

March 27, 2014

Honorable James E. LaFave  
Administrative Law Judge  
Office of Administrative Hearings  
600 North Robert Street  
P.O. Box 64620  
Saint Paul, Minnesota 55164-0620

The Honorable Mr. LaFave:

This letter is in regards to OAH Docket No. 60-2200-30791 regarding the Minnesota Pollution Control Agency's (MPCA) rulemaking for river eutrophication/ total suspended solids water quality standards. The Minnesota Department of Agriculture received electronic notification of MPCAs rulemaking for the above mentioned standards via email through the GovDelivery message service in June 2013. Our staff also review the Minnesota Pollution Control public rulemaking docket on a periodic basis, which is available on MPCAs website. The October 1, 2013 public rulemaking docket included information about the standards on Page 5 of the docket.

The Minnesota Department of Agriculture has staff assigned to track proposed water quality rules and regulations at the state and federal level, who then meet with assigned Commissioners Office and Division level management on a regular basis to evaluate the potential impact of rules or regulations that potentially affect agriculture.

In this particular case, after reviewing the rulemaking information, the Minnesota Department of Agriculture decided not to comment on the proposed standards. If you need additional information regarding this matter, please do not hesitate to contact me at 651-226-0385.

Sincerely,



Matthew Wohlman  
Assistant Commissioner



## SCOTT COUNTY NATURAL RESOURCES

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March 28, 2014

Judge LaFave, Administrative Law Judge  
Office of Administrative Hearings  
600 North Robert Street  
P.O. Box 64620  
Saint Paul, Minnesota 55164-0620

Ms. Carol Nankivel  
Minnesota Pollution Control Agency  
520 Lafayette Road, St. Paul, MN 55115-4194

Re: Additional Comments on Proposed Water Quality Standards for River Eutrophication and Total Suspended Solids

Honorable Judge LaFave:

I testified at the Public Hearing, January 8, 2014 at the Minnesota Pollution Control Agency regarding the Proposed Water Quality Standards for River Eutrophication and Total Suspended Solids and sent in additional comments. I wish to thank you for reopening the comment period. The purpose of this letter is to provide additional comment under the extended comment period. In particular, I address/rebut some of the post-hearing response to public comments completed by the Minnesota Pollution Control Agency (MPCA). Many of the responses prepared by the Agency did not address the technical concern nor did they provide information supporting their position where it was pointed out that such corroborating evidence was missing. This lack of transparency makes it hard to determine technical merit and reasonableness, demonstrating the need for an independent technical review. The following rebuttals provide a few examples of the inadequacy of the agency responses and rebuttals.

- 1. Post-Hearing Response to Public Comments: Attachment I Spreadsheet Summary of Comments and MPCA Responses page 30 line 157 where the Agency response is "High gradients near the mouths of streams is relevant to the management of a stream channel; however, it would not be a major determinant of which region these stream should be located in."** The primary factor affecting the capacity for suspending of solids in streams is the flow rate (i.e., discharge). Flow rate or discharge is in turn a function of the flow velocity and the cross sectional area. Particle or sediment size also affects suspension. Basically if the energy of the flow as reflected in the velocity is sufficient to overcome the mass/resistance of the particle it can be suspended. Stream slope is a large determinant of velocity and therefore is a relevant factor. These relationships and affects are true whether the stream in a natural or altered condition.

I also want to reemphasize the points we made previously (letter dated January 8, 2014 to Judge LaFave, particularly the Attachment by Dr. Patrick Belmont) about the steep





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grades and knick points (i.e., channel slopes) of the tributaries that cut through the Minnesota River Valley as they flow down to the incised Minnesota River. Bottom line is that the tributaries in the Lower Minnesota River Basin are unique and natural background with respect to the suspension of solids is not like the Central Nutrient Region. Agency responses do not refute this conclusion.

MPCA's staff response to the issue when raised is to skirt it as demonstrated in Attachment I to the January 28, 2014 Post-Hearing Response to Public Comments page 30 line 157 where staffs response is *"High gradients near the mouths of streams is relevant to the management of a stream channel; however, it would not be a major determinant of which region these stream should be located in."* The response to make this just about whether area is the right ecoregion skirts the issue of whether it is reasonable to expect these streams to exhibit the same natural background as stream in the Central Region given their undeniably unique setting. Contrary to the Agency's response these high gradient areas are relevant to setting appropriate standards because the Standard is expected to be met in the entire reach(es) of the stream – including areas with high gradients and knick points. Further this response can be taken to the ridiculous and interpreted that the Agency believes that ecoregion mapping is so much the driving force in determining stream natural background TSS concentrations that local physical characteristics are irrelevant, or the Agency is saying that high stream slopes and residual knick points are not natural. The question is whether the ecoregion approach recognizes the variability that exists for natural background over the range of conditions that are present. It does not! The response is also disingenuous in that the Agency deviated from the ecoregion approach in other places.

2. **Narrative response completed by the Agency OAH Docket # 60-2200-30791 and Attachment II Regarding the Proposed Nutrient Regions.** MPCA is not listening to warnings by the USEPA in its guidance and to local experts when using aggregated Level III Ecoregions for setting regional values particularly with respect to the Lower Minnesota River Basin. Again I refer you to the previously submitted review by Dr. Belmont. I also refer you to a second letter I submitted during the Hearing period dated January 28, 2014. In the second letter we make the point the USEPA provides a warning about using the aggregated level II regions, and that there is no geospatial statistical analysis of TSS data showing distinct differences along the proposed River Nutrient Region boundaries – neither by MPCA or USEPA! For the most part MPCA staff responses are dismissive or deflecting saying *"See Attachment II response to Comments on Regionalization. This portion of the Central River nutrient Region is mapped properly."* (see pages 1 and 2 lines 7 and 9 of the Post Hearing Response to Public Comment January 28, 2014). The point is not whether it's in the correct Region according to some map. It is about whether the map/regionalization itself is reasonable given what we know about this area. If we follow the response to the narrative response completed by the Agency OAH Docket # 60-2200-30791 and Attachment II to that document you will find nine reasons listed by the Agency in support of the methodology used. These reasons along flaws in the responses are provided in the following table.





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MPCA Supporting Points (paraphrased)	Flaws
1 through 3 basically these three points can be summarized as the ecoregion approach was developed and established by USEPA based on Omernik (1987), therefore it's reasonable.	These responses ignore warnings by the USEPA about variability. It also ignores warnings by experts and local water quality professionals about this area <sup>1</sup> , and ignores more recent information gathered about the area and improved understanding sediment sources and transport in Lower Minnesota River Basin tributaries. The response also does not provide any evidence that TSS has been evaluated in the context of the proposed RNR approach. One of our points is that no definitive analysis has been completed by the Agency, USEPA or Omernik demonstrating that natural background TSS concentrations do in fact follow ecoregion boundaries in this case. Good scientific process requires evidence backing up such claims. The Agency responses do not provide this evidence.
4. The ecoregion approach is the basis for regionalizing Minnesota Lakes eutrophication standards, therefore it's a consistent regional framework streams as well.	This response ignores the fact that factors affecting the suspension of solids are quite different in streams. Lakes don't have a gradient/slope – the surfaces of lakes are flat.
5. Purpose of the Fandrei et al. (1988) report was to help characterize water resources.	This is not relevant to the points made by Scott County. Nor is it a reason for not considering more recent information and improved understanding of the Lower Minnesota River Basin and it's tributaries..
6. "Most typical" areas – one such area is considered "most typical" of the North Central Hardwood Forest ecoregion.	This is not relevant or made in response to Scott County comments. Nor is it a reason for not considering more recent information and improved understanding of the Lower Minnesota River Basin and it's tributaries.
7 and 8 RNR approach for Carver County and tributaries in Scott County are characterized properly... or are mapped appropriately.	This is true only if one considers this only as a mapping exercise. This is clearly not true with respect with respect to setting appropriate Water Quality Standards in the Lower Minnesota River Basin given recent research and its unique setting.
9. Rosgen classification is not a basis for classifying stream for water quality standards	Scott County concurs that the Rosgen classification is not appropriate. However, inclusion of the Lower Minnesota River Basin tributaries in the Central Region without explicit data supporting that, in face of data





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	showing otherwise and without considering unique characteristics of the area, or factors affecting the suspension of solids is also not a reasonable basis. An alternative to placing the tributaries in the Lower Minnesota River Basin would be to develop a classification system that actually considers physical factors affecting the suspension of solids.
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<sup>1</sup> This refers to the Lower Minnesota River Basin where we have requested a change to the proposed River Nutrient Regions.

- MPCA responses to the request to validate use of the 90<sup>th</sup> percentile for the TSS Standard.** I am Ok with using the 90th percentile if the assumption is validated as being appropriate and reasonable. I suggested such a validation at the hearing. Validation is a normal part of good scientific process. It would only require a modest effort to calculate the 90th percentile for the reference streams determined by the percentile ranking completed by the Agency and reported in the Technical documentation. The Agency response to this request again deflects. Here is the Agency Response: *"The 90<sup>th</sup> percentile TSS measurement of the reference stream forms the basis of comparison for the standard, and the average reference stream, by definition, then meets the standard with its 10% exceedance level..."* However, in the draft Technical Documentation for TSS page 25 it says *"These 168 reaches were then ranked within the three River Nutrient Regions according to mean (emphasis added) TSS levels. Stream reaches ranked from the 10<sup>th</sup> to the 40<sup>th</sup> percentiles in terms of mean TSS water quality in the South River Nutrient Region and the 30<sup>th</sup> to the 50<sup>th</sup> percentiles in the Central and North River Nutrient Regions were considered to be reference streams."* Thus, the actual analysis is reported as being completed for means and then as percentile ranks of streams – not 90<sup>th</sup> percentiles of specific reference stream TSS concentration data sets. The draft Technical Documentation (same page) then goes on to state how the 90<sup>th</sup> percentile was selected for the standard. These reasons are paraphrased with flaws or gaps identified in the following table. Bottom line is that little solid justification is provided. Good science means using data when it's available and validating assumptions.

MPCA Rationale	Flaws/Gaps
Can be easily calculated	Is not a justification for specifically selecting 90 <sup>th</sup> percentile
Good indication of stream health in terms of TSS	No documentation of this claim is provided
Matches with the current MPCA assessment criterion	This is for a different parameter the use of which the Agency acknowledges is problematic

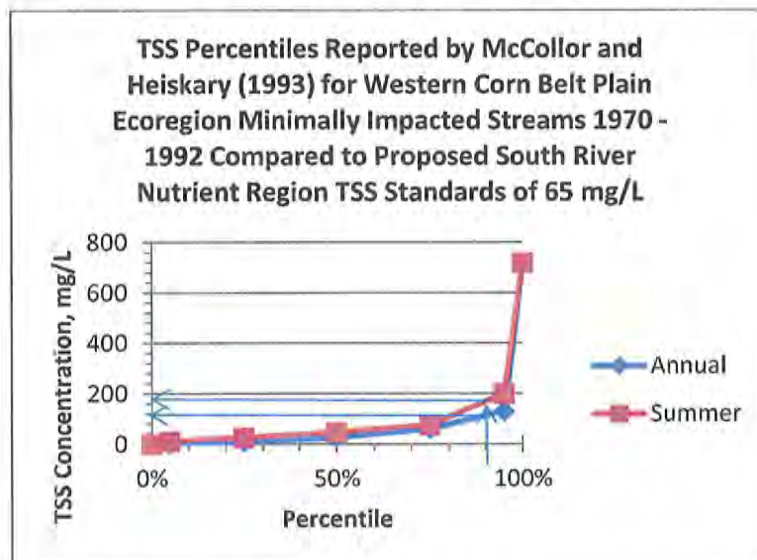




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There is on the other hand some data that suggests use of the 90<sup>th</sup> percentile will be problematic as I pointed out in my testimony and comment letters. It's a little old and is not a very robust set of information, but it comes from McCollor and Heiskary (1993)<sup>i</sup> (which by the way is the only actual data regarding TSS that I could find in any of the technical documentation – USEPA, MPCA or Omernik - included as part of any ecoregion argument). I plotted the TSS percentiles from this report for the Western Corn Belt Ecoregion and compared the results with the proposed TSS Standard for the South River Nutrient Region in the graph below. As you can see in both cases these "minimally impacted" streams would exceed the proposed 90<sup>th</sup> percentile. MPCA staff argued that these "minimally impacted" streams did not include point sources, but could have nonpoint source impacts. That may or may not be true, but they have been promoted for years by the Agency as "reference comparison conditions." The graph below should give enough pause to realize that a validation is called for and is appropriate. The Agency has nothing to lose if the 90<sup>th</sup> percentile works with respect to reference streams and real monitoring data.



90th percentiles clearly exceed 65 mg/L. Therefore, some or all minimally impacted streams assessed in this ecoregion would likely end up being listed as impaired.

Finally the "by definition they are not impaired" argument given by the Agency as the response is circular reasoning. The equivalent analogy is the student who said "you can't give me a C. I'm an A student."

In closing the Agency has not addressed the technical issues that we brought up during the hearing process. The proposed standards will be in place for decades. It is therefore reasonable and appropriate to make sure that they are technically correct and reasonable. The County still asks that the Lower Minnesota River Basin and its tributaries be placed in the South River Nutrient Region and that the assumption using the 90<sup>th</sup> percentile for the TSS standard be



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validated. Another alternative that the County would support would be an independent technical review.

Thank you for considering our comments. I am available to answer questions and can be reached at 952-496-8054 or [pnelson@co.scott.mn.us](mailto:pnelson@co.scott.mn.us).

Sincerely

Paul Nelson  
Natural Resources Program Manager

Cc: Patrick Belmont, Ph.D.  
Mitch Rasmussen, County Engineer  
Tim Sundby, Water Analyst, Carver County

---

<sup>i</sup> McCollor, S. and S. Heiskary, 1993. Selected water quality characteristics of minimally impacted streams from Minnesota's seven ecoregions. Addendum to: Descriptive characteristics of the seven ecoregions of Minnesota. MPCA St. Paul MN.

March 28, 2014

Minnesota Department of Natural Resources  
Mississippi River Team  
1801 S. Oak Street  
Lake City, MN 55041

Subject: Docket # 60-2200-30791 - Water Quality Standards (Mn. Rules chapters 7050 and 7053), regarding the addition of Total Suspended Solids standards and Eutrophication standards for rivers, streams, Mississippi River navigation pools and Lake Pepin.

Dear Ms. Carol Nankivel:

We are submitting comments on behalf of the Minnesota Department of Natural Resources' (DNR) Mississippi River Team to convey our support for the proposed suspended solids and eutrophication standards proposed for the Mississippi River navigation pools and Lake Pepin. The Mississippi River Team consists of biologists and managers from multiple disciplines in the DNR who are engaged in natural resource work on the Mississippi River. Staff have represented the Department on the Lake Pepin Science Advisory Panel and Stakeholder Advisory Committee for the South Metro Mississippi River turbidity TMDL and the Lake Pepin eutrophication TMDL. Much of the data used to establish these water quality standards for the Mississippi River have been collected by Mississippi River Team members through their involvement with the federal Long Term Resource Monitoring Program (LTRMP) and the EPA's Environmental Monitoring and Assessment Program (EMAP). Team members are also involved in policy and planning for river activities including restoration projects for improving fish and wildlife habitat. In addition to our career involvement on the river, most members live locally and recreate with friends and family on this unique and world-class resource.

We believe the proposed 32mg/L total suspended solids standard for the Mississippi River above Lake Pepin is a sound goal and is supported by empirical evidence and by the scientific community on the Mississippi River. Recent analysis of our data has shown that reduced total suspended solids loads beginning in 2005 and caused by decreased discharge have resulted in an ecological shift of the biological community in the impaired reach of Pool 4 above Lake Pepin. We have documented an increase in submersed aquatic vegetation above Lake Pepin due to increased water clarity along with a shift in the fish community to a more clear water-associated community. Given these results, we feel confident that improvements in the watershed leading to reduced suspended solids loads will improve habitat for fish and wildlife, particularly in upper Pool 4 and the pools upstream.

