and by the Everglades Forever Act in 1994. Thus, an overview of the problem and of management efforts to control exotics is a useful component of the 2001 Everglades Consolidated Report.

This chapter begins with a history of organized efforts to assess the environmental problems caused by invasive species, and to reverse or control their spread. There are a number of these initiatives, supported through numerous agencies and mandates. A comprehensive plan that coordinates these many efforts into a consistent strategy is required and is identified in the chapter as a major future need. It is hoped that the Noxious Exotic Weed Task Team (NEWTT), established by the SFERTF and Working Group and funded in 1999, will develop comprehensive interagency strategies for eliminating or controlling the spread of noxious plants. As pointed out, a similar effort is needed for exotic animal species in the Everglades. To this end, an ad hoc interagency team established by the Working Group in 1998 has been gathering information for an assessment of the status of non-indigenous animals, including efforts by various agencies to deal with them.

The focus of this chapter is limited almost entirely to invasive plants, including the activities of the Exotic Pest Plant Council (EPPC) in identifying and categorizing non-native plant species, and documenting their status. The narrative that describes these efforts, and projects targeted toward selected species, should be rewritten in a more logical and concise manner. The distinctions between the most noxious and less noxious categories of species become confusing (e.g., the EPCC Category I and II lists versus the “priority species” and “secondary species” lists). The chapter does not provide information on the ecological effects of invasive species, such as their competitive interactions, alterations of habitat conditions, and effects on food chain pathways and nutrient cycling. Although such information may be limited for many species, an indication of research in these areas would be appropriate.

A more informative presentation of information in this chapter might be to select those species that have been the major targets for monitoring and control, and for each to describe briefly such aspects as: 1) their major ecological effects and threats; 2) techniques or processes used for their control; 3) level of success so far; and 4) costs (if such information is available). The section on herbicides would be more useful if these compounds and application methods were described in the context of which species they are used to control. The appendix could be modified to present only the melaleuca data as an example of a comprehensive program to control an invasive plant.

Although the emphasis on plants in this chapter is explained, some description of the impacts of invasive animal species is warranted, especially since 26% of the resident mammals, birds, reptiles, amphibians and fish in South Florida are not native. Even though the effort to assess the spread and effects of exotic animals has lagged behind that of plants, the Panel feels that a description is needed of the major species problems, especially those associated with exotic fish. Perhaps information from the ad hoc team report could be incorporated to give reviewers a sense of the extent of exotic animal species, management issues, and needs. The 2000 Consolidated Report also noted the absence of information on invasive animal species and recommended that the addition of information on animals be included in future reports.

The section on information gaps and future needs is particularly important, in pointing to the need for coordinated efforts among agencies in the control of invasive species, and for building public/private partnerships that enable a regional approach to pest management.

Conclusions

1. There is a strong need for a comprehensive plan that coordinates strategies for management of invasive species among agencies, and also develops strategies for developing partnerships with private landowners.
2. There needs to be much more study of the ecological impacts of invasive plant and animal species, of the potential use of biological control organisms, and of the potential invasiveness of many species that have received less attention.

Recommendations

1. The chapter should provide more information on the ecological effects of invasive species, such as their effects on food chains and nutrient cycling in ecosystems, rather than focusing chiefly on monitoring and control programs.
2. Information on the effects of invasive animal species in South Florida, and the status of programs to monitor and control them, should be included, even though such studies have lagged behind work with invasive plant species.

PART III: WATER QUALITY AND MERCURY IN THE EVERGLADES PROTECTION

CHAPTER 4: Status of Water Quality Criteria Compliance in the Everglades Protection Area

This chapter, in addressing standard compliance, presents a major line of evidence demonstrating management's accountability for the water quality 'goals' established for the Everglades. The tables of standard violations attempt to summarize large volumes of data into a digestable format. The discussions of standard violations, organized by water quality constituent, provide additional insight into the nature of the issues facing water quality managers in the Everglades. The appendix presenting the dissolved oxygen standard analysis is well done and documented as is the appendix addressing chronic toxicity based guidelines for pesticides and priority pollutants.

The 2001 Chapter 4 presentation incorporates many of the recommendations made during the peer review of the 2000 report. The upfront summary tables, followed by constituent-by-constituent is an effective presentation of the information. Given the lack of a standard and well accepted means of performing water quality standard evaluation assessments, the authors of Chapter 4 are evolving, report to report, a data analysis and presentation format that communicates well. To produce the Chapter's results, considerable efforts is devoted to collecting the samples, analysing them in the laboratory, placing them in a data base, retrieving them for analysis, preparing the data records for analysis, choosing statistical methods to analyse the data, and reporting the results. A brief summary of the steps leading to the results (i.e. the design of the monitoring system), should be included in the appendix to remind the reader of Chapter 4 each year of the effort involved in obtaining the information. Such an appendix, included in each report, would help connect the annual reports.