We are also supportive of the proposed nutrient standard of 0.10 mg/L for total phosphorus. Much of the scientific literature shows that concentrations at or below this level results in a healthier biological community. Not only would this reduction in phosphorus help to achieve the proposed Lake Pepin chlorophyll goal of 28  $\mu\text{g/L}$ , but it is also likely to improve the health of



backwater lakes on the Mississippi River by reducing excessive duckweed and filamentous algal growth.

We feel that the proposed water quality standards for the Mississippi River pools and Lake Pepin have been developed through sound scientific methods and adequate peer review. Achieving these goals through improved watershed health will greatly improve the ecological health of the Mississippi River. We look forward to this process moving forward and to actions implemented in the watershed to achieve the proposed water quality standards. We would also like to thank your agency for leading this effort to establish water quality standards for the Mississippi River and to address the current sediment and nutrient impairments on the river.

Sincerely,

Walt Popp  
MN DNR Mississippi River Team Chair

Rob Burdis  
MN DNR / LTRMP Water Quality Specialist



# MESERB

Minnesota Environmental Science  
and Economic Review Board

Using science and economics to improve environmental regulations

March 28, 2014

Hon. James E. LaFave  
Administrative Law Judge  
600 North Robert Street  
P.O. Box 64620  
St. Paul, MN 55164-0620

**BY E-MAIL ONLY**  
[rulecomments@state.mn.us](mailto:rulecomments@state.mn.us)

**Re: Proposed Amendment of Water Quality Standards, Minnesota Rules Parts 7050.0150, 7050.0220, 7050.0221, 7050.0222, 7050.0467, 7050.0468 and 7053.0205 Relating to Eutrophication of Rivers, Streams, Mississippi River Pools and Lake Pepin, the Revision of the Turbidity Standard to a Standard of Total Suspended Solids and Minor Clarifying Changes;  
Revisor's ID Number 4104  
OAH Docket No. 60-2200-30791**

Dear ALJ LaFave:

The following supplemental comments on the above-referenced proposal are offered on behalf of the Minnesota Environmental Science and Economic Review Board (MESERB). The Appendix attached hereto is identical to the document provided to the Office of Administrative Hearings in MESERB's March 13, 2014 Motion to Supplement the Administrative Record.

Both in written commentary and in verbal testimony at the January 8 hearing, MESERB and other interested stakeholders identified fundamental flaws in the scientific analysis underlying the standards proposed by MPCA staff. In short, the MPCA proposes to use simplified regressions to "prove" that nutrients or sediment were the cause(s) of an ecological condition (e.g., elevated biochemical oxygen demand (BOD), poor fish or invertebrate population) in the river or stream.

In 2010, EPA's Science Advisory Board specifically concluded that such simplified methods were not scientifically defensible unless the analysis demonstrated that other factors (e.g., habitat alteration) did not cause the same effect, and that relevant physical characteristics influencing the impact of the pollutant and the metric were accounted for. In November 2010, EPA subsequently issued a national guidance document specifying the same.

Although MPCA staff have effectively acknowledged that (1) their analyses did not analyze the critical factors identified by EPA's Science Advisory Board, (2) the standards did not properly apply to smaller streams which constitute about 90% of the state waters, and (3) the standards do not conform to EPA's current guidance on how to properly derive stream nutrient criteria,



MPCA staff continue to claim that the approach is defensible and should be imposed on all flowing waters of the state.

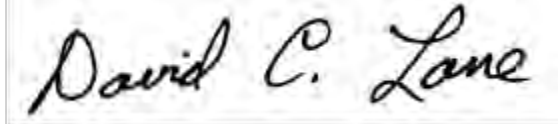
The proposed approach will lead to the widespread impairment listings that bear no reasonable relationship to reality or actual environmental needs. In a similar case that relied on the same type of simplified regression methods to develop nutrient criteria, a blue ribbon panel of experts recently concluded that such nutrient criteria intended to be applied to Great Bay Estuary in New Hampshire were not scientifically defensible, should not be used for impairment listings, and needed to be revised to properly direct state and local resources (see Appendix).

The key findings of the peer review panel were that the confounding factors analysis that is necessary to justify the application of such methods was never completed; therefore, there was no reliable scientific basis to conclude that the relationships predicted by the simplified methods were in fact accurate. During the public hearing, MPCA staff admitted they have never completed the necessary analysis; therefore it is clear that the same fatal scientific flaw was made in deriving the proposed nutrient standards.

Thank you for the opportunity to provide these supplemental comments.

Sincerely,

MINNESOTA ENVIRONMENTAL SCIENCE AND ECONOMIC REVIEW BOARD

A handwritten signature in black ink that reads "David C. Lane". The signature is written in a cursive style and is positioned above a thin horizontal line.

David C. Lane, Environmental Coordinator  
Rochester Water Reclamation Plant  
MESERB President

DCL/swn

Appendix: Victor J. Bierman, Jr., Ph.D., BCEEM *et al.*, "Joint Report of Peer Review Panel for Numeric Nutrient Criteria for the Great Bay Estuary, New Hampshire Department of Environmental Services, June, 2009" (February 13, 2014)

**February 13, 2014**

# **Joint Report of Peer Review Panel**

**for**

**Numeric Nutrient Criteria for the Great Bay Estuary  
New Hampshire Department of Environmental Services  
June, 2009**

Photo: US Fish & Wildlife Northeast Region



Victor J. Bierman, Jr., Ph.D., BCEEM  
Robert J. Diaz, Ph.D.  
W. Judson Kenworthy, Ph.D.  
Kenneth H. Reckhow, Ph.D.





## Table of Contents

<b>Introduction .....</b>	<b>6</b>
<b>Review Process.....</b>	<b>7</b>
<b>PANEL RESPONSES TO CHARGE QUESTIONS.....</b>	<b>8</b>
<b>Question 1. The report titled “NUMERIC NUTRIENT CRITERIA FOR THE. . .</b>	<b>8</b>
a) Given the available data, is transparency an important factor in the presence/absence of eelgrass in the various segments of the estuary including the upper tidal rivers, great bay, little bay, the Piscataqua River, and/or Portsmouth Harbor? If yes, is it the controlling factor? .....	13
b) Given the available data/studies, is nitrogen an important factor in the presence/absence of eelgrass in various segments of the estuary (please be specific in terms of the impact or lack of impact in the tidal rivers, great bay, little bay, the Piscataqua River, or Portsmouth Harbor)? If yes, is it the primary factor? .....	18
c) Does the available information indicate that increased algal growth is causing or significantly contributing to a loss of eelgrass and that nitrogen reductions will significantly improve the conditions for eelgrass growth and/or restoration? .....	24
d) Does the available information indicate that algal growth is the reason for low do conditions in the tidal rivers and that nitrogen reduction will significantly improve do in the tidal rivers that flow into the great bay estuary? .....	31
e) Were the statistical methods used to derive the numeric thresholds based on acceptable scientific methods? Are the results of these analyses reliable for predicting responses to nitrogen in this system (including do, transparency, eelgrass, macroalgae, phytoplankton, etc.)? .....	35
<b>Question 2. The DES 2009 REPORT uses a “weight of evidence”. . .</b>	<b>39</b>
a) Is “weight of evidence” a reasonable approach to selecting final thresholds for areas with eelgrass impairments and low do? .....	40
b) Does the “weight of evidence” (i.e., an assessment of available data and studies for this estuary) support the conclusion that excess nitrogen was the primary factor that caused (1) the decline of eelgrass populations or inability of eelgrass to repopulate specific areas, and (2) low do in the tidal rivers? .....	46
c) Does the DES 2009 REPORT and/or subsequent data reasonably assess the potential reasons for eelgrass loss besides cultural eutrophication in the various areas? .....	49
d) Are the selected TN criteria for eelgrass protection consistent with (1) data/studies available for this estuary and (2) TN levels found to be protective in other northeast estuarine systems? .....	50



e) Does the available information demonstrate that, for the protection of eelgrass habitat, the annual median total nitrogen concentration should be less than or equal to 0.25-0.30 mg N/L, depending on the eelgrass restoration depth? Will attaining these values achieve the desired restoration depth for transparency? .....	54
<b>Question 3. The DES 2009 Report established thresholds for. . . . .</b>	<b>57</b>
<b>Question 4. The DES 2009 Report was published nearly five years. . . . .</b>	<b>60</b>
a) If you were charged with updating the DES 2009 Report, what approach would you take given the information now available? .....	60
b) Would a reference waters approach to establish a TN threshold based on various eutrophic responses such as macroalgae growth, low dissolved oxygen, and eelgrass loss be appropriate and feasible for the great bay estuary? If so, how would you recommend such an approach be developed? .....	64
c) Are there other approaches that you would recommend as alternatives for setting site specific nutrient criteria for the tidal Piscataqua and Cocheco rivers? .....	66
d) Do you have any recommendations for the long-term (10-year) monitoring and evaluation of the estuary to assess changes in conditions over time? .....	67
<b>REFERENCES .....</b>	<b>70</b>

## List of Tables

Table 1. Annual estimates of eelgrass cover and percent change in cover (total change and percent per year) for the Great Bay Estuary between 1996 and 2012. ....	21
---	----

## List of Figures

Figure 1. Summary of Great Bay from the National Estuarine Eutrophication Assessment update (Bricker et al. 2007) .....	9
Figure 2. Log Kd versus Log TN .....	17
Figure 3. Categories for Eelgrass .....	22
Figure 4. A “best fit” Classification Tree .....	23
Figure 5. Time Trends for Median Chlorophyll .....	29
Figure 6. Eelgrass versus TN for categories on Chlorophyll .....	30
Figure 7. Nomogram for dissolved oxygen in fresh water (FW) and sea water (SW) at 10 and 30oC .....	32
Figure 8. Baseline relationship among variables .....	34
Figure 9. Effects of eelgrass from low DO and TN concentrations .....	34
Figure 10. Examples of total abundance frequency distributions of the capitellid polychaete <i>Capitella capitata</i> and the brittle star <i>Amphiura filiformis</i> in relation to the expected number of species per 50 individuals (ES50) values for all samples in which they occur. ....	43
Figure 11. Location of National Coastal Assessment stations in the Great Bay region. ....	44
Figure 12. Eelgrass – TN relationship at monitoring stations.....	47
Figure 13. Downward trend in eelgrass coverage for Little Harbor/Back Channel.....	47
Figure 14. Time trends for eelgrass at monitoring stations.....	48
Figure 15. The predicted effect of the one of the proposed TN water quality criterion.....	53
Figure 16. Variation in sources of nitrogen for three US systems. From CERN (2010). Absent from consideration were oceanic sources, which may be an important sources for systems such as Great Bay.62	
Figure 17. Conceptual model for complexity of interactions within estuarine systems. ....	68

## INTRODUCTION

This peer review was authorized through a collaborative agreement sponsored by the New Hampshire Department of Environmental Services (DES) and the Cities of Dover, Rochester and Portsmouth, New Hampshire. The purpose was to conduct an independent scientific peer review of the document entitled, “Numeric Nutrient Criteria for the Great Bay Estuary,” dated June, 2009 (DES 2009 Report).

The peer review was conducted by a four-person panel (Panel) consisting of:

Victor J. Bierman, Jr., Ph.D., BCEEM  
Senior Scientist  
LimnoTech  
Oak Ridge, North Carolina

Robert J. Diaz, Ph.D.  
Professor Emeritus  
Virginia Institute of Marine Science  
College of William and Mary  
Gloucester Point, Virginia

W. Judson Kenworthy, Ph.D.  
109 Holly Lane  
Beaufort, North Carolina 28516

Kenneth H. Reckhow, Ph.D.  
Professor Emeritus  
Nicholas School of the Environment  
Duke University  
Durham, NC

The point of contact for the Panel throughout the review process was Ms. Sally L. Brabble, Litigation Paralegal, at the law firm of Sheehan Phinney Bass + Green in Manchester, New Hampshire.



## REVIEW PROCESS

A kick-off teleconference was held on October 29, 2013. Participants on the call included the Panel and representatives from DES and the Cities of Dover, Rochester and Portsmouth. The agenda included a brief history and purpose, an update on contracts, guidance on communications, written public comments, and consideration of a future public meeting. The Panel was given discretion to decide whether to prepare a single consensus report or to submit individual reports.

Subsequent to this kick-off teleconference, requests were made by individual panel members for data, additional data analyses, and additional documents to support their reviews. On November 13, a teleconference was held with DES to discuss these requests and the schedule for DES responses.

On November 18, the Panel requested a time extension from January 31, 2014 to February 28 for completion of its final report. The basis for this request was to allow adequate time for DES to respond to Panel requests for additional information, and for the Panel to review and evaluate this information. On November 25, the sponsors agreed to a compromise time extension to February 19, 2014.

On November 25, an in-person meeting of the Panel was held in Durham, North Carolina. The Panel discussed the DES 2009 Report and the review process. A decision was made to prepare a single joint report, but not to strive for a consensus document. As part of this decision, each panel member agreed to conduct an independent review, arrive at their own independent conclusions, and share written drafts of these conclusions with other members of the Panel.

On November 27, the Panel was provided with numerous written public comments that were solicited as part of the peer review. The Panel was instructed that it was not necessary for them to respond to these comments.

On January 7 and 29, the Panel held two teleconferences to discuss the status of their review comments and the schedule for their final joint report.

## PANEL RESPONSES TO CHARGE QUESTIONS

A list of specific charge questions was provided to the Panel for their review of the DES 2009 Report. These charge questions appear below and each is followed by the individual responses of the four panel members. Although this joint report is not explicitly a consensus document, the Panel conclusions reflect high degrees of convergence and agreement.

**QUESTION 1. THE REPORT TITLED “NUMERIC NUTRIENT CRITERIA FOR THE . . . GREAT BAY ESTUARY” (hereafter the “DES 2009 REPORT”) was developed over a five-year period starting in 2004. Is the “conceptual model” used in THE DES 2009 REPORT (at 4 and appendix B) to interpret the nutrient criteria reasonably supported by the data and studies for the estuary, the relevant scientific literature and the subsequent information/analyses available for the estuary?**

### BIERMAN RESPONSE

The “conceptual model” used in the DES 2009 Report is based on the National Oceanic and Atmospheric Administration (NOAA) estuarine eutrophication model (Bricker et al. 2007) that relates external nutrient inputs to primary and secondary symptoms of eutrophication. It also draws upon the conceptual model of coastal eutrophication by Cloern (2001) and technical guidance from the U.S. Environmental Protection Agency (2001) on estuarine and coastal waters.

The “conceptual model” used in the DES 2009 Report is technically sound and widely accepted in the scientific community; however, the site-specific application of this model to Great Bay Estuary for the purpose of developing numeric nutrient criteria did not consider all of the underlying direct/indirect linkages among the relevant stressor variables, response variables and confounding variables. See my response to Question 1e for a more complete discussion.

### DIAZ RESPONSE

Much of the conceptual model used to by DES was developed for the first National Estuarine Eutrophication Assessment (NEEA) under the leadership of Suzanne Bricker (Bricker et al. 1999, 2007). The NEEA was a survey of the extent, severity, types, and probable causes of eutrophic symptoms in US coastal systems, with Great Bay being one of 141 systems examined (Figure 1).

The basic NEEA assessment method evaluated eutrophication by examining influencing factors, and primary and secondary symptoms. Overall eutrophic condition and future outlook for eutrophication was then assessed in each system. Bricker et al. (2008) summarized the influencing factors and overall eutrophic condition as:

# Great Bay

## SUMMARY

In Great Bay, increases in dissolved inorganic nitrogen have occurred over the past 20 years. Increases in chlorophyll a and turbidity have been identified with augmented eutrophication in the inner estuary. As a result, eelgrass biomass has declined by 70% in the last 10 years and the occurrence of nuisance macroalgae is becoming more evident.

### Influencing Factors

Any level nitrogen input and low to moderate susceptibility (good ability to dilute and flush nutrients).

### Future Outlook

Nutrient related symptoms observed in the estuary are likely to substantially worsen.



### Eutrophic Conditions \*\*\*

Primary symptoms high but problems with more serious secondary symptoms still not being expressed.



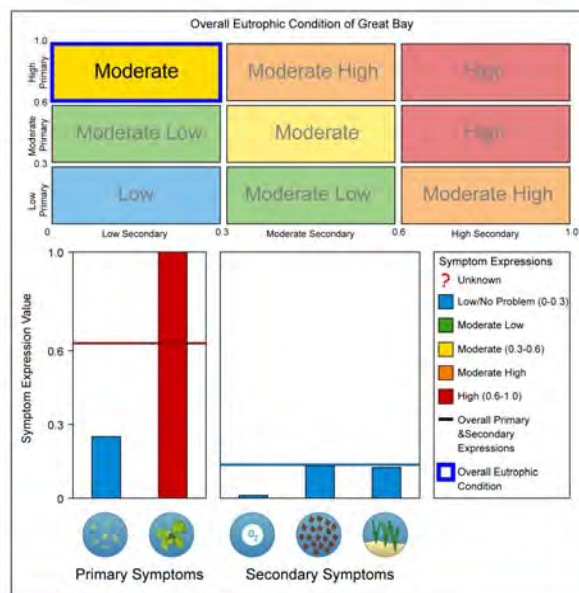
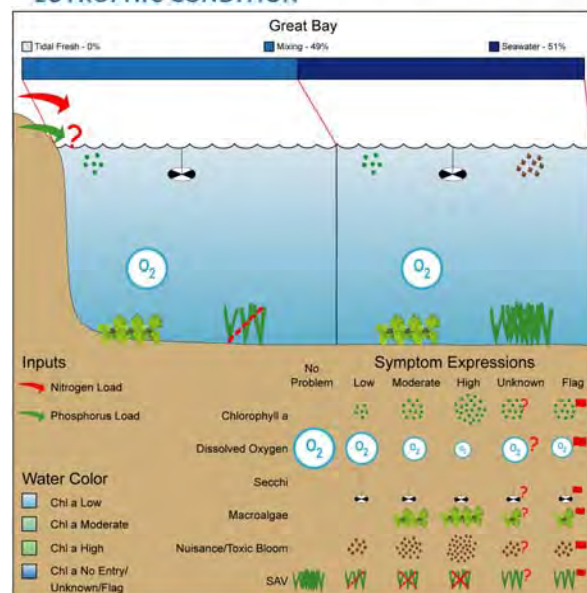
### ASSETS Rating

Assessment of Estuarine Trophic Status based on the three factors evaluated in NEEA.



Influence/eutro/future	Unknown	Low	Mod Low	Moderate	Mod High	High	Reliability and Confidence
ASSETS	Unknown	High	Good	Moderate	Poor	Bad	? Unknown * Low ** Moderate *** High

## EUTROPHIC CONDITION



## WATERSHED AND ESTUARY CHARACTERISTICS

Estuary	Landuse / Population			Watershed Details / Input Loads	
Area (km <sup>2</sup> )	47	Urban (km <sup>2</sup> )	477 (19.2%)	Area (km <sup>2</sup> )	2,555
Tidal fresh zone area (km <sup>2</sup> )	0	Agriculture (km <sup>2</sup> )	202 (8.1%)	Mean elevation (m)	102
Mixing zone area (km <sup>2</sup> )	23	Forest (km <sup>2</sup> )	1,740 (70%)	Max. elevation (m)	470
Saltwater zone area (km <sup>2</sup> )	24	Wetland (km <sup>2</sup> )	65 (2.6%)	Watershed: estuary ratio	54.4
Volume (1,000 x m <sup>3</sup> )	177,660	Range (km <sup>2</sup> )	3 (0.1%)	TSS (tonne y <sup>-1</sup> )	48,800
Depth (m)	3.78	Barren (km <sup>2</sup> )	0 (0%)	DIN (kg y <sup>-1</sup> )	905,000
Tide Height (m)	2.38	Total (km <sup>2</sup> )	2,486 (0%)	DIP (kg y <sup>-1</sup> )	Unknown
Residence Time (d)	1	Population	236,203	TSS/est. area (tonne km <sup>-2</sup> y <sup>-1</sup> )	1,038
		Popn: est. area ratio	5,026	DIN/est. area (kg km <sup>-2</sup> y <sup>-1</sup> )	19,255
				DIP/est. area (kg km <sup>-2</sup> y <sup>-1</sup> )	Unknown

Figure 1. Summary of Great Bay from the National Estuarine Eutrophication Assessment update (Bricker et al. 2007)



**INFLUENCING FACTORS:**

*“Influencing factors help establish a link between a system’s natural sensitivity, or susceptibility, to eutrophication as a result of flushing and dilution characteristics, and the nutrient loading and eutrophic symptoms that are observed. In most cases, if the water (and therefore nutrients) is flushed quickly, there is insufficient time for eutrophic symptoms to develop (i.e. low susceptibility). However, if the estuary has a long residence time, there is time for nutrients to be taken up by algae and for blooms to develop. Physical and hydrologic data are used separately to define dilution and flushing ratings which are combined by a matrix to give a susceptibility rating. The susceptibility rating is combined in a matrix with a rating for nitrogen loads to determine the final influencing factor rating. The load component is estimated as the ratio of nitrogen coming from the land (i.e. human-related) to that coming from the ocean (Bricker et al., 2003; Ferreira et al., 2007).”*

*“The load rating also provides insight into load management since loads that are primarily oceanic in origin will not be easily controlled. In addition to evaluating influencing factors, susceptibility can be used to forecast what symptoms may potentially occur. For example, in some shallow lagoon systems, additional nutrients may result in increased macroalgal abundance rather than high concentrations of phytoplankton/chlorophyll a (Nobre et al., 2005). A typology of these systems is being developed in order to increase assessment and forecasting accuracy by accounting for differences in how systems respond to nutrient inputs (Bricker et al., 2007).”*

**OVERALL EUTROPHIC CONDITIONS:**

*“Assessment of the overall eutrophic condition is based on assessment of five symptoms. For each symptom, a level of expression is determined by evaluating the occurrence, spatial coverage and frequency of the symptom. Chlorophyll a and macroalgae are considered primary symptoms that, at high levels, indicate the first stage of water quality degradation associated with eutrophication. The three secondary symptoms represent more serious impacts: low dissolved oxygen levels, loss of submerged aquatic vegetation, and occurrences of HABs. The average of the primary symptoms and the worst case of the secondary symptoms (a precautionary approach) are combined by a matrix to determine the overall eutrophic condition rating.”*

*“In many estuaries, primary symptoms lead to more serious secondary symptoms. In some cases secondary symptoms can exist in the estuary without originating from primary symptoms. This occurs in many North Atlantic estuaries where some HABs may be transported into the system from the coastal ocean (Bricker et al., 2006). Such systems were consequently given a lower rating (i.e. indicating lesser impact) for HABs than those systems for which these blooms originated within the system. Low ratings, rather than a designation of no problem, were used because it is unclear whether offshore HABs grow and are maintained by landbased nutrient sources once they enter the system.”*

*“It should be noted that nutrient concentrations are not used as an indicator because they reflect the net biological, physical, and chemical processes such that even a severely degraded system may exhibit low concentrations due to uptake by phytoplankton and macroalgae. Conversely a relatively healthy system might have high concentrations due to low algal uptake, strong filter feeder populations, or may flush nutrients so quickly that phytoplankton do not have the opportunity to bloom extensively.”*

The DES 2009 Report did not include sufficient details on Great Bay influencing factors. This becomes an important problem later in addressing many of the charge questions. Of the five symptoms used in the NEEA, the DES 2009 Report used four. Primary symptoms of Chlorophyll a and macroalgae, and secondary symptoms of low dissolved oxygen levels and loss of submerged aquatic vegetation. The occurrence of HABs was not used in the DES 2009 Report because they do not present a threat to Great Bay. The DES 2009 Report added an additional secondary symptom, the effects of accumulated organic matter in sediments on benthic infauna, based on Jim Cloern’s (2001) model of eutrophication impacts. The selection of primary and secondary symptoms was appropriate for assessing eutrophication in Great Bay.

In summary, the Great Bay conceptual model used in the DES 2009 Report included key elements of both the NEEA and Cloern conceptual models but also excluded key elements. The excluded elements were influencing factors (Bricker et al 2008) and complexity of interactions (Cloern 2001) that would have greatly improved interpretation of conditions in Great Bay for setting numerical criteria on nitrogen concentration. DES also used guidance from the 2001 EPA nutrient criteria technical manual (EPA 2001), which has since been reviewed by EPA’s SAB (EPA 2010a), for structuring the case for numeric criteria for nitrogen.

## KENWORTHY RESPONSE

The conceptual model utilized by in the DES 2009 Report was based on the NEEA Eutrophication Assessment (NEEA) (Bricker et al. 1999, 2007) and one element of a model developed by Cloern (2001). This approach was an appropriate framework and reasonable starting point to begin the assessment. The NEEA protocol is well supported by the published scientific literature and Cloern’s work is widely cited and recognized as an important contribution to understanding processes of eutrophication. The overall approach calls for assessing five symptoms of eutrophication; two primary symptoms, chlorophyll-a and microalgae, and three secondary symptoms, harmful algal blooms (HABs), low dissolved oxygen levels and loss of submerged aquatic vegetation (eelgrass). DES decided not to include HABs, stating that HABs were not a significant threat to water quality in the Great Bay Estuary. The element of the Cloern model adopted by DES included consideration of sediment organic matter.

In practice, application of the DES conceptual model to the Great Bay Estuary failed to address several influencing factors identified by the NEEA protocol and needed to fully evaluate the effects of nitrogen on eelgrass. Many of the factors explicitly indicated by the NEEA, for example; hydraulic flushing and water residence time (Bricker 1999), were not considered in the DES model. These two physical factors (among several others) are especially important in controlling nitrogen loading, processes of nitrogen

cycling, and nitrogen concentrations in New England Estuaries (Latimer and Rego 2010). Hydrological modelling of individual embayments is a centerpiece of the Massachusetts Estuaries Program (MEP) for developing TMDLs and one of the tools used to evaluate nitrogen loading and its effect on eelgrass. Even though DES cites the MEP work as influential for developing and implementing their approach in the Great Bay estuary, there was no effort made to consider these other important factors.

The NEAA conceptual model was also inadequate because it failed to recognize algal epiphytes as a very important symptom of eutrophication that affects light attenuation and eelgrass abundance (Neckles et al. 1993, Kemp et al. 2004; Ralph et al. 2007). The NEAA and DES did not recognize epiphytes as a contributor to light attenuation; however, empirical research and modelling studies published in the scientific literature clearly demonstrate that one of the primary symptoms of nitrogen over-enrichment and eutrophication in seagrass systems is the overgrowth of micro- and macroalgae on the leaves of seagrasses (Ralph et al. 2007). Much like phytoplankton blooms (water column chlorophyll-a), algal overgrowth on seagrass leaves attenuates light and negatively affects seagrass growth (Neckles et al. 1993, Kemp et al. 2004). Eelgrass beds exposed to eutrophication typically exhibit symptoms which include high epiphyte loading. Additionally, epiphyte loading may be exacerbated by low dissolved oxygen concentrations which limit the metabolism and feeding activities of algal grazers that are primarily responsible for mitigating the potential effects of the excessive growth of epiphytes. Hence, providing a positive feedback mechanism and leading to more excessive epiphyte growth and further light attenuation at the eelgrass leaf surface (Kemp et al. 2004). According to the site specific study referenced in the DES 2009 Report (Morrison et al. 2008), light attenuation in Great Bay can be attributed to water (32%), turbidity (29%), CDOM (27%) and chlorophyll-a (12%). Since these results suggest chlorophyll-a is responsible for only a small fraction of light attenuation and DES implicates nitrogen as the main factor responsible for eelgrass loss, it would be reasonable to evaluate the effect of epiphytes as a diagnostic symptom of eutrophication in the Great Bay system. In their assessment DES did not explicitly state whether they considered epiphytes as a potential eutrophication problem. If we assume that DES did not simply ignore this factor and epiphytes are not contributing significantly to light attenuation, and chlorophyll-a is only a minor contribution to light attenuation, nitrogen cannot be directly implicated as the major cause of light attenuation and eelgrass declines in the Great Bay estuary.

## RECKHOW RESPONSE

Yes, the conceptual model is a reasonable choice. Unless stated otherwise, the analyses that I present in this peer review are based on pooling all the stations and sites NH data, which were provided by NH DES.



***Specifically respond to the following:***

- a) Given the available data, is transparency an important factor in the presence/absence of eelgrass in the various segments of the estuary including the upper tidal rivers, great bay, little bay, the Piscataqua River, and/or Portsmouth Harbor? If yes, is it the controlling factor?**

**BIERMAN RESPONSE**

Yes, it is an important factor.

Conceptually, it is the controlling factor, assuming that the prerequisite physical-chemical requirements are met. These include current velocity, waves, tides, salinity, sediment grain size distribution (GSD), sediment total organic carbon (TOC) and sediment sulfide concentration (Koch 2001). Another important factor is explicit consideration of estuarine bathymetry. The data and analyses in the DES 2009 Report did not adequately demonstrate that transparency is the controlling factor in Great Bay Estuary because it did not explicitly investigate any of these confounding factors.

**DIAZ RESPONSE**

Yes, transparency is one of many important factors that affect eelgrass presence/absence and growth/health.

**KENWORTHY RESPONSE**

Water transparency controls the availability of light for underwater plants and is an important factor controlling the distribution and abundance of seagrasses, including eelgrass (Dennison and Alberte 1982, 1985, 1986, Dennison et al. 1993). When considering all of the potential symptoms of eutrophication and the stressor response relationships, the most well documented, consistent, and empirically supported relationship is between transparency and eelgrass response (Krause-Jensen et al. 2008). DES was correct in considering transparency as a factor in their assessment. But transparency is not the only important factor, and the relationship of eelgrass loss to transparency varies by estuarine water depth with the greatest eutrophication induced responses documented for deeper waters. The effect of transparency will also be influenced by the light requirements of eelgrass which may be different depending on ambient water quality and sediment conditions (Kenworthy and Fonseca 1996, Duarte et al. 2007, Kenworthy et al. 2013). Eelgrass growth, abundance and distribution are also controlled by temperature, nutrient availability (primarily nitrogen and phosphorus), tidal range, water motion, wave action, water residence time, bathymetry, substrate type, substrate quality, severe storms, disease, plant reproduction and anthropogenic disturbances (Short and Wyllie Echeverria 1996, Koch 2001, Short et al. 2002, Kemp et al. 2004, Moore and Short 2006, Krause-Jensen et al. 2008). Eelgrass distribution and abundance in an estuary results from the complex interaction of some or all of the factors listed above, and no two estuaries or sub-embayments of an estuary are identical in all of these factors (see Figure 5 in Krause-Jensen et al. 2008). In order to determine if one or more of these are “controlling” it would be necessary

to either consider all of them and their interactions, or be able definitively eliminate certain factors as insignificant contributors.