The purpose of the 2001 Chapter 4, as defined in paragraph two of the 'Background' subsection, is to 'provide an update concerning the water quality status for each region of the Everglades Protection Area for WY 2000.' The chapter title indicates that the subject of the chapter is 'criteria compliance.' A quote in the 'Background' subsection (which is not referenced) indicates the two agencies involved with the report are to 'evaluate existing water quality standards.' Under the 'Excursion Analysis Methods' subsection, the approach used in preparing the report is to 'provide an overview of the status of compliance with water quality criteria in the EPA.' It would help this reviewer if there were an introduction to the chapter that explained its major purpose along with more specific details about specific subobjectives.

To illustrate potential content of a clear statement of purpose, the following wording is provided as an example: The purpose of this chapter is to provide an overview of the status of compliance with water quality standards in the Everglades Protection Area. More specifically, the chapter will:

1. Describe the standards that apply to the Everglades Protection Area;
2. Provide an overview of the monitoring system, including data analysis methods, employed to determine compliance with applicable water quality standards;
3. Summarize areas, times and constituents where standards are not being met and indicate trends in compliance over time and space;
4. Discuss standards violations as to causes and management actions taken;
5. Present analysis of the dissolved oxygen standard violations and propose an alternate standard that better reflects background conditions; and,
6. Review all pesticide and priority pollutant data currently available to determine guidelines for future screening detected concentrations.

With such a list of sub objectives, the chapter's subtitles and appendices could be structured to guide the reader through the chapter's material in a manner clearly connected to its purpose. Chapter 5's subtitle arrangement provides an example that includes a clear statement of purpose and overview of the subject being included in the chapter.

The title of Chapter 4, which refers to 'criteria compliance,' appears to confuse the terms 'criteria' and 'standard'. A criterion is generally considered a scientific judgement used to define the level of a constituent deemed protective of a given use of water. A criterion is not associated with a specific water body. A standard is defined as a designated use of water (protecting a native ecosystem in the case of the Everglades) along with the criteria required to protect that use. While a criterion is a scientific judgement, a standard is legal and, as such, a major ‘management tool.’ Thus, it appears that ‘standard compliance’, as opposed to ‘criteria compliance’, is the subject of the chapter.

In the last paragraph on page 4-8, mention is made to ‘loose’ hypothesis testing and ‘common scientific practice’ but no references are provided to support the use of science in the manner described. Upon checking the reference list for Chapter 4, it is noted that many of the references (15 of 24) are derived from Florida. Furthermore, there are no references regarding the options available for conducting assessments of standard compliance, to better support the approach being used in the chapter. The latest water quality criteria document referenced is 1976 – many additional criteria documents have been issued since this date.

Chapter 4 documents the methods used to collect and analyse samples, via reference to methodology documents, but does not address potential changes that have occurred in the sample and laboratory methods over the years. Changes in methods over time may be interpreted to be changes in water quality. An assessment of possible changes in methods, that could influence results of the data analysis, would strengthen the chapter’s findings from a scientific point-of-view.

Whenever a large water quality data set is analysed, questions regarding how missing data, outliers, and non-detects are handled must be addressed. Chapter 4 explains how non-detect data are being handled, but does not indicate how outliers and missing data, if critical to the analysis, are being handled during the analysis. This need could be met with the brief overview of the steps taken to produce the results of Chapter 4 (i.e. monitoring system design), mentioned above.

The dissolved oxygen site-specific alternative criterion development description in the appendix contains a well-documented definition of compliance. The authors are to be complemented for adding this critical component to their criterion development. By adding a clear definition of compliance, future analysis of monitoring data for standard compliance is also defined. It is strongly recommended that future criterion development for P also contain a well-documented definition of compliance.

In Table 4-9, how was the unionized ammonia concentration calculated? Calculating the unionized ammonia using the outflow annual averages for pH, temperature and total nitrogen minus the nitrite+nitrate yields a value of approximately one-half the value reported. Is the total nitrogen value actually TKN? A value for Ammonia-N is not given; therefore, the calculation was made as described above. It is recognized that using concentrations from individual analyses would give a different average value, but not by a factor of two unless some of the individual values were very large.

Other Comments and Questions

1. The definition of the term ‘excursion’ is confusing. Are excursions violations of standards and/or guidelines? Is the concept of a ‘violation’ of a standard used in the report? What is the difference between an excursion and a violation?