In their assessment of transparency and its controlling effect on eelgrass, DES considered a sub-set of the factors listed above; nutrient availability, tidal range, disease, and two anthropogenic factors (dredging and mooring fields) (R-WD-09-12, Numeric Nutrient Criteria for the Great Bay estuary). Because nutrient availability does not directly affect transparency, this factor was addressed indirectly through the interaction between nitrogen concentration and chlorophyll-a using a linear regression approach between chlorophyll-a and the light attenuation coefficient measured as  $K_d$ . Tidal range was incorporated into the assessment using a model developed by Koch (Koch and Beer 1996, Koch 2001). Disease was incorporated into the assessment of eelgrass status in the Great Bay Estuary by considering the effects of wasting disease on temporal and spatial fluctuations in eelgrass cover (WD Doc R-WD-08-18, Methodology and Assessment Results related to Eelgrass and Nitrogen in the Great Bay Estuary for Compliance with Water Quality Standard for the New Hampshire 2008 Section 303(d) List). The eelgrass assessment also considered historical and current information on the potential effects of dredging and vessel mooring fields on eelgrass. A critical deficiency in the DES 2009 Report was the fact that DES did not attempt to present evidence for ruling out the other factors listed above that could be controlling the presence or absence of eelgrass (e.g., temperature, water motion, wave action, bathymetry, water residence time, substrate type, substrate quality, severe storms, disease, epiphytes, and plant reproduction). Before critically evaluating the DES approach and responding to the remaining questions, it is first necessary to consider how DES evaluated the status of eelgrass in the Great Bay Estuary.

#### **DES 2008 EELGRASS ASSESSMENT METHODS USED FOR THE 2009 REPORT AND ESTABLISHMENT OF NITROGEN CRITERIA FOR THE GREAT BAY ESTUARY**

As per the New Hampshire Department of Environmental Services (DES) assessment methodology used in the DES 2008 and 2009 Reports, a significant loss of eelgrass (*Zostera marina*) habitat would constitute a violation of the narrative standard ENV-Ws 1703.19 and create a water quality standard violation for biological integrity (WD Doc R-WD-08-18). To conduct the assessments, DES originally selected eelgrass cover data in 11 geographically distinct assessment zones as an indicator for water quality impairment determinations (see Table 2 in WD Doc R-WD-08-18). The 11 original zones were assessed for eelgrass cover up to 2005 and have since been subdivided into 13 zones by DES after recognizing one further subdivision of the Piscataqua River and distinguishing Portsmouth and Little Harbors as distinct zones (Table 1). DES eelgrass cover data are now available up to 2012, but the original assessment terminated in 2005. The historical cover data for the DES 2009 Report were derived from a wide range of sources dating back to 1948 and considered the catastrophic effects of the wasting disease on eelgrass in 1931-1932, and subsequent wasting disease events in 1984 and 1988-1989. Standardized mapping of eelgrass cover in the Great Bay Estuary using nationally accepted protocols was not initiated until 1986 and included only the assessment zones in Great Bay, and the Winnicut, Squamscott and Lamprey Rivers. All 13 zones were first simultaneously mapped with standardized protocols for eelgrass cover in 1996 and again in 1999 with a continuous annual record that is now available between 1999 and 2012.

To conduct their assessments of changes in eelgrass cover in each of the zones DES used two methods; a zone will be considered to have significant eelgrass loss if 1) the change from historic levels is >20% or, 2) where annual surveys were available, there was a statistically significant ( $p < 0.05\%$ ) decreasing trend that shows a loss of 20%. To further minimize the effect of annual variation on the analyses conducted with method #1, DES used the median eelgrass cover for three years (2003, 2004, and 2005) as the contemporary reference point to compare with the historical data. Selection of the 20 % threshold was based on an analysis of the variation in a continuous record of eelgrass cover (1990-1999) in one zone, Great Bay. This analysis indicated a relative standard deviation of 6.5%. DES selected three relative standard deviations as the threshold for the upper bound of natural variation ( $3 * 6.5$ ) to constitute the threshold and assumed that the variation in cover in Great Bay was representative of the other zones in the Estuary. Currently there is no citable published precedent in the scientific literature for using a threshold of 20% change in any eelgrass monitoring program, and the implications for selecting a threshold of 20% change could be very different depending on the time interval over which the change occurs. To the best of my knowledge, the State of Washington conducts the only long-term and large-scale statewide eelgrass monitoring program in the country that utilizes a threshold change criteria of 20%. The Washington State eelgrass sampling program is probabilistic based, and the criteria are time dependent, utilizing data from annual monitoring of eelgrass cover over a period of 10 years to conduct the change analysis. It is also my understanding that the Washington State monitoring program is undergoing an internal technical and quality control review. The DES eelgrass monitoring program could gain substantial benefits and a better understanding of the difficulties in establishing statistically significant eelgrass change detection by consulting the Washington State program.

#### ***DES EELGRASS ASSESSMENT RESULTS AND NITROGEN CRITERIA***

Seven of the original 11 zones (Squamscott, Lamprey, Oyster, Belamy, Little Bay, Upper Piscataqua and Lower Piscataqua) were assessed using method #1, based on historical data from 1948, 1962 and 1980-81. All seven of these assessments met the DES criteria for impairment with respect to eelgrass status. In two zones, Upper and Lower Piscataqua Rivers, different years were combined to get historical reference totals, but the DES 2009 Report does not provide adequate explanations justifying the combination of data collected 20 years apart.

Four of the original 11 zones (Winnicut, Great Bay, Portsmouth Harbor/Little Harbor and Sagamore) were assessed using method #2, based on linear regressions. Winnicut River and Great Bay were analyzed for the period 1990-2005, and Portsmouth Harbor/Little Harbor and Sagamore Creek for the period 1996-2005. Of these four zones, the only significant decreasing trend was detected in the Winnicut River. In Great Bay, where the largest amount of eelgrass resource is found in the estuary, eelgrass actually increased from historical levels reported in both 1948 and 1980-1981 and the median cover for years 2003-2005 was higher than the cover in 1990 at the start of the regression analysis.

#### ***CRITICAL EVALUATION OF THE DES EELGRASS ASSESSMENT METHOD***

The DES assessment reports were correct in dividing the Great Bay Estuary into 11 distinct assessment zones, each with independent analyses of eelgrass status. This approach is consistent with the approach taken by the Massachusetts Estuaries Project in assessing nitrogen loading in coastal embayments. A

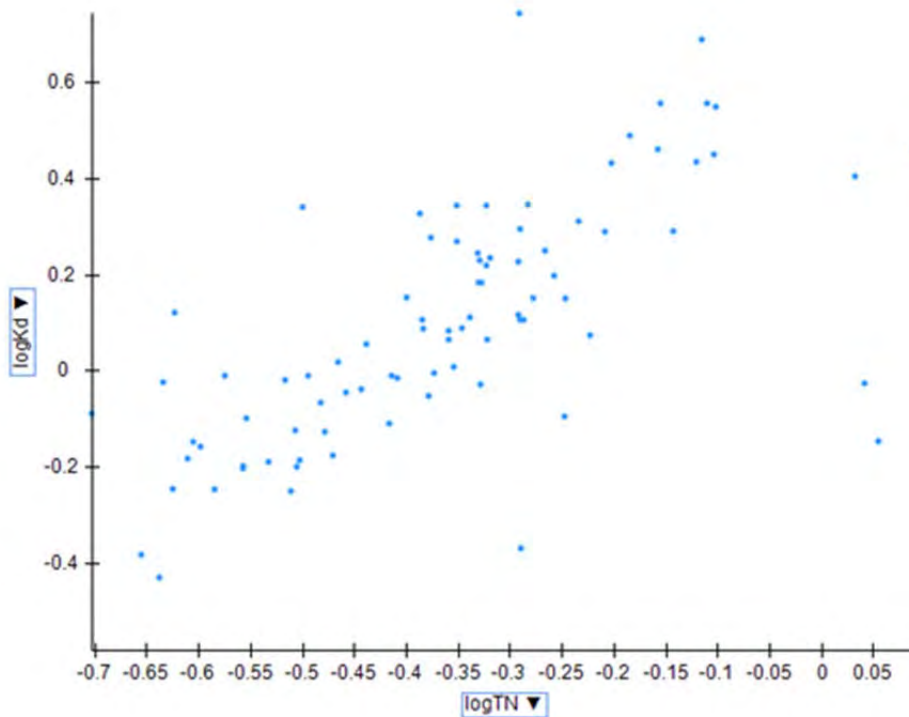


main strength in this approach is that it implicitly recognizes heterogeneity in the estuarine system as well as the possibility that there may be important differences in the biophysical characteristics of the zones which could affect eelgrass distribution and abundance. Spatial variation in factors such as natural watershed landscape characteristics, non-point source water runoff, water depth, sediment type, substrate stability, wind and wave exposure, tidal velocities, freshwater discharge, non-point source runoff, groundwater discharge and land use are known to interact and determine different eelgrass distributions in shallow water coastal ecosystems (Thayer et al. 1984, Larkum et al. 2006, Orth et al. 2010a, b). Stochastic events like severe storms, ice scour and climate variation were not considered even though these are known to affect eelgrass (Frederiksen et al. 2000 a, b, Orth and Moore 2006, Krause-Jensen et al. 2008). The assessment completely ignored biological aspects of the system including plant reproduction, grazing and bioturbation. Some of these factors can limit eelgrass growth, reproduction and distribution to the extent that the species can be completely eliminated from an estuary (see Figure 5 in Krause-Jensen et al. 2008). The importance of considering multiple controlling factors also directly applies to eelgrass restoration as empirically determined by Short et al. (2002) in Great Bay and elsewhere in New England estuaries. These confounding factors can obscure the relationship between nitrogen loading/eutrophication and eelgrass response, therefore the assessment was weakened by not explicitly considering any of these factors in their evaluation of eelgrass loss. The DES case was further weakened by only considering information for the anthropogenic effects of dredging and the existence of mooring fields as other potential factors controlling eelgrass distribution in the Great Bay estuary.

DES was correct to factor in consideration of the effects of “wasting disease” on eelgrass populations and the general distribution and abundance of eelgrass in the Great Bay Estuary, but the effects of wasting disease on eelgrass should have been considered uniformly across all of the different zones. In five zones which utilized historical data as a baseline from 1948, 1962, and 1980-81 (Oyster, Bellamy, Little Bay, Upper Piscataqua, Lower Piscataqua), DES failed to acknowledge the possible effects of wasting disease events that were reported in the estuary in 1984 and 1989. Reliable and consistent mapping data for these five zones was not available until 1996, so it was incorrect to identify the baseline cover prior to the two contemporary wasting disease events if their effect could not be assessed. A further indication that DES was inconsistent in their consideration of the wasting disease was the fact that DES explicitly recognized the effects of the disease in the Great Bay zone and did not initiate the regression analysis for the assessment until 1991.

## RECKHOW RESPONSE

Transparency is one of several factors determining the presence/absence of eelgrass. It is no more/less controlling than is TN. To see this Kd-TN covariation conundrum, consider the graph below:



**Figure 2. Log Kd versus Log TN**

TN and Kd are highly correlated, which is likely due to the fact that TN affects algae (chlorophyll), and algae affects Kd. Based on scientific knowledge, this is a plausible causal relationship, and it is supported by this graph.

**b) Given the available data/studies, is nitrogen an important factor in the presence/absence of eelgrass in various segments of the estuary (please be specific in terms of the impact or lack of impact in the tidal rivers, great bay, little bay, the Piscataqua River, or Portsmouth Harbor)? If yes, is it the primary factor?**

## **BIERMAN RESPONSE**

Yes, it is an important factor.

It is one of the primary factors, not the sole primary factor. Light is also a primary factor. Other important factors are those listed above in my response to Question 1a. The DES 2009 Report did not adequately demonstrate that nitrogen is the primary factor in the Great Bay Estuary because it did not explicitly consider any of the other important, confounding factors in developing relationships between nitrogen and the presence/health of eelgrass.

These answers apply to the Estuary as a whole and to its various individual segments.

## **DIAZ RESPONSE**

Yes, overall nitrogen is an important factor for eelgrass growth, but in the context of numeric nitrogen criteria it is the concentration of nitrogen that disrupts the balance of primary producer species that are known to negatively interact with eelgrass (Neckles et al. 1993). With increasing nutrients there is a shift in primary producers from perennial macroalgae and seagrasses toward a dominance of ephemeral macroalgae, epiphytes and phytoplankton (Neckles et al. 1993, Cloern 2001). Within the various estuarine segments, the importance of nitrogen as a controlling factors needs to be balanced by other co-varying factors, such as transparency and sediment quality (Kenworthy et al. 2013), and those listed in Kenworthy's response.

## **KENWORTHY RESPONSE**

The eelgrass assessment document (WD Doc R-WD-08-18) states explicitly that DES used a methodology to determine compliance with water quality standards for biological integrity using eelgrass cover as an indicator. In this document DES also included their assessments of chlorophyll-a in each of the zones and determined that there were four zones with nitrogen impairment and seven zones without nitrogen impairment; implicitly linking eelgrass impairment to nitrogen impairment. Four of the seven zones with eelgrass impairment were not declared nitrogen impaired. This is not very compelling evidence linking nitrogen impairment to eelgrass impairment if only 36% of the zones in the Great Bay Estuary are considered impaired for both, and more than half of the zones with eelgrass impairment were not declared nitrogen impaired. Even if it were correct to infer a linkage between chlorophyll-a data, nitrogen impairment and eelgrass status in the Great Bay estuary, it was inappropriate for the DES to imply a linkage in the 2008 and 2009 reports. The chlorophyll-a data were from the period 2000 – 2008 while the eelgrass changes in the zones that were declared impaired are based on historical data from 1948, 1962 and 1980-81 and changes that may have occurred during extended periods without eelgrass

cover data or environmental monitoring. There is no basis for a scientifically defensible linkage between nitrogen impairment and eelgrass impairment presented in the report.

DES eelgrass cover data using standardized protocols is now available up to 2012 with a nearly spatially complete and continuous 17 year record beginning in 1996 (Table 1). The potential implications of more recent eelgrass cover data were suggested in the DES 2009 Report on page 66 where DES acknowledges that even where the lowest concentrations of nitrogen occur in Portsmouth and Little Harbors conditions are not pristine and eelgrass is declining. There are several aspects of this more recent data set that provide significant insights and improvements in the assessment of eelgrass status with regard to nitrogen impairment and other factors that may affect eelgrass growth and distribution. First of all, the more recent 17 year record avoids the uncertainties associated with unreliable and aggregated historical data sets used in the original assessment and eliminates the necessity of using two different assessment methods. It would also avoid uncertainties and assumptions about undocumented effects of wasting disease and other environmental stressors that may have affected eelgrass during periods of time when environmental monitoring was incomplete and eelgrass cover was not assessed between 1948 and 1996. Second, the more contemporary eelgrass data set would coincide more closely with regularly monitored environmental data (e.g., chlorophyll a, light attenuation, salinity, temperature, etc.) in the estuary presented in the 2009 DES Report.

A preliminary analysis of this more recent eelgrass cover data set re-affirms the DES general concerns for the declining status of eelgrass cover throughout the Great Bay estuary (Table 1). With the exception of just one zone, Little Bay, all of the individual zones with eelgrass cover present in 1996 displayed >20% declines and should the linear regressions be significant as per the DES criterion #2, these zones could be legitimately declared impaired with regard to eelgrass cover. Furthermore, this preliminary analysis suggests that the Great Bay zone (- 35.95% decline) could be considered impaired, whereas in the original assessment it was ambiguously declared threatened. Little Bay actually displayed a small increase (5.81%). Three zones could not be assessed because there was no eelgrass cover in 1996. In two of these zones (Lamprey and Bellamy Rivers) small coverage's of eelgrass were detected during the time interval, but eelgrass was not present in 2012.

In addition to this preliminary assessment of eelgrass status, I have also calculated specific rates of annual change in the different zones of the Great Bay estuary (%  $y^{-1}$ ; see Table 1) and compared these to the reported rates of decline for seagrasses in general (Waycott et al. 2009) and eelgrass in Massachusetts (Costello and Kenworthy 2011). Rates of decline ranged from - 2.43 %  $y^{-1}$  in Sagamore Creek to - 6.25 %  $y^{-1}$  in the upper Piscataqua River. The average rate of decline for the nine zones that could be analyzed was - 4.19 %  $y^{-1}$ . Based on a global assessment of 217 sites, the median annual rate of decline for seagrasses since 1980 was - 5 %  $y^{-1}$  (Waycott et al. 2009). This global assessment attributed seagrass declines to overexploitation, physical modification, nutrient and sediment pollution, introduction of nonnative species, and global climate change. Nearby in Massachusetts, where there has been well documented concern for nutrient impairments derived from groundwater nitrogen discharges, a statewide change analysis of eelgrass abundance over a period of 12 years reported rates of decline ranging from - 2.21%  $y^{-1}$  to -3.51%  $y^{-1}$ . In some of the most nutrient impaired embayments in Massachusetts eelgrass



has been completely extirpated in the past three decades. Based on the average rate of decline in the Great Bay estuary, eelgrass could be lost from large portions of the system in two to three decades.

As suggested above, the preliminary analysis using the more current eelgrass cover data affirms scientifically defensible DES concerns for eelgrass declines in the Great Bay estuary; however, by no means does this infer a direct relationship with nitrogen impairment as suggested by the original assessment in WD Doc R-WD-08-18, Methodology and Assessment Results related to Eelgrass and Nitrogen in the Great Bay Estuary for Compliance with Water Quality Standard for the New Hampshire 2008 Section 303(d) List. In fact, this new analysis confirms a fundamental flaw in the DES approach to setting nitrogen concentration criteria using the regression method in the DES 2009 Report. This DES 2009 Report clearly shows that nitrogen (Figures 4, 6, and 17), chlorophyll-a (Figures 13, 14 and 17) concentrations, light attenuation (Table 9) and turbidity (Figure 17) are highest in the tidal tributaries and are progressively diluted by ocean water down to the mouth of the estuary. Yet, even at locations furthest downstream from the tributaries (e.g., Portsmouth Harbor, Little Harbor and the Lower Piscataqua River) with the lowest concentrations of chlorophyll-a, nitrogen, turbidity, and greater water transparency, eelgrass is declining at significant rates (Table 1). Two alternative conclusions can be drawn from this analysis; 1) either the proposed nitrogen criteria will not protect eelgrass from further declines or, 2) there are other factors contributing to the eelgrass fluctuations and declines which have not been adequately addressed in the DES assessment reports.

**Table 1. Annual estimates of eelgrass cover and percent change in cover (total change and percent per year) for the Great Bay Estuary between 1996 and 2012.**

Data provided on my request by the New Hampshire Department of Environmental Services.

nd = no data collected, na = data not applicable

YEAR	Winnicut River	Squamsco tt River	Lamprey River	Oyster River	Bellamy River	Great Bay	Little Bay	Upper Piscataqua River	Lower Piscataqua River North	Lower Piscataqua River South	Portsmouth Harbor	Little Harbor	Sagamore Creek
1996	7.6	0	0	14	0	2495.4	32.7	1.6	20.9	10.2	245.6	70.1	1.8
1997	7.5	0	0	nd	0	2297.8	Nd	Nd	Nd	nd	Nd	Nd	Nd
1998	10	0	0	nd	0	2387.8	Nd	Nd	Nd	nd	Nd	Nd	Nd
1999	10.2	0	0	0	0	2119.5	26.2	0.5	7.4	4	244	50.1	3
2000	0	0	0	0	0	1944.5	7.5	1.6	3.8	7.6	260.5	60.9	0.9
2001	4.1	0	0	0	0	2388.2	10.9	2	9.7	10.7	274.2	45.3	2.2
2002	3.5	0	0	0	0	1791.8	4.3	0.5	8	9.3	268.9	63.1	2.3
2003	3.5	0	2.2	0	0	1620.9	14.2	2.9	22.9	9.2	270.1	54.7	2.2
2004	4.2	0	0	0	0.8	2037.6	12.8	0.7	13.5	6.5	225.2	65.8	2.5
2005	9.1	0	0	0	0	2165.7	25.8	0.4	14.5	9.6	232.5	47.9	6.1
2006	0.8	0	0	0	0	1319.8	12.2	0.8	10.8	11.6	217.6	52.1	0.9
2007	0	0	0	0	0	1245.3	0.1	0	0.4	5.6	201.3	42.7	0.6
2008	0	0	0	0	0	1394.9	0	0	0	3.9	183.8	41.4	2.3
2009	0.1	0	0	0	0	1700.6	0	0	0	6.4	155	30.2	0.5
2010	0	0	0	0	0	1722.2	0.3	0	0	3.5	128	42.5	0.2
2011	0	0	0.5	0	0	1623.2	48.2	0	0	6.9	178.8	31.6	1.5
2012	0.3	0	0	0	0	1598.4	34.6	0	1.6	5.1	139.6	36.4	1.1
Percent Change	-96.05	na	na	-100.00	-100.00	-35.95	5.81	-100.00	-92.34	-50.00	-43.16	-48.07	-38.89
Percent Change Per Year	-6.00	na	na	-6.25	na	-2.25	0.36	-6.25	-5.77	-3.13	-2.70	-3.00	-2.43

## RECKHOW RESPONSE

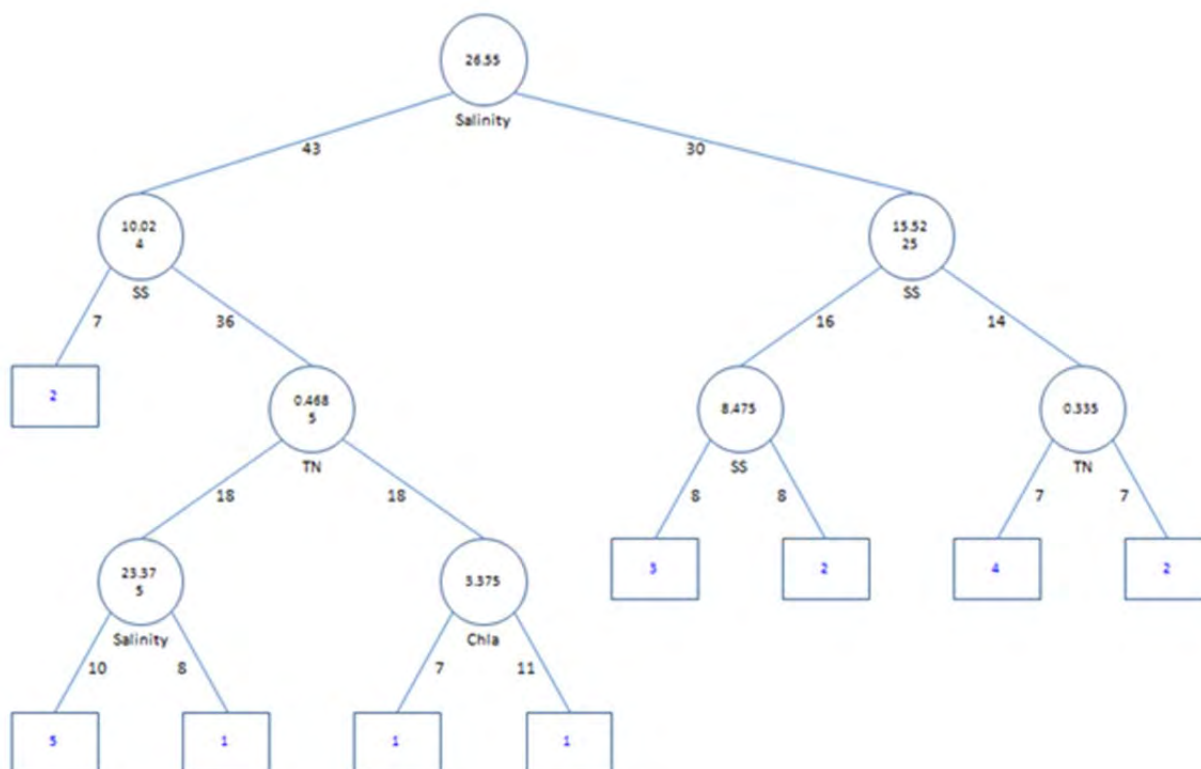
To assess the importance of several factors on eelgrass areal coverage, I applied some multivariate pattern recognition techniques to the NH data. One approach that I used is called a “classification tree.” A classification tree is somewhat like a multiple regression model, in that it yields a predictive model for a single variable. The response variable in regression is usually continuous, while the response variable in a classification tree is categorical. Even though eelgrass areal coverage is a continuous variable, I chose to apply a classification tree (with five discrete classes for eelgrass acreage) because the tree diagram provides an informative visual display.

Category	Eelgrass Acreage
1	0
2	0 < eelgrass < 10
3	10 < eelgrass < 70
4	120 < eelgrass < 275
5	eelgrass > 1200

**Figure 3. Categories for Eelgrass**

A classification tree partitions the multidimensional space of the predictor variables into regions, each of which is assigned to a category for the response variable. One way to fit classification tree models and partition the space of predictor variables into classes can be described on a conceptual level as follows. At the beginning, all observations are signed to the same class (or given the same prediction for a regression tree). In the first step the observations are split into two classes based on a criterion that minimizes the impurity or maximizes the homogeneity of each class. Additional splits are determined on a step-by-step basis, not optimized for the entire tree at one time. At each split, the predictor variable that minimizes a classification error criterion is selected to provide the classification split.

The next figure presents the best-fit model using the predictor variables chlorophyll, salinity, SS, TN, TP; the five eelgrass categories for the response variable are presented in the table. Note that salinity is the first (most important) split/classification predictor variable. Other variables provide optimal splits down in the branches of the tree. The interpretation of this classification tree is as follows. Applying the classification tree algorithm, we find that salinity is the best classifier for the five eelgrass categories, so starting at the top of the tree, if salinity is less than 26.55 (the number in the top circle) for a data point, we move to the left branch. If salinity is greater than 26.55 we move to the right.



**Figure 4. A “best fit” Classification Tree**

Moving down the left branch, the next split for a classifying variable is for SS (suspended solids); in this case if the suspended solids concentration is less than 10.024, we go down the left branch, which leads to the data point being placed in eelgrass category two ( $0 < \text{eelgrass} < 10$ ). If the suspended solids concentration is greater than 10.024, we move down to the right where the next classification split is for TN.

This classification tree, and other analyses I have undertaken on the NH data set, clearly show the multivariate relationships among the variables. The effectiveness of TN load reductions clearly varies from site to site, suggesting that a site-specific numeric nutrient criterion should be considered.

**c) Does the available information indicate that increased algal growth is causing or significantly contributing to a loss of eelgrass and that nitrogen reductions will significantly improve the conditions for eelgrass growth and/or restoration?**

**BIERMAN RESPONSE**

According to Piscataqua Region Estuaries Partnership (PREP) (2013), phytoplankton chlorophyll-a concentration has not shown a positive or negative trend in Great Bay between 1975 and 2011. The NOAA national eutrophication assessment covering the 1990s and early 2000s (Bricker et al. 2007) also indicated that chlorophyll-a was not a serious problem, and may have declined over the assessment period.

No data were presented for algal growth (primary productivity) in either the PREP (2013) report or the DES 2009 Report. In both of these reports, phytoplankton are characterized exclusively by chlorophyll-a concentration, a snapshot-in-time measurement that represents standing stock, not rate of algal growth.

As stated above in my response to Question 1b, light is one of the primary factors controlling eelgrass growth and, presumably, restoration. Conceptually, if nitrogen concentration and chlorophyll-a were positively correlated, then reductions in nitrogen could lead to improvement in underwater light because chlorophyll-a is one of the factors contributing to underwater light attenuation.

In the Great Bay Estuary, the following are the contributions to  $K_d$  (underwater light attenuation coefficient) from the site-specific model by Morrison et al. (2008): water (32%), turbidity (29%), CDOM (27%) and chlorophyll-a (12%). The DES 2009 Report assumes that CDOM is not related to algal primary productivity and ignores water because it is a constant background component.

An immediate observation is that not only is chlorophyll-a a small component of  $K_d$ , median chlorophyll-a concentrations in Great Bay are low and range between 1-7  $\mu\text{g/l}$  (Table 6). It is unlikely that reductions in nitrogen concentration could cause significant improvements in light by causing reductions in chlorophyll-a concentration.

To establish a scientifically defensible linkage between nitrogen concentration and  $K_d$  in Great Bay Estuary, the following multiple, component linkages require investigation using more than a simple linear regression (SLR) analysis:

1. Chlorophyll-a versus nitrogen
2. POC versus chlorophyll-a
3.  $K_d$  versus POC
4.  $K_d$  versus turbidity
5. Turbidity versus POC
6. Turbidity versus ISS
7.  $K_d$  versus chlorophyll-a



The first three component linkages represent the conceptual model for the influence of nitrogen concentration on  $K_d$  (Benson et al. 2013). That is,  $N \Rightarrow \text{chlorophyll-a} \Rightarrow \text{POC} \Rightarrow K_d$ . The fourth component linkage is important because the model by Morrison et al. (2008) indicates that turbidity makes a significant contribution to  $K_d$  in Great Bay Estuary. The fifth and sixth linkages are important because the DES 2009 Report states on Page 64 that turbidity in Great Bay Estuary is due to POC and ISS. The seventh linkage is important because it must be shown that changes in chlorophyll-a concentration (due to changes in nitrogen concentration) can cause significant changes in  $K_d$ .

The DES 2009 Report showed SLR results for chlorophyll-a versus nitrogen concentration (Figures 15 and 17), but not for POC versus chlorophyll-a or  $K_d$  versus POC. It showed SLR results for turbidity versus POC (Figure 35) but not for  $K_d$  versus turbidity, turbidity versus ISS or  $K_d$  versus chlorophyll-a.

Results in Figure 35 indicate that POC explains 47% of the variability in turbidity. Consequently, POC explains 47% of the variability in the factor that accounts for 29% of the contribution to  $K_d$ . Total dissolved nitrogen (TDN) explains 34%/46% (maximum/minimum) of the variability in POC (Figure 34). Consequently, TDN explains less than half of the variability in POC, which itself explains less than half of the variability in the factor that accounts for 29% of the contribution to  $K_d$ .

Regarding the SLR results for chlorophyll-a versus nitrogen concentration (Figures 15 and 17), DES provided, at my request, supplementary SLR results with nitrogen concentration replaced by salinity for Figure 15. The strength of the correlation with salinity was comparable to that with nitrogen concentration. Given the strength of the correlation between salinity and nitrogen concentration (Figure 21;  $R^2 = 0.680$ ), this makes sense. Consequently, the results in Figure 15, in conjunction with the supplementary results with nitrogen replaced by salinity, demonstrate only that chlorophyll-a and nitrogen concentrations co-vary with salinity, not that there is a causal relationship between chlorophyll-a and nitrogen.

Results in Figures 36-37 for regressions of turbidity versus nitrogen concentration appear spurious because there was no explicit consideration of the co-varying/confounding factors ISS or salinity. Similarly, results in Figures 38-39 for regressions of  $K_d$  versus nitrogen concentration appear spurious because there was no explicit consideration of the co-varying/confounding factors ISS or salinity. In fact, when salinity is substituted for nitrogen concentration as the independent variable in Figure 38 (supplementary results provided by DES at my request), the correlation between  $K_d$  and salinity is almost as strong as the correlation between  $K_d$  and nitrogen concentration. Consequently, the results in Figure 38, in conjunction with the supplementary results with nitrogen replaced by salinity, demonstrate only that  $K_d$  and nitrogen concentration co-vary with salinity, not that there is a causal relationship between  $K_d$  and nitrogen.

In summary, the DES 2009 Report failed to analyze all of the linkages (co-varying factors) between nitrogen concentration and  $K_d$  in their conceptual model of Great Bay Estuary. My opinion is that the SLR results in Figures 38-39 for  $K_d$  versus nitrogen concentration are based on weak evidence and are unreliable due to lack of explicit consideration of all the underlying direct/indirect linkages among the relevant stressor variables, response variables and confounding variables.