2. How is the term 'parameter' defined, especially relative to the parameters used in the statistical tests conducted? The definition of 'parameter' used in the Glossary is not consistent with its use in the field of statistics, but is in common use in water quality management. In a peer reviewed report where statistical analysis is being utilized, there is concern about confusion in terminology.
3. Is the excursion analysis method employed in this report exactly the same as used in the last two reports? If not, how have the methods changed? Again, by having a summary of the monitoring data analysis methods in the appendix, this question would be answered.
4. How did the Class III dissolved oxygen standard of 5 mg/l come to be applied to the Everglades in the first place? Were no DO measurements taken prior to 1994 in the EPA?
5. A 'one-tailed' test is mentioned on page A4-2-16. What hypothesis (both null and alternate) is being tested? What alpha level was used?
6. The statements referring to Type I and II errors discussed on pages A4-2-25 and A4-2-37 are not clear. Are the errors associated with comparing model predictions to the actual data or are they related to determining if a violation has occurred? How do Type I and II errors enter into standard compliance when simple proportions are being computed?
7. In development of the DO SSAC (page A4-2-37), what data are being used – at all sites? Only reference sites? On what basis was the 'final model' chosen? What selection criteria were used?
8. Why is 10% used as the breakpoint for deciding a violation has occurred on page A4-2-55 when 5% is used on page 4-9? EPA uses a different set of categories in developing 303(d) lists, why is this approach not used in Chapter 4? Is there literature that could be cited to justify use of the 5%?
9. Criteria, for some water quality constituents, are related to environmental factors such as hardness, pH and temperature. Reference to this literature would enhance the scientific basis for the discussion of the dissolved oxygen SSAC where efforts are being made to produce a seasonal criterion.
10. Appendix 4-4 refers to a number of U.S. EPA publications but does not list them in the reference list. They should be listed as formal references.
11. In Table 4-12 TKN is reported rather than TN as reported in Table 4-9. Were two different concentrations available? Consistency in reporting the data would be helpful.

Conclusions

1. The overall strategy employed to determine water quality standard compliance is deemed appropriate and the findings are presented in an easy to follow format – summary tables followed by verbal explanations of each constituent's excursions.
2. The chapter suffers from lack of an 'Introduction' section with a clear statement of purpose tied to the organization of the material in the chapter.
3. The exact means by which the data used in Chapter 4 are produced has been described in previous reports. A summary of the monitoring program design, included in the appendix, would help remind readers of the source of the data.
4. The dissolved oxygen alternative criterion assessment is well developed and documented. The inclusion of a clear and well-documented definition of compliance in the study is viewed as being on the cutting edge of criteria development.
5. The evaluation of chronic toxicity based guidelines for pesticides and priority pollutants is straightforward and well documented.

6. The definitions of criteria and standards used in the chapter do not appear to follow standard norms. A criterion appears to be a legally enforceable limit while it is usually considered a scientific derived value deemed necessary to protect a given use of water. This problem appears to be beyond the scope of the chapter due to the wording employed in the Everglades Forever Act.

Recommendations:

1. The chapter could benefit from an 'Introduction' section, improved subtitle development (following a clear statement of the chapter's purpose), and a brief explanation of the monitoring system that results in the information being presented. Also, a brief appendix describing the monitoring program design that produces the data being analyzed would help remind readers how the data were obtained.
2. When a P criterion is established, a means should be added to the ultimate P criterion/standard to define a standard 'violation' which can serve as a basis for future data analysis to compute P compliance (using the dissolved oxygen strategy as a possible model). The current approach leaves the ultimate definition of violation, relative to data analysis and interpretation, undefined and, therefore, subject to individual interpretation. Chapter 4's current approach to standard compliance, while judged acceptable from the viewpoint of similar efforts, it is not defined as the establishment of the criterion/standard.
3. Use of the terms 'criteria' and 'standard' need clarification to ensure clear interpretation of the results of chapter 4.

CHAPTER 7: The Everglades Mercury Problem

The Hg chapter in this years report focuses on the state of knowledge and on the research needed to answer some of the key questions relating to Hg deposition and cycling within the Everglades. While understanding the relative contribution of various inputs of Hg into the Everglades ecosystem is one of three aspects of the Hg problem, two other factors are critical: 1) understanding the complex relationships between inorganic and MeHg (and the factors affecting methylation), and; 2) understanding how Hg cycles through the biotic components within different trophic levels. These three questions are examined in this years report, and together address the significance of the Hg problem in the Everglades.

Overall, it was an excellent idea to organize the chapter with introductory material followed by summaries of all the major points concerning the Hg problem, followed by summaries of appropriate research. The in-depth appendices that followed were then much easier to follow and provided the details that were essential to evaluate the Hg problem. Within the appendices, however, some critical information was lacking regarding sample protocol, sample sizes, detection limits, and variance around means.

Concern for Hg in the Everglades was derived initially from the unacceptably high level of Hg in the tissues of sport fish, which resulted in consumption advisories. The high levels of Hg in fish tissue occur despite the fact that water samples do not exceed the water quality criterion. Further, the question of potential harm to other ecological receptors is important in the light of population declines of some high-profile species and species groups. These factors suggest that the water criterion is too high to protect biota residing within the system. However, it should be mentioned that Hg levels in fish tissue track the general pattern of high and low MeHg concentrations in sediments and surface water in the Everglades. One overall goal is to arrive at a suitable criterion that will protect the health of the biota residing within the system, including humans.

This chapter addresses three major questions:

1. Sources of Hg input to the Everglades
2. Hg dynamIcs within the Everglades
3. Ecological risks of biota of the Everglades

Sources of Hg: The atmospheric input of mercury to the Everglades is high, and the yearly input is about five times higher now than in 1900. The total pool accumulated in sediments and peat over thousands of years of both total Hg and MeHg in the peat is thus very large. Understanding the sources of Hg input to the Everglades is obviously critical to managing and restoring the system.

The report indicates that 95 % to 98 % of the input of Hg is from atmospheric deposition, and that only 5% comes from local sources by inflow from upstream areas. The important question, however, is the relative contribution of local sources of atmospheric Hg compared to global sources. If atmospheric Hg is mostly global, it limits the potential reductions in the Hg that will result from further reductions in local sources. It would be easier to evaluate the relative contribution of local vs global sources of atmospheric Hg if there were one clear section devoted entirely to showing the data and models, and assumptions, made to derive this estimate. While there are a number of appendices devoted partially to this problem, the data necessary to evaluate this aspect are not presented in the current report. This information includes: the assumptions inherent in these models; the sampling regime implemented during all months, and the lack of data on atmospheric deposition data for several years. Some of this information was provided in presentation at the public workshops, but was not presented in enough detail or in written form, making it difficult at present. These data, however, are extremely important, and should be presented in one clear section in future reports.

The clear trend in decreasing Hg levels in Largemouth Bass and Egrets (as measured by feathers) is so striking that some very large source of MeHg must have decreased at the same rate a few years earlier, yet this is not evident from the data presented. It seems particularly unrelated to atmospheric deposition, unless there is a lag phase. This important relationship deserves more explanation in this section.

The University of Michigan models as presented are both useful and laudable, but the data presented in appendices seem to concentrate on limited field work. Presentations at the Workshop made it clear that extensive field data are available, and these should be incorporated in future reports. These data would be easier to evaluate if there were one detailed section on mercury inputs to the Everglades.

In any event, it is not known what fraction of atmospheric Hg is from local and regional (within Florida) sources, which presumably could be controlled, and what fraction comes from truly global sources, which will be harder to control. The decline in Hg to the Everglades fish and bird feathers over the last several years may partially result from reductions in local and regional air emissions. Monitoring should be instituted to determine the percentage of atmospheric Hg that is due to local and regional atmospheric inputs, particularly from the east coast of Florida.

It would be useful to know whether agricultural sources of Hg have been examined. For example, in some places Hg was used in agriculture as a seed dressing.

Hg cycling within the Everglades: It appears that nearly all of the Hg deposited to the Everglades is retained and accumulates in the peat and sediments. Any disturbance of this pool, whether by mechanical or hydrological effects, can flush out total Hg and MeHg. It is this internal cycling of total Hg and MeHg that is critical and bears further investigations. The efforts of the SFWMD are clearly directed toward understanding these relationships, and this understanding is guiding management and restoration efforts.

Several relationships about Hg cycling within the Everglades are apparent from reading the report and appendices, but some of these require further explanation and development. While the data are in the appendices, it could be more easily interpreted if presented in one place. These include the relative relationships and the role of links between: a) construction work and MeHg levels in fish and birds; b) drying and reflooding caused by La Nina in 1999 and the increase in MeHg in surface water; c) initial flooding of STAs and flushing of MeHg and total Hg from the peat soils; d) total Hg and MeHg during pre and post-flooding events; e) fluxes of total Hg and MeHg within the STAs; f) bioaccumulation factors in different regions of the Everglades, and; g) sulfur and methylation. The importance of maintaining sufficient water levels in the STAs so that there is not drying and reflooding, which increases methylation, is a critical point worth further development.

While the overall cycling of Hg in various forms is of interest to understanding the Hg problem in the Everglades, from the viewpoint of ecological receptors, the conversion of elemental Hg to MeHg is the key step. This is controversial because of the many factors that affect methylation rates. Since Hg can be sequestered in sediments, it is available for later resuspension and methylation long after water Hg levels appear low (particularly if bottom sediments are disturbed).

The relationship between sulfur, Hg and methylation needs to be examined and discussed more clearly in Chapter 7. Mesocosm studies, some of which are on-going, appear to provide a useful method of sorting out the relationships of sulfur, Hg loading, and MeHg production and bioaccumulation.