## DIAZ RESPONSE

While declining seagrass in favor of macroalgae or phytoplankton is an all too common response from nutrient driven eutrophication (Burkholder et al. 2007), a causal link between eelgrass and macroalgae in Great Bay is not clear. Monitoring data and other published accounts indicate the occurrence of macroalgal has increased in Great Bay, but there does not seem to be any strong association between macroalgae and eelgrass in Great Bay. Relative to nutrients, Burkholder et al. (2007) say the following in their abstract:

*“The most common mechanism invoked or demonstrated for seagrass decline under nutrient over-enrichment is light reduction through stimulation of high-biomass algal overgrowth as epiphytes and macroalgae in shallow coastal areas, and as phytoplankton in deeper coastal waters. Direct physiological responses such as ammonium toxicity and water-column nitrate inhibition through internal carbon limitation may also contribute. Seagrass decline under nutrient enrichment appears to involve indirect and feedback mechanisms, and is manifested as sudden shifts in seagrass abundance rather than continuous, gradual changes in parallel with rates of increased nutrient additions.”*

At some level, macroalgae, eelgrass, and nitrogen are connected and interact. The DES 2009 Report is a step in the right direction, but the approach taken needs to include the complexity of interactions as pointed out by Burkholder et al. (2007) and Kenworthy et al. (2013), and the other peer review responses to this question.

## KENWORTHY RESPONSE

Strictly speaking this question is difficult to answer because there are no direct measurements of algal growth in the DES 2009 Report. All data for algae in the water column are presented as concentrations of chlorophyll-a, not phytoplankton growth. Macroalgal growth was considered in their assessment as stated explicitly in the 2009 DES Report *“The nitrogen threshold for the protection of eelgrass was derived using a weight of evidence approach which included the thresholds for macroalgae proliferation”*, assuming proliferation implies growth. In a scientific context ‘proliferation’ is an ambiguous term and DES should have used a more direct and quantitative metric for characterizing macroalgae. However, it was clear that the DES 2009 Report attempted to attribute eelgrass loss to the growth of macroalgae and incorporate this information into the weight of evidence for determining nitrogen thresholds for eelgrass.

The DES was correct in their consideration of the potential effects of macroalgae on seagrass distribution and abundance in the Great Bay estuary and as possible evidence for nitrogen impairment. It is well documented that the proliferation of ephemeral macroalgae (e.g., *Gracilaria* and *Cladophora spp*) from nitrogen enrichment can negatively affect the distribution and abundance of seagrasses in general (McGlathery et al. 2007), and eelgrass in particular (Valiela et al. 1992, Short and Burdick, 1996, Hauxwell et al. 2001, Hauxwell et al., 2003). There is compelling scientific evidence that if nitrogen levels exceed seagrass nutrient requirements macroalgae can proliferate to the extent that it will shade eelgrass and outcompete eelgrass for light. Blooms of macroalgae can displace eelgrass and affect the

physical and chemical properties of the sediment to the extent that the blooms will limit distribution and abundance or prevent the re-growth of eelgrass.

As weight of evidence for determining nitrogen thresholds based on the status of macroalgae in the Great Bay estuary, DES was unable to definitively document spatial or temporal trends in macroalgae distribution and abundance for the period during which eelgrass declines were documented. The DES 2009 Report cited historical studies of macroalgae species composition and distribution as well as references to anecdotal reports of increases in nuisance macroalgae, but made no attempt to quantitatively summarize the baseline of macroalgae species composition and distribution or temporal changes in macroalgae abundance that coincided with most of the eelgrass declines (see page 37 in R-WD-09-12, Numeric Nutrient Criteria for the Great Bay Estuary). Hence, any relationship between nitrogen impairment, macroalgae growth and eelgrass abundance cannot be supported.

In an attempt to establish a relationship between total nitrogen concentration and the potential effects of macroalgae on eelgrass in the Great Bay estuary, DES relied on a single study conducted in 2007 in the Great Bay zone only (Pe'eri et al. 2008). This remote sensing study utilized hyperspectral imagery to map eelgrass beds and macroalgae mats in Great Bay and relied on another monitoring survey (Short, 2008) to ground truth and verify the benthic habitat signatures. Using the information from these two studies the DES 2009 Report (see page 37) identified 1246 acres of eelgrass and 137 acres of macroalgae in Great Bay in 2007. DES then compared eelgrass coverage in 2007 to eelgrass coverage in 1996 (2421 acres) and by way of Figure 18 (see page 39 in DES 2009 Report) where they illustrated the spatial distribution of the 137 acres of macroalgal mat. Based on this analysis DES concluded that 5.7% of the area (137 acres ÷ 2421 acres) formerly occupied by eelgrass in Great Bay in 1996 was replaced where the median concentration of nitrogen was 0.42 mg N/L as determined by water quality monitoring surveys. Without providing quantitative criteria for determining what constituted significance, DES further concluded that the study by Pe'eri et al. (2008) showed that significant amounts of eelgrass are replaced by macroalgae when median total nitrogen concentration is 0.42 mg N/L.

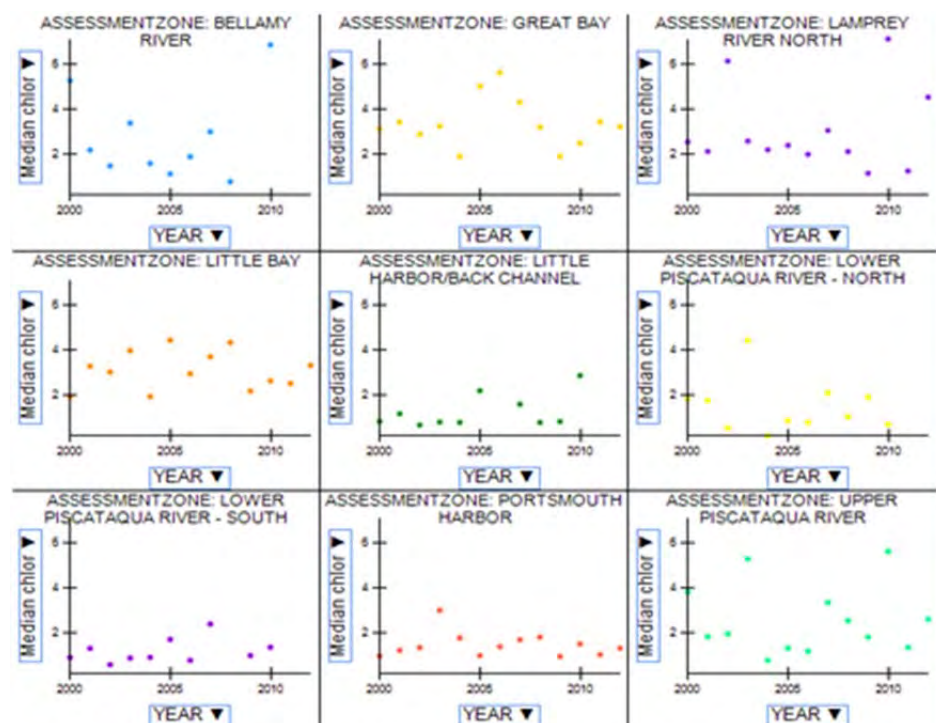
The data and arguments provided in the DES 2009 Report to support the weight of evidence for a relationship between nitrogen concentration, macroalgal abundance and eelgrass loss are neither compelling nor scientifically defensible. First of all, DES was inconsistent in their interpretation of what constitutes a significant eelgrass loss. In the original assessment of the status of eelgrass in the Great Bay estuary DES declared that a change would be considered significant if it was >20 %. The empirical basis for this value was based on the recorded variability of eelgrass cover in Great Bay as determined by monitoring surveys conducted between 1990 and 1999 (WD Doc R-WD-08-18, Methodology and Assessment Results related to Eelgrass and Nitrogen in the Great Bay Estuary for Compliance with Water Quality Standard for the New Hampshire 2008 Section 303(d) List). In their consideration of macroalgae DES did not explain why they concluded that a 5.7% change in eelgrass cover was significant when they had previously identified a 20% threshold for significance.

The second major problem with their evidence regarding the effect of macroalgae is that the data in the Pe'eri report are a study of a single year in one location in the Great Bay Estuary. On page 38 in their report DES correctly acknowledged it is not clear whether the same threshold would apply to other

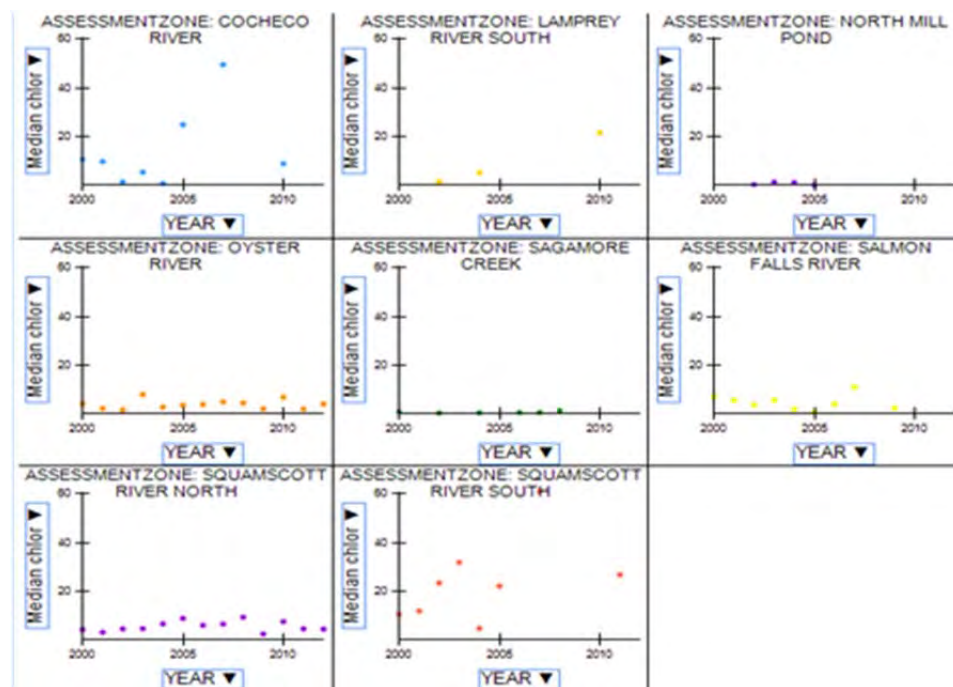
sections of the estuary where environmental conditions (e.g., substrate type, sediment stability, water depth, wave energy) may affect the growth and abundance of macroalgae and the interactions between macroalgae and eelgrass. Furthermore, a single year ( $n = 1$ ) cannot be considered representative of a highly dynamic shallow water macrophyte system consisting of eelgrass and macroalgae. Although DES has the capability to measure variation in eelgrass cover based on annual surveys (e.g., see Table 1), there are no data for variation in macroalgal abundance, so DES cannot determine if 2007 was representative of some average or median value for macroalgae in a longer time series. If 137 acres of macroalgae were having a permanent negative effect on eelgrass abundance in 2007, how do you explain the fact that eelgrass cover increased in Great bay during 2008, 2009, and 2010 (Table 1)? In 2010 there were 477 more acres of eelgrass in Great Bay than present in 2007. This additional eelgrass cover is 3.5 times more eelgrass cover than was allegedly displaced by macroalgae according to the 2007 study. Inconsistency in the definition of what constitutes significance, the data for variation in eelgrass cover, and the extremely limited data for macroalgal cover and abundance renders any conclusions regarding nitrogen thresholds based on macroalgae effects unsupported.

## RECKHOW RESPONSE

First of all, the NH data for chlorophyll do not present a time trend at the individual sampling sites; see the figures below. So, there is no chlorophyll time trend in the site-specific data, but there are spatial variations in chlorophyll among the sites. For the site-dates pooled data set, I plotted eelgrass coverage versus TN concentration for ordered categories of chlorophyll a concentration; this is presented in the next figure below. Note that there is no clear pattern between eelgrass and TN as we scan the plots from low to high chlorophyll. Thus, while I might expect that TN reductions will reduce chlorophyll levels, increase water clarity, and provide more light penetration for eelgrass growth, this is not supported in the cross-site data analysis.



A)



B)

Figure 5. Time Trends for Median Chlorophyll



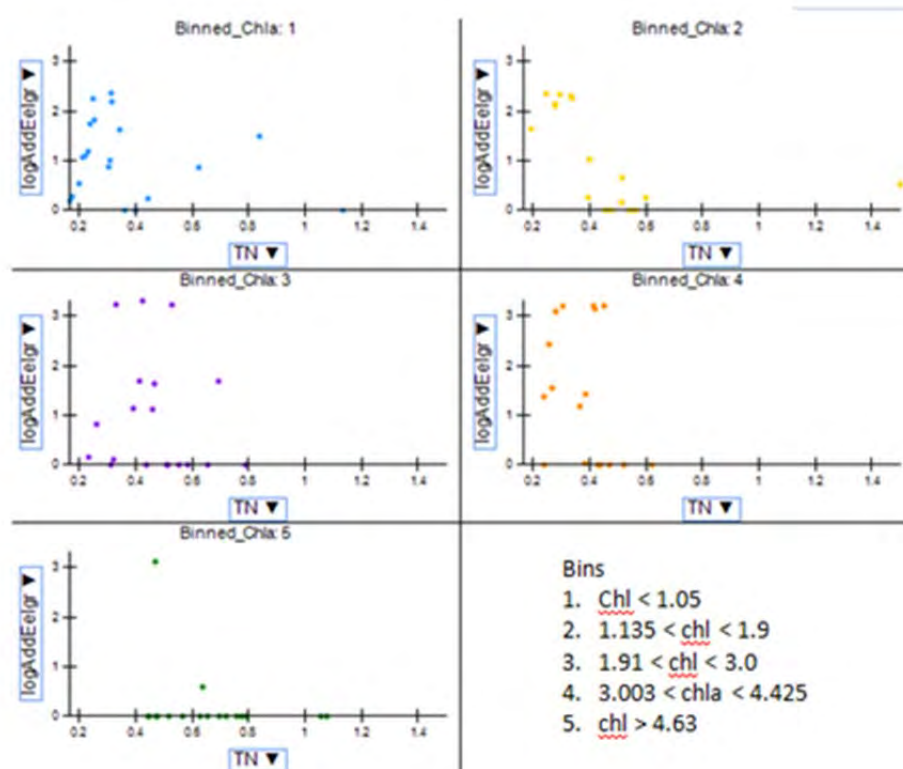


Figure 6. Eelgrass versus TN for categories on Chlorophyll

**d) Does the available information indicate that algal growth is the reason for low DO conditions in the tidal rivers and that nitrogen reduction will significantly improve DO in the tidal rivers that flow into the Great Bay estuary?**

## **BIERMAN RESPONSE**

As stated above in my response to Question 1c, no data were presented for algal growth (primary productivity) in the DES 2009 Report. Phytoplankton are characterized exclusively by chlorophyll-a concentration.

With the exception of the nitrification process, nitrogen concentrations are not directly linked to DO, but are only indirectly linked through primary production and the subsequent sequence of physiological processes that utilize the produced organic matter. These include respiration, oxidation of DOC exudates, oxidation of POC, and sediment oxygen demand (SOD). Another necessary and confounding factor, with regard to lower DO, is physical stratification/vertical stability of the water column.

For the above reasons, development of scientifically credible statistical relationships between nutrient concentrations as a causal variable and DO as a response variable is difficult under any circumstances. In fact, even EPA itself was unwilling to demonstrate such a relationship in its own guidance. A notable omission, not generally recognized, is that the EPA Technical Guidance Document for Stressor-Response Relationships (EPA 2010b) does not contain a single example for dissolved oxygen as a response variable.

My opinion is that the results in Figures 28-29 of the DES 2009 Report for statistical relationships between DO and nitrogen concentrations, and the conclusions drawn from these results, are weak and unreliable because univariate linear regression approaches do not adequately represent the underlying direct/indirect cause-effect mechanisms. Conditions in Great Bay are driven by a set of physical, chemical and biological dynamics for which process-based mass balance models would be more appropriate tools for assessing water quality and resulting eutrophication. See my response to Question 4a for a more complete discussion.