Hg is methylated by sulfate reducing bacteria at the peat surface and, to a more limited degree, in the periphyton layer. Sulfate is in excess in the Everglades due to agricultural runoff; agricultural practices result in export of sulfate to the Everglades Protection Area. Since the STAs attenuate sulfate only weakly, there is a sulfate gradient south through the Everglades.

This chapter explores the relationships between phosphorus (P) and sulfur in the context of methylation and food chain effects.

The relationship between P and Hg methylation, discussed more strongly in previous reports, is complex. The suggestion is that with increases in P and eutrophication, plant production increases, standing crop increases, and decomposition increases, which leads to higher production at all trophic levels. This leads to biodilution of the toxicants. There are many problems with this, including a lack of a tight relationship between P and methylation. Even with biodilution the Hg remains in the system and can continue to be cycled. Also, methylation is associated with other biogeochemical factors such as C and Fe. Gilmour and Krabbenhoft found no direct effect of phosphate and nitrate on MeHg production rates in sediment cores.

The report suggests that the relationship between sulfate levels and mercury bioavailability is complex, may not be linear, and may both stimulate and reduce bacterial methylation, depending upon levels. The report indicates that agricultural sulfur enhances MeHg production and bioaccumulation, but that sulfide inhibits Hg uptake by methylating bacteria. Thus, in the parts of the Everglades with the highest eutrophication, sulfide accumulation inhibits MeHg production. The balance between sulfate load and sulfide accumulation is thus a crucial factor in controlling MeHg production throughout the Everglades. Consistent with this, MeHg concentrations in all matrices were highest in central Everglades, but were lower in both the most pristine areas and in the most eutrophic areas (WCA2A, ENR). The exploration of the dynamics of the sulfur chemistry in the central Everglades is an important aspect of the on-going research.

Given that MeHg occurs, there are two other questions that are critical to understanding (and thus managing) the Hg problem in the Everglades: what factors affect bioavailability, and how does the MeHg enter the food chain. It would be useful to see some data on the levels of selenium in the Everglades, particularly in the regions of high, medium and low MeHg levels. Selenium is known to reduce the absorption of MeHg mercury in vertebrates, and to partially ameliorate the effects of MeHg. Thus, to understand the effects of MeHg it is essential to know the levels of both in biota.

Drying events and fire are increasing the concentrations of MeHg, and need to be examined more closely with respect to Hg cycling, and management of the STAs. Drying events, followed by flooding, appear to release a massive pulse of MeHg production, and may provide a useful method to quantify how hydrologic flow pathways as well as how the sulfate/sulfide balance controls methylation, and should be explored whenever the opportunity permits. It also suggests that the effects of drying and flooding events and fire need to be factored into the mercury cycling models for the Everglades.

Methylated Hg leaves the sediments (and the periphyton layer) by solute efflux from the sediment porewaters, by movement of benthic invertebrates into the water (or water column), and by direct grazing on surface sediments, benthic invertebrates, and the periphyton. The finding that methylation is very rapid in periphyton is extremely interesting and potentially important because it provides a rapid and direct method of entry into the aquatic food web, leading directly to higher trophic level fish, birds and mammals.

Finally, the use of E-MCM models is a powerful tool not only to examine past relationships, but to predict future relationships and to test hypotheses. It is critical to link these models to others, such as Phosphorus models and to incorporate sulfur dynamics as well as increased concentrations and fluxes of MeHg after drying and flooding. This will allow a bottom-up bioenergetics representation which will be exceedingly useful in understanding the relationships between sulfur, phosphorus and Hg. It is remarkable that the mechanistic model predicts a *linear* relationship between atmospheric deposition and Hg and MeHg in fish.

It is critical that the E-MCM model is used as a research tool to help test the hypotheses being put forward to explain issues. In that sense, the changes being made to the model to link the phosphorus transport and fate model and to incorporate sulfur state variables and associated processes into the mercury model are critical. The refined E-MCM needs to then be used in a research mode to test the hypotheses in the context of all the other forcing functions and competing processes. Among the types of observations amenable to hypothesis testing include the effect of drying/burning on mercury cycling and MeHg production in the system; the importance of diel vertical migration of phytoplankton and zooplankton on food chain bioaccumulation of MeHg; the role of sulfur transport and cycling in explaining the north-to-south gradient of MeHg (especially the "hotspot" in WCA3) and associated bioaccumulation, and the linkage between Hg emissions, Hg deposition, and aquatic system response in terms of the impact and timing of reduction of local emissions on fish uptake.

The interaction, mentioned above, between the process experiments, field monitoring and observations, and modeling synthesis is an important effort to be made in the Mercury Science Program. For example, the E-MCM does not currently have the diurnal plankton migration in its framework to create and exposure pathway for planktivore MdHg bioaccumulation from sediments. The model could be run in a sensitivity mode to evaluate the impact of incorporating this additional pathway relative to simulations when it is not included. The same approach could be used for the drying effect once sulfur dynamics are incorporated into the model. Such a component analysis is an important diagnostic use of a model like E-MCM.

Currently the model has been calibrated to a relatively small area (around WCA3-15) and over a relatively short period of time during which calibration data have been collected. The problem is that this model is underconstrained by this calibration data set. Therefore, there is not a unique set of coefficients that can be used to affect a calibration. Unfortunately, the alteration of these coefficients (particularly the ones that affect long-term burial of Hg in the system), while still meeting short-term calibration targets, can have a major effect on the long-term response of the system to external perturbations or remediation efforts. For this reason, it is the panel's recommendation that a long-term hindcast calibration needs to be attempted with this model. To accomplish this, the modeling team will have to attempt to reconstruct the atmospheric loading history and other forcing functions (e.g., hydrology) over about a twenty year period during which there is fish and bird feather or egg mercury trend data to which the model can be compared.

Along the same lines, it will be important to apply the model in a field test mode to other parts of the EPA that do not have the same conditions (loads, vegetation, etc.) as the WCA3-15 and evaluate the performance of the model in those areas. Again, a successful confirmation of the model in terms of its robustness to varying environmental conditions is another way to gain confidence in its use as a management tool.

Risks to Wildlife; The crux of the Everglades Hg problem is the potential risks Hg poses to biota, including humans. While the problem of risk to humans has been partially addressed in the short term by issuing consumption advisories, this solution is not ideal because some people, often subsistence and low-income fishers, continue to eat fish from the Everglades despite consumption advisories.

The larger question involves the risks from Hg to non-human biota within the Everglades. There are currently some methods of testing for bioavailability of Hg in tissues that might be useful in examining the cycling of Hg in the food chain. The approach taken in the report was to compare the Hg concentrations from oligotrophic reference areas of the Everglades to the actual Hg levels seen in lower organisms of the food chain. The assessment involves using biomagnification factors observed in the Everglades food chain, Hg levels found in the tissues of wading birds, diets of wading birds, and Hg levels found in prey organisms of appropriate sizes. The SFWMD is to be commended for undertaking a research program to examine both the fate and effects of Hg in these important and indicator species (wading birds).

Risk assessments for wildlife are difficult for several reasons. In general, effects research usually involves controlled laboratory conditions, which limit the species of birds that can be used. Much of the effects work with Hg involved ducks, which appear to be more sensitive than wading birds and seabirds. While all researchers in this area recognize the problems with using LOELs and NOELs derived from Mallards in laboratory experiments, they remain the only currently available points. The SFWMD is encouraged to continue working with researchers to develop LOELs and NOELs with more relevant species, including wading birds.

Traditional ecotoxicological laboratory studies usually fail to compare the tissue levels associated with effects (although doses are given). Further, when effects have been noted in the field, they are usually confounded by the presence of a wide suite of pollutants, in addition to natural stressors such as predators and food scarcity. Thus, attributing cause and effect has been difficult.

In this area, the research program undertaken by the SFWMD is laudable because it includes controlled experiments on effects, measurement of the dose and tissue levels of Hg, and examination of ecologically-relevant endpoints. Having said this, there is still a wide range of studies that are required before it is possible to conclude that wading birds show no effects. There is considerable data on seabirds to indicate that the sensitive period for metals is during the period of early development, and that this is particularly true for Hg in fish and mammals.

The finding that there is no obvious effect on reproductive success in wading birds in areas of high and low Hg levels does not answer the question about early developmental effects. While it is difficult to examine the effect of mercury on chicks from day one to fourteen, experiments during this critical period would help answer the question about effects.

One method of examining behavioral teratology in wading birds would be to follow an experimental protocol in the field, as has been done with lead studies in seabirds. By exposing one or two-day old chicks to Hg while they are in the nest (with appropriate controls within clutches), and allowing parents to raise the chicks under an otherwise natural regime, sublethal effects of Hg that might have an important chronic effect could be examined. Neurobehavioral effects might be the most critical endpoint in wading birds, leading to long term chronic effects that might be cumulative over the lifespan of birds. Such chronic effects may lead to deficits in parental care, deficits in courtship, and lowered rates of breeding attempts. Monitoring the proportion of a population that fails to even attempt to breed is difficult, but some of these neurobehavioral deficits have been noted with other neurotoxicants.