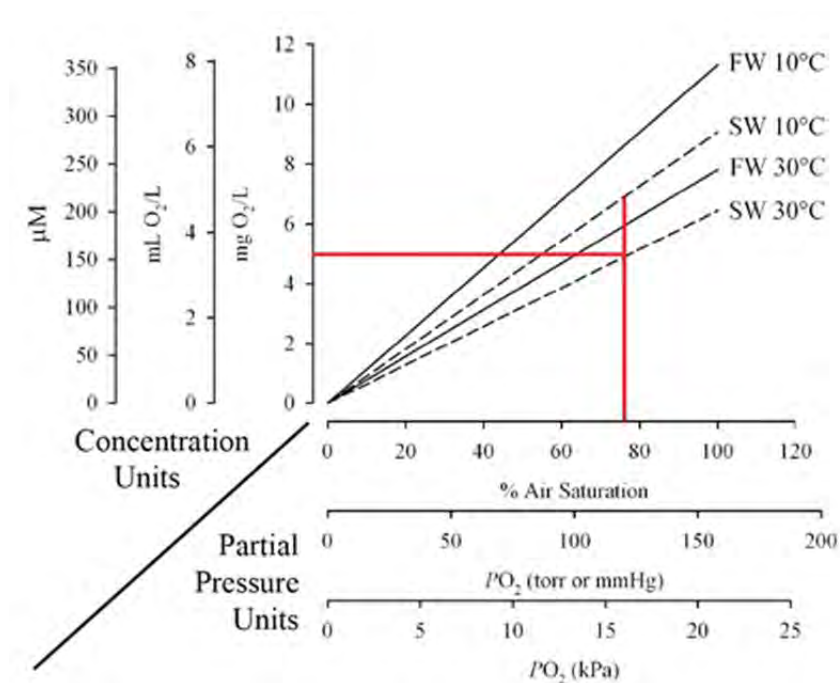
## **DIAZ RESPONSE**

Historically, there is no evidence of oxygen problems in the Great Bay region. In the mid 1980s when the first national assessment coastal waters was conducted there was no evidence of low dissolved oxygen (DO) conditions in Great Bay (Whitledge 1985) and the 2000-2001 National Coastal Assessment did not find indications of low DO in the New Hampshire Estuaries (EPA 2008). During the 2003-2006 National Coastal Assessment poor water quality was found in Great Bay (EPA 2012):

*“...Pockets of poor water quality are apparent at stations in Great Bay, NH; Narragansett Bay, RI; Long Island Sound; New York/New Jersey (NY/NJ) Harbor; the Delaware Estuary; and the western tributaries of Chesapeake Bay. These hot spots largely reflect patterns of population density (see Figure 3-4) and industrial and agricultural activity in the Northeast.”*

The direction taken in the DES 2009 Report relative to low DO appears logical given long-term trends in Great Bay, and what is known about other systems that have developed low DO and hypoxia from excess nutrient driven eutrophication.

Setting the threshold for low DO at 5 mg O<sub>2</sub>/l at all times and 75% air saturation on a daily basis is a high bar that would be protective of all living resources within Great Bay. For coastal systems, 2 to 2.8 mg O<sub>2</sub>/l is the point at which negative impacts on benthos are obvious (Diaz and Rosenberg 1995). The DES values for oxygen also mix concentration and partial pressure units. Depending on salinity and temperature, 75% saturation would range several mg O<sub>2</sub>/l, for example for seawater from 10 to 30°C 75% saturation would be about 7 to 5 mg O<sub>2</sub>/l (Figure 2).



**Figure 7. Nomogram for dissolved oxygen in fresh water (FW) and sea water (SW) at 10 and 30°C**

Modified from Diaz and Breitburg 2009. Concentration units are on Y-axis, and partial pressure units are on X-axis. Red lines are the DES defined points for low DO

The combination of physical, chemical, and biological processes that lead to hypoxia differs in magnitude and importance by water body. For hypoxia to develop the amount of DO in the water column needs to be decreased by the process of respiration at a faster rate than resupply through atmosphere exchange, photosynthetic production of oxygen, or advection. Two factors must then be present for the development of hypoxia:

- Density stratification of the water column that isolates the bottom water from exchange with oxygen-rich surface water. Stratification is most commonly driven by salinity or temperature.
- Decomposition of organic matter in the isolated bottom water that consumes dissolved oxygen. In eutrophic systems, organic matter is supplied in excess of what the system is normally able to process.

Stratification of the water column is a physical characteristic of a system and must be present for low DO in the bottom water to develop. The role played by nutrients would be through enhancing the production of organic matter. Assuming the strength of stratification is beyond management, the goal of management would be to keep organic matter below the levels that would lead to low DO.

It is well known that excess algal (phytoplankton and macroalgae) growth can lead to hypoxia, but the question for algal growth and DO within the Great Bay system would be: Are the areas affected by low DO the same areas where the algal biomass production ends up? The most detailed information on macroalgal distribution in the DES 2009 Report is for Great Bay, but most of the low DO problems seem to be in the tributaries where chlorophyll-a, a measure of phytoplankton standing stock, tends to be higher (See DES 2009 Report figures 14, 18, and 25). If autochthonous primary production is the main source of organic matter to the Great Bay system and reductions in nitrogen loads lead to lower primary production then DO may improve. If allochthonous organic matter from terrestrial sources or municipal/industrial discharges is the main source, then the benefits of lowering nitrogen may be difficult to detect.

To assess if nitrogen reductions will improve DO conditions, data on the origin, quantity, and quality of organic matter in the various assessment regions of Great Bay are needed. In addition, the well-known relationship between sediment grain-size and organic matter has to be controlled (Hyland et al. 2005). Assessment region differences in depth, salinity, and sediment hydrodynamics also likely contribute to the linear regression relationship in many of the DES 2009 Report figures and need to be controlled. In particular, relating DO to nitrogen concentration as in figures 28 and 29 of the DES 2009 Report without accounting for the co-varying influence of these factors is too simple.

## **KENWORTHY RESPONSE**

I defer to my colleague on the review panel, Dr. Diaz, who is an expert on the topic of dissolved oxygen in estuarine waters to provide a comprehensive response to this question. I do, however, reiterate what I indicated above with respect to macroalgal growth. Even though it is well documented that excessive growth of macroalgae could be responsible for low DO in a shallow estuarine system, the DES 2009 Report provides insufficient information on the distribution and abundance of macroalgae to link macroalgae to low DO and any implications for nitrogen reduction and eelgrass protection.

## **RECKHOW RESPONSE**

Scientific understanding would support a positive answer to this question. I developed a causal Bayesian probability network to assess if the pooled sites-dates data support this statement. To understand the interpretation of a Bayes network, consider the figure below. This model describes linkages between variables, which are represented by the lines in the figure that connects the boxes. The model indicates that the node, or variable, “Chla” is conditionally dependent on the variables TN, Salinity, and SS. Similarly, the node “DO” is conditionally dependent on the node “salinity” alone.

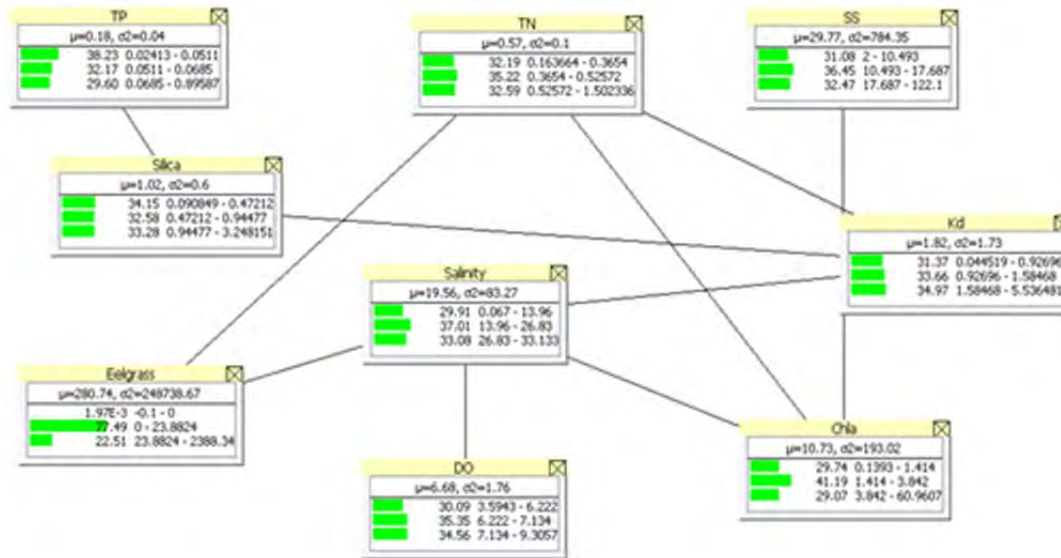


Figure 8. Baseline relationship among variables

The next figure shows how low DO and high TN affects eelgrass; low DO and high TN are represented by the red bars. The effect is relatively small as indicated by the change in the eelgrass bars between the two figures. This conclusion is demonstrated visually by how much the eelgrass green bars from Figure 8 are changed in Figure 9 for each category. The change in the length of the green bars even under the worst conditions for TN and DO is in the “expected” direction (toward lower eelgrass, as shown by the middle green bar in each figure), but it is small due to the limited available data and “noise” in the relationships.

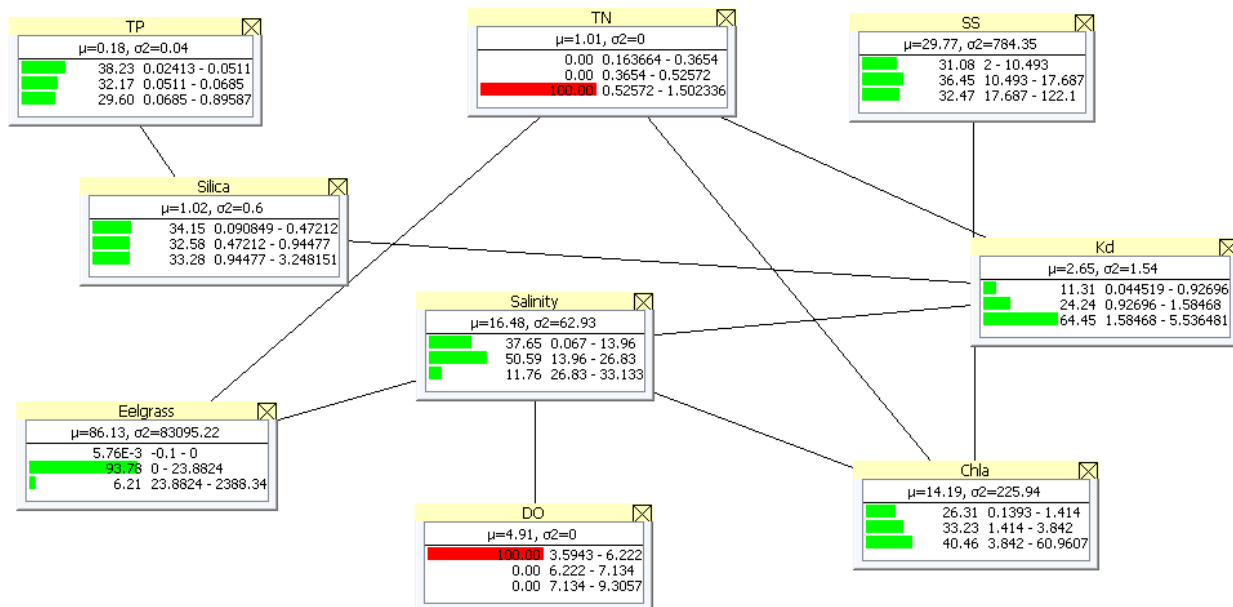


Figure 9. Effects of eelgrass from low DO and TN concentrations



**e) Were the statistical methods used to derive the numeric thresholds based on acceptable scientific methods? Are the results of these analyses reliable for predicting responses to nitrogen in this system (including DO, transparency, eelgrass, macroalgae, phytoplankton, etc.)?**

## BIERMAN RESPONSE

The statistical methods used to derive the numeric thresholds were not based on acceptable scientific methods and the results of these analyses are not reliable for predicting the complexity of responses to changes in nitrogen concentration in the system, including DO, transparency, eelgrass, macroalgae and phytoplankton.

EPA (2010b), published 17 months after the DES 2009 Report, provides guidance for use of stressor-response relationships to derive numeric nutrient criteria. Key points in this guidance are the following:

- Statistical analyses can be applied to different types of waterbodies (including estuarine and marine systems) if sufficient data are available on causal variables, response variables and confounding factors
- A source of uncertainty in the accuracy of estimates of stressor-response relationships is the potential effect of environmental factors that co-vary with nutrient concentrations. These are called confounding factors and are environmental variables that also can influence the selected response variable. When the effects of a possible confounding variable are not controlled, the relationship estimated between the nutrient variable and the response variable may partially reflect the un-modeled effect of the confounding variable.
- The first step in evaluating the accuracy of a stressor-response relationship is to revisit the list of all possible confounding factors.

The DES 2009 Report did not adequately consider confounding factors in its SLR analyses. Some of these confounding factors include bathymetry, vertical stratification, currents, waves, tides, salinity, hydraulic flushing, phosphorus concentrations, total suspended solids (TSS), sediment GSD, sediment TOC and sediment sulfide concentrations. A detailed example is given below for salinity, but the same reasoning could be applied to these other confounding factors as well.

In the DES 2009 Report, the following SLR results are presented pertaining to benthic index of biological integrity (B-IBI):

- Figure 19: median B-IBI versus median TN, negative trend (R squared = 0.632)
- Figure 20: median B-IBI versus median salinity, positive trend (R squared = 0.638)
- Figure 21: median salinity versus median TN, negative trend (R squared = 0.680)

Page 40 of the DES 2009 Report states the following:

*“While the B-IBI was well correlated with nitrogen concentrations (Figure 19), the best explanatory variable for B-IBI was salinity (Figure 20). Diversity and abundance of benthic infauna species are strongly affected by salinity. The B-IBI algorithm developed by EPA does*

*not correct for the effect of salinity on benthic community composition and is most accurate for higher salinity areas as discussed in Hale and Heltshe (2008). Therefore, the relationship between B-IBI and nitrogen concentration is probably just an apparent correlation caused by the inverse relationship of nitrogen and salinity in the estuary (Figure 21)."*

This logic makes sense, but it is not clear why DES did not also apply it to their analyses of the other response variables in the report (chlorophyll, DO, turbidity, Kd). Figures 20 and 21 are the only SLR results in the report that explicitly include salinity. If the relationship between I-IBI and nitrogen concentration is, in fact, just an apparent correlation caused by the inverse relationship of nitrogen and salinity in the estuary (Figure 21), then why could this not also be the case for chlorophyll, DO, turbidity or Kd?

At my request, DES provided supplementary SLR results with nitrogen concentration replaced by salinity for Figures 15, 23, 28, 34 and 38 in the DES 2009 Report. In general, the strength of the correlations with salinity is comparable to those with nitrogen concentration. Given the strength of the correlation between salinity and nitrogen concentration (Figure 21; R squared = 0.680), this makes sense.

Several (some very literal) interpretations of the above results are possible:

1. The water quality/ecological health of Great Bay Estuary could be improved by increasing salinity, not by decreasing nitrogen.
2. Water quality/ecological health could be improved by decreasing nitrogen, not by increasing salinity.
3. Statistically, increasing salinity and decreasing nitrogen are the same remedies because they are strongly correlated.
4. In reality, increasing salinity and decreasing nitrogen are different remedies because the former would require alteration of freshwater inputs and/or tidal hydrodynamics, and the latter would require reductions in nitrogen loads from the watershed.
5. Salinity itself is not a causative factor, but an indicator of freshwater inputs, tidal hydrodynamics and hydraulic flushing rates, confounding factors that have not been explicitly considered in the analyses.