The research program of Spaulding and Frederick (among others) with wading birds is excellent, but such studies are time-consuming and involve many years before all relevant aspects can all be examined. The plan of the SFWMD to examine embryonic stages and developmental abnormalities is sound in light of research with other neurotoxicants, but these studies should be conducted in the field (see above) as well as at Patuxent. Further, the plan to examine effects of Hg on adult reproductive success is also essential, but some thought should be given to examining all endpoints in the same species. That is, all endpoints should be examined in White Ibises, Snowy Egrets and Great Egrets, not just some endpoints in each. One might also consider examining some of these endpoints in Anhinga that live within these systems to a greater degree. It is possible to have birds with the highest levels of Hg be adversely affected while populations levels of the species overall are stable or increasing. Since many factors affect reproductive success (such as inclement weather stresses, food scarcity, predators, human disturbance), population trends in themselves are not the only measure to use in examining the effects of Hg. Further, in the field, the effects of Hg might be either enhanced or reduced by interactions with other contaminants.

The planned experiments with dosed wild Great Egrets, whereby fledglings will be followed by telemetry, should yield very important and key data. It is essential that these studies have appropriate controls that experience the same initial sham dosing regime, radiotelemetry, and post-fledging dosing. While the research work undertaken to date with wading birds is excellent, and of high quality, there are other endpoints to consider, including:

1. Wood Storks - of interest because they are endangered, are a key species in the Everglades, respond to management practices, and they feed on large fish.
2. Raptors have proven to be sensitive to contaminants, and Osprey feed on relatively large fish. They might be expected to accumulate high levels, have long lives, and are high on the food chain.
3. Mammals, such as bats, may provide some useful information as they have been shown to bioaccumulate Hg in other studies.
4. The possibility that wading birds demethylate Hg should be examined in wading birds, as a possible mechanism that explains the lack of population effects in wading birds. This would involve examining the MeHg/inorganic Hg levels in liver of wading birds.

The SFWMD is to be commended for their use of probabilistic risk assessment for the wading birds. This is the current cutting edge risk methodology, and the assumptions and parameters used in these assessments are sound and reasonable. While the NOEL may be high because of its development for Mallards, it is the conservative approach until another NOEL can be developed that is more appropriate. A sensitivity analysis may indicate what factors are most subject to having an effect on the affects endpoints.

A feeding study of MeHg with a piscivorous bird should be conducted, and the species chosen should be taxonomically distant from Ciconiformes. We further suggest that the specific components of piscivory that determine MeHg toxic response be examined while the birds are in hand and the feeding trial(s) is/are under way. These might include enzymatic activity, absorption and distribution, physiological Hg speciation/depuration & etc. This kind of mechanistic data will increase the confidence with which the findings of the new feeding trial and its resultant new reference dose may be extended from the test species to other potentially at-risk species (Gray et al. 1998). It is also important relate tissue concentrations to effects.

Potential damage to bats should always be considered when assessing risk or deriving standards for waterborne contaminants, especially those that bioaccumulate. Bats are long-lived and have low reproductive rates. Although MeHg content of emergent aquatic insects is much lower then MeHg content of fish at the same site, bat insect ingestion rates are high (wet weight of insects on the order of 0.5x-1.0X the bat's body weight/night) so that the potential for contaminant exposure and accumulation via the food chain is high. For example, a bat of 10 grams body weight, and 5 to 10 gram/day food intake rate, if feeding on insects with total Hg concentrations such as those found in Clear Lake aquatic insects (0.012 – 0.5 ppm), would be ingesting 5 to 20 times the mammalian Hg NOAEL of 0.16 mg/kg/day used in the GLWQI model. At the 29th North American Symposium on Bat Research last year, Massa and Grippo reported that insectivorous bats in areas under fish advisories had elevated tissue Hg levels, and that the body burden increased with age. Of the 40 bats sampled, 8 had fur or tissue Hg levels that exceed the USFWS hazard level (Massa and Grippo 1999).

Some other endpoints and approaches that may be worth considering are egg exposure studies and endocrine disruption. The published work on MeHg egg exposure does not include any piscivorous species so this should be a goal of future work.

The endocrine-disrupting potential of MeHg in birds is so far unreported, however, work with fish and invertebrates suggest that some investigation is warranted, as does the skewed sex ratio of the egrets in the Spalding & Frederick study. Kernaghan and coworkers reported that freshwater mussels exposed to MeHg in the water column or via the diet exhibited significant bioaccumulation and decreased estradiol concentration following dietary exposure of 10 ng/L (Kernaghan et al. 1999). For a period of 6 months, two groups of walleye were reared on untainted catfish fillets, while two test groups were fed fillets injected with methylmercury, one group receiving 0.1 mug Hg g-1 food (low-mercury diet) and the other receiving 1.0 mug Hg g-1 food (high-mercury diet). After the exposure period, fish fed the low- and high-mercury diets had mean body burdens of 0.254 : 0.015 mug Hg g-1 and 2.37 : 0.09 mug Hg g-1, respectively. Dietary mercury significantly impaired both growth and gonadal development in males, which was apparent as reduced fish length, weight, and gonadosomatic index. Testicular atrophy was observed in fish fed the mercury-tainted fillets, but was nonexistent in control animals. Mercury also suppressed plasma cortisol in juveniles (sexes combined). Furthermore, these results suggest that methylmercury might also affect reproductive potential of teleosts by impairing testicular development in young (Friedmann et al. 1996). Some recent articles from the human health literature may provide helpful inputs for model development (Chapman 2000, Ginsberg 2000).

Conclusions and Recommendations

1. Determining the input sources from atmospheric and old accumulated Hg and MeHg in peat to the Everglades is a high priority. Understanding the variations in the contribution of local and global atmospheric Hg seasonally and annually are critical to the models for Hg inputs into the Everglades. Since there is the possibility of control of Hg from local sources, the relative contribution of local sources should be examined with respect to spatial, seasonal, and annual patterns.
2. The factors that affect mercury methylation remains a key issue. Mercury methylation is very complex, and a greater understanding of the relationship between phosphorus and methylation is required. The data suggest that reducing P levels may increase Hg within fish and other biota within the Everglades. Adaptive management, in an iterative manner, will be required to track declines in P and changes in biodilution of Hg and biota.
3. One of the key aspects in understanding Hg cycling within the Everglades presumably is the relationship between sulfur, phosphorus, and methylation by bacteria. This is critical to setting the phosphorus standard, but also in terms of agricultural interests, and its regulation. Therefore, further research on the relationship between phosphorus, sulfur and methylation by bacterial is absolutely critical to any consideration of the Hg problem and to food chain accumulation.
4. The relatively recent finding of the importance of the periphyton to methylation needs to be further examined and studied to understand its contribution to the food chain (relative to surface sediments). The temporal and spatial factors that affect the relative percentage that periphyton contributes to overall MeHg in the Everglades should be examined over enough seasons to understand fully its importance.
5. While the research on wading birds is laudable, and clearly very important to the understanding of Hg fate and effects, there are some additional data needed to evaluate the effects on birds more clearly, including; 1) radio-tracking data on the whereabouts of wading birds throughout the year, and the relative importance of the "hot spots" to yearly foraging patterns; 2) comparable data on Hg fate and effects during the embryonic and early life stages of egrets, and anhinga (a species that eats relatively large fish), and; 3) the fate and effects of Hg in eggs, young and adults following massive events (such as fire, very low water).
6. Much of the Hg problem in the Everglades has focused on plant communities, fish, and birds, with relatively little attention devoted to other receptors. What are the levels of Hg in developing alligator embryos and young, and Ospreys and Eagles, and in raccoons and bats? Are alligators and raccoons eaten by subsistence peoples, as they are in other regions in the South, and should this be a consideration?
7. The role of exotic and invasive plants in exacerbating the Hg problem by methylation needs to be considered. While not directly related to the Hg problem, the relationship between exotic and native fish as a food source for wading birds should be examined, as well as the relative levels of Hg in exotic and native fish of comparable size (i.e. the threat to consumers from prey fish).
8. Quantitative measurements and estimates of fluxes except atmospheric deposition are few in the report. It is therefore strongly recommended that such data be presented in future reports.
9. The development of a quantitative understanding of transport, fate, bioaccumulation and effects of Hg in the entire Everglades Protection Area requires a collaborative and

interactive relationship between process experimentation (provides understanding and parameterization for model development), field monitoring data (provides input and credibility for models), and modeling (provides insights and makes projections). The Mercury Science Program is strongly encouraged to continue and even enhance this relationship be using the E-MCM model to synthesize new findings and to field test working hypotheses at the whole system level.

10. The existing calibration of the E-MCM is insufficient for it to be used as a management tool for making assessments relative to management actions in the EPA (e.g., impact of reduced Hg emission, impact of phosphorus control measures, impact of sulfur reductions). The modeling team should strive to conduct a long-term hindcast calibration (at least 20 years) and to field test the model calibration at a variety of sites within the EPA (STAs, enriched portion of WCAs, Loxahatchee National Wildlife Refuge, and ENP).

11. The stable mercury isotope *in situ* mesocosm experiments (being initiated by Gilmour and Krabbenhoft within the ACME project) are critical to developing a process-level understanding of the role that sulfur, phosphorus, and organic carbon play in mercury methylation and subsequent bioaccumulation. These experiment should be the "cornerstone" of continued work on mercury dynamics within the aquatic ecosystem of the Everglades. One way to accomplish the interactive relationship between process experimentation like this and the E-MCM development would be to use the E-MCM to model and thereby interpret the results of these mesocosm experiments.

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