The importance of hydraulic flushing rates is also suggested by two other lines of evidence. First, the DES 2009 Report relied upon the conceptual model by Bricker et al. (2007). Although this model is presented in the form of a high-level pictorial and not a detailed schematic with all of the relevant stressor, response and confounding variables, it does contain explicit mention of hydraulic flushing as an influencing factor in Figure 4-1, a conceptual diagram of the North Atlantic. Second, on Page 17 of the DES 2009 Report it is stated that river inflow to the estuary is only 2% of the tidal prism exchange, and on Page 28 it is stated that most of the estuary (88% by volume) has salinity greater than 20 ppt. That is, more than half of the water in the estuary is ocean water. These statements not only point to the importance of considering how flushing rates differ among the 22 assessment zones, they beg the question of the load-response relationship for the system. For example, if nitrogen loads from the watershed are reduced, how much reduction in water column nitrogen concentration can be expected in Great Bay Estuary, and what would be the differences in responses among the 22 assessment zones?

My opinion is that DES should have first adopted a detailed conceptual model that explicitly represented all of the relevant direct/indirect causal linkages among stressor variables, response variables and confounding variables. Then DES could have used this conceptual model to design their statistical analyses to include causal linkages that make biological sense, not just statistical sense, and to explicitly account for co-varying/confounding factors. Instead, in most cases, they by-passed these critical steps and went directly to SLR analyses that presumed cause-effect relationships driven by nitrogen concentrations.

## **DIAZ RESPONSE**

The statistical approach taken in the DES 2009 Report is understandable but fails to account for the complexity of interactions between response and explanatory variables. While EPA guidance on stressor-response relationships for deriving numeric criteria was not published till 2010, any further work on defining numeric nitrogen concentration criteria needs to conform to EPA guidance and best available statistical modeling.

The DES 2009 Report did not adequately consider confounding factors in its simple linear regression approach, which makes the interpretation and predictive ability of these regressions weak. For example, from figure 19 in the DES 2009 Report there appears to be an inverse relationship between median B-IBI and median TN, but salinity and sediment grain-size, two of the primary confounding factors that affect indices like the B-IBI were not controlled for. The DES 2009 Report does acknowledge that salinity is an important factor in assessing B-IBI and then points out the “...apparent correlation caused by the inverse relationship of nitrogen and salinity...”, but does not go further. Defining the relationship between B-IBI and any single water quality variable is difficult. In Chesapeake Bay it took a comprehensive multivariate approach to examine the relationship between a B-IBI and low DO (Dauer et al. 1992, Christman and Dauer 2003).

## **KENWORTHY RESPONSE**

The statistical approach taken in the DES 2009 Report to derive the numeric thresholds for nitrogen were largely based on using simple linear regression to describe trends in total nitrogen concentrations and symptoms of eutrophication (e.g.; chlorophyll-a,  $K_d$ ) and ultimately either the loss of eelgrass or the prevention of eelgrass recovery. The severe deficiency in this approach stems from the fact that it oversimplifies a stressor response in a highly complex estuarine ecosystem which may have important interactions between unaccounted for, and potentially confounding variables, such as temperature, salinity, currents, wave energy, bathymetry, water residence time, grazing, bioturbation, disease, and plant reproduction. From simple linear regressions you may be able to draw inferences about spatial or temporal trends in the relationships between variables (e.g., total N concentration and chlorophyll-a or  $K_d$ ), but you cannot make strong inferences about cause and effect (stressor response) without empirical data to support the linkages. This is problematic for DES because there are no published empirical studies demonstrating the effects of total N on eelgrass which could be used to support their inference regarding a specific nitrogen concentration. There are numerous studies which have examined various forms of inorganic nitrogen (e.g., ammonium and nitrate) (e.g., Short and Burdick 1995, or see Burkholder et al. 2007 for a review) and the response of chlorophylls-a, epiphytes, light and eelgrass growth and biomass

that could be used to support relationships suggested by linear regressions. But DES does not develop a strong case for total N using these empirical studies. In fact, DES relies almost exclusively on citing total N values derived in Massachusetts embayments by the Massachusetts Estuaries Project (MEP) to support their determination of total nitrogen criteria. The value proposed by DES is similar to the range of values derived by the MEP. But the MEP used a reference condition approach supplemented and improved by linking mechanistic hydrological and watershed loading models to determine numeric total nitrogen criteria. The statistical approach taken by DES is much simpler than the MEP approach and it is difficult to support the proposed criteria because, as indicated earlier in my response to question #1, eelgrass is still declining in locations (reference conditions) with the lowest concentration of total nitrogen and the most transparent water. This would suggest that there are confounding factors affecting the response of eelgrass to the primary symptoms. The simple linear regression approach that identifies the upstream-downstream trend in total nitrogen and symptoms of eutrophication suggests this alternative conclusion, but more rigorous evaluation of the potentially confounding factors and use of more sophisticated statistical analytical and modelling tools are needed to develop strong inferences for setting nitrogen criteria.

## **RECKHOW RESPONSE**

The statistical methods applied in the report are almost exclusively focused on univariate and bivariate relationships, yet the report writers recognize the multivariate nature of the relationships affecting eutrophication. Given that, and given my analyses on the multivariate patterns in the data, I do not think that the results in the report are acceptable or reliable for setting nutrient criteria.

**QUESTION 2. THE DES 2009 REPORT USES A “WEIGHT OF EVIDENCE”. . . approach to identify a range of possible values for a TN threshold between 0.20 and 0.38 mg/L to protect eelgrass resources. TN thresholds of 0.25 to 0.30 mg/l were selected for areas with eelgrass, based on the regression of transparency to TN and depending on the restoration depth. THE DES 2009 REPORT selected 0.45 mg/L to maintain instantaneous do concentrations greater than 5 mg/L.**

## **BIERMAN RESPONSE**

No response to preface.

## **DIAZ RESPONSE**

Weight of evidence is a reasonable approach to setting numerical nitrogen concentration criteria. This approach when combined with best professional judgment can be a powerful tool for drawing conclusions in many areas of water quality management. EPA (2011) issued guidelines on using weight of evidence in screening for endocrine disruptors. Much of the description of weight of evidence is applicable to numeric nitrogen criteria. EPA (2011) describes weight of evidence (WoE) as:

*“Generally, WoE is defined as the process for characterizing the extent to which the available data support a hypothesis that an agent causes a particular effect (USEPA 1999; 2002a; 2005). This process involves a number of steps starting with assembling the relevant data, evaluating that data for quality and relevance followed by an integration of the different lines of evidence to support conclusions concerning a property of the substance. WoE is not a simple tallying of the number of positive and negative studies (US EPA 2002a). Rather it relies on professional judgment. Thus, transparency is important to any WoE analysis. A WoE assessment explains the kinds of data available, how they were selected and evaluated, and how the different lines of evidence fit together in drawing conclusions. The significant issues, strengths, and limitations of the data and the uncertainties that deserve serious consideration are presented, and the major points of interpretation highlighted.”*

Part of the WoE approach is a set of general assessment factors to apply to the information used (EPA 2011):

- Soundness - Scientific and technical procedures, measures, methods or models employed to generate the information are reasonable for, and consistent with, the intended purpose.
- Applicability and Utility - The information is relevant for the Agency’s intended use.
- Clarity and Completeness - The degree of clarity and completeness with which the data, assumptions, methods, quality assurance, sponsoring organizations and analyses employed to generate the information are documented.
- Uncertainty and Variability - The uncertainty and variability (quantitative and qualitative) in the information or the procedures, measures, methods or models are evaluated and characterized.



- Evaluation and Review - The information or the procedures, measures, methods or models are independently verified, validated, and peer reviewed.

Overall, the DES 2009 Report does a good job with Soundness, and Applicability and Utility. Clarity and Completeness could be improved by applying more appropriate models that capture the complexity of interactions between nitrogen and assessment parameters. More could also be done with Uncertainty and Variability. Few of the data figures in the DES 2009 Report have variability estimators. When using median as the measure of central tendency, the range for the central 50% of data point should be included. Finally, the DES 2009 Report is under rigorous evaluation and comprehensive review.

## KENWORTHY RESPONSE

No response to preface.

## RECKHOW RESPONSE

No response to preface.

### ***Specifically respond to the following:***

**a) Is “weight of evidence” a reasonable approach to selecting final thresholds for areas with eelgrass impairments and low do?**

## BIERMAN RESPONSE

The U.S. EPA Science Advisory Board (EPA 2010a), in its review of the August 17, 2009 draft technical guidance (the “Guidance”) on Empirical Approaches for Nutrient Criteria Derivation (EPA 2009), stated the following on “weight of evidence” approaches:

*“When properly developed, statistical associations can be useful in supporting cause and effect arguments as part of a weight-of-evidence approach (further discussed in Section 3.3, recommendation #7 of this advisory report) to criteria development. Therefore, the final Guidance should provide more information on the supporting analyses needed to improve the basis for conclusions that specific stressor-response associations can predict nutrient responses with an acceptable degree of uncertainty. Such predictive relationships can then be applied, with mechanistic or other approaches, in a tiered weight-of-evidence assessment using individual lines of evidence in combination to develop nutrient criteria.”*

*“The Guidance should contain a quantitatively based weight-of-evidence framework using multiple methods and then combining them into figures and tables for visualization. Multiple statistical methods on one data set do not equate to a reasonable weight-of-evidence that significantly reduces uncertainty. Rather, the weight-of-evidence should involve different assessment methods (e.g., different data sets, different biological endpoints, measures of*

*habitat, etc.). This premise has been embraced by other EPA programs and the scientific community (Adams, 2003; Burton et al. 2002; Chapman, 2007; Chapman et al., 2002; Collier, 2003; Cormier et al., 2010; Fox, 1991; Linder et al., 2010; Linkov et al., 2009; Suter et al., 2002; Suter et al., 2010; U.S. EPA, 2000c; Weed, 2005; Wickwire and Menzie, 2010)."*

*"The Guidance can be used to develop numeric nutrient criteria in a tiered, weight-of-evidence assessment using appropriately modified EPA approved procedures together with other approaches that address causation. Large uncertainties in the stressor-response relationship and the fact that causation is neither directly addressed nor documented indicate that the stressor-response approach using empirical data cannot be used in isolation to develop technically defensible water quality criteria that will "protect against environmental degradation by nutrients." The Guidance can, however, be used in a tiered, weight-of-evidence assessment (using appropriately modified U.S. EPA-approved procedures, e.g., EPA's Causal Analysis/Diagnosis Decision Information System [CADDIS]), (U.S. EPA, 2009b)."*

I am in agreement with these review comments by the Science Advisory Board, and my opinion is that "weight of evidence," so defined, is a reasonable approach to selecting final thresholds for areas with eelgrass impairments and low DO.

EPA (2010b) (published 17 months after the DES 2009 Report) recommends three types of scientifically defensible approaches for developing numeric nutrient criteria:

- Reference condition approaches
- Stressor-response analysis
- Mechanistic modeling.

In this context, stressor-response analysis refers to empirical statistical analysis and mechanistic modeling refers to process-based mass balance water quality modeling.

The DES 2009 Report focused primarily on stressor-response analysis and secondarily on a reference condition approach. It did not use process-based mass balance modeling.

Development of numeric nutrient criteria involves establishing quantitative linkages between nutrient concentrations and direct response variables such as chlorophyll-a concentrations, and indirect response variables such as DO and eelgrass. These are complex relationships and require explicit consideration of many co-varying/confounding variables. My opinion is that a scientifically defensible "weight of evidence" approach to development of numeric nutrient criteria should include lines of evidence based on all three of the above approaches recommended in EPA (2010b).

Page 66 of the DES 2009 Report summarizes the "weight of evidence" used to determine a nitrogen threshold for protection of eelgrass. Although data from other estuarine/marine systems were cited, this line of evidence was not sufficiently detailed to constitute a comprehensive reference condition approach. As stated above in my response to Question 1e, the statistical methods used in the DES 2009 Report for stressor-response relationships did not follow accepted scientific methods, and the results of these analyses are not reliable for predicting responses to changes in nitrogen concentrations in the system.

Although EPA has not developed technical guidance for use of process-based mass balance models to develop site-specific numeric nutrient criteria, such guidance is now available in a report by the Water Environment Research Foundation (Bierman et al. 2013).

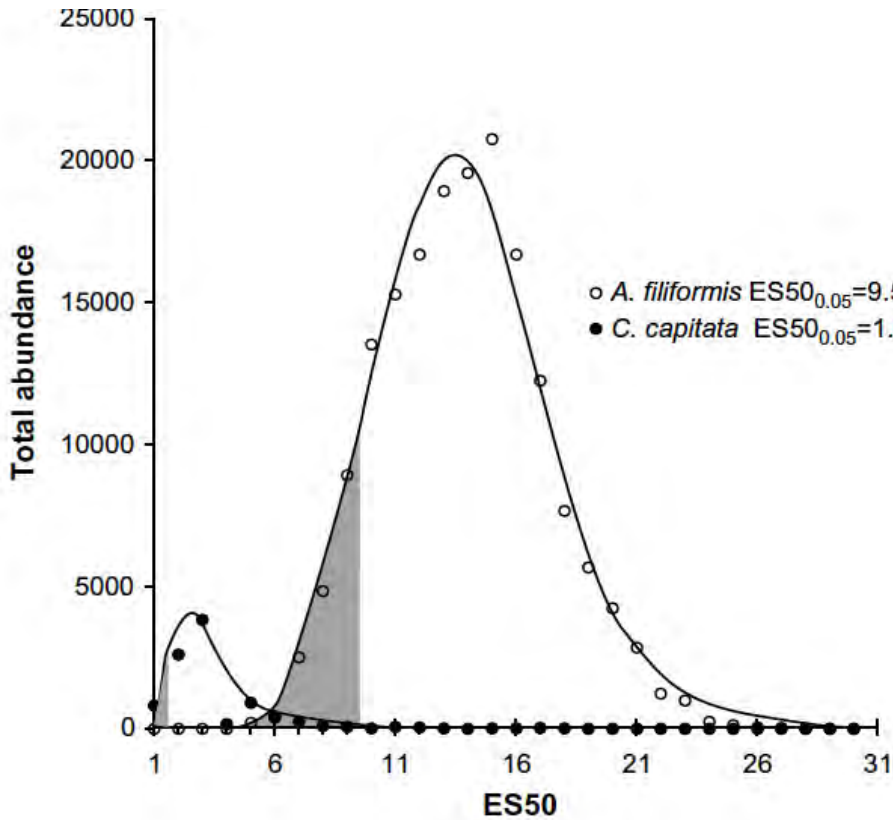
## DIAZ RESPONSE

Weight of evidence is a reasonable approach for evaluating causes and effects of low dissolved oxygen. As stated in the DES 2009 Report: “For aquatic life use support, DES investigated nutrient thresholds for the protection of the benthic invertebrate community, dissolved oxygen, and eelgrass.” It is typically assume that low DO poses an immediate impairment threat primarily to benthic invertebrate communities, but low DO may also directly impair eelgrass physiology (Holmer and Bondgaard 2001). In addition, low DO can lead to cascading effects by releasing eelgrass epiphytes from invertebrate grazing pressures, further stressing eelgrass (Moksnes et al. 2008, also see Kenworthy response).

Relative to benthos, samples collected in the Great Bay system by the National Coastal Assessment were used to characterize benthic communities, total organic carbon content of the sediment, and sediment grain-size. From these data a benthic index of biologic integrity (B-IBI) developed by the Atlantic Ecology Division of EPA for the Gulf of Maine was calculated. This B-IBI is based on a multiple linear regression with three variables. The B-IBI increases with higher Shannon-Wiener H' diversity and mean of 5<sup>th</sup> percentile of total abundance frequency distribution of each species in relation to its ES50 value (Figure 3). The B-IBI decreases as the percent abundance of capitellid polychaetes increases:

$$\text{B-IBI} = 0.494 * \text{Shannon} + 0.670 * \text{Mean\_ES50.05} - 0.034 * \text{PctCapitellidae}$$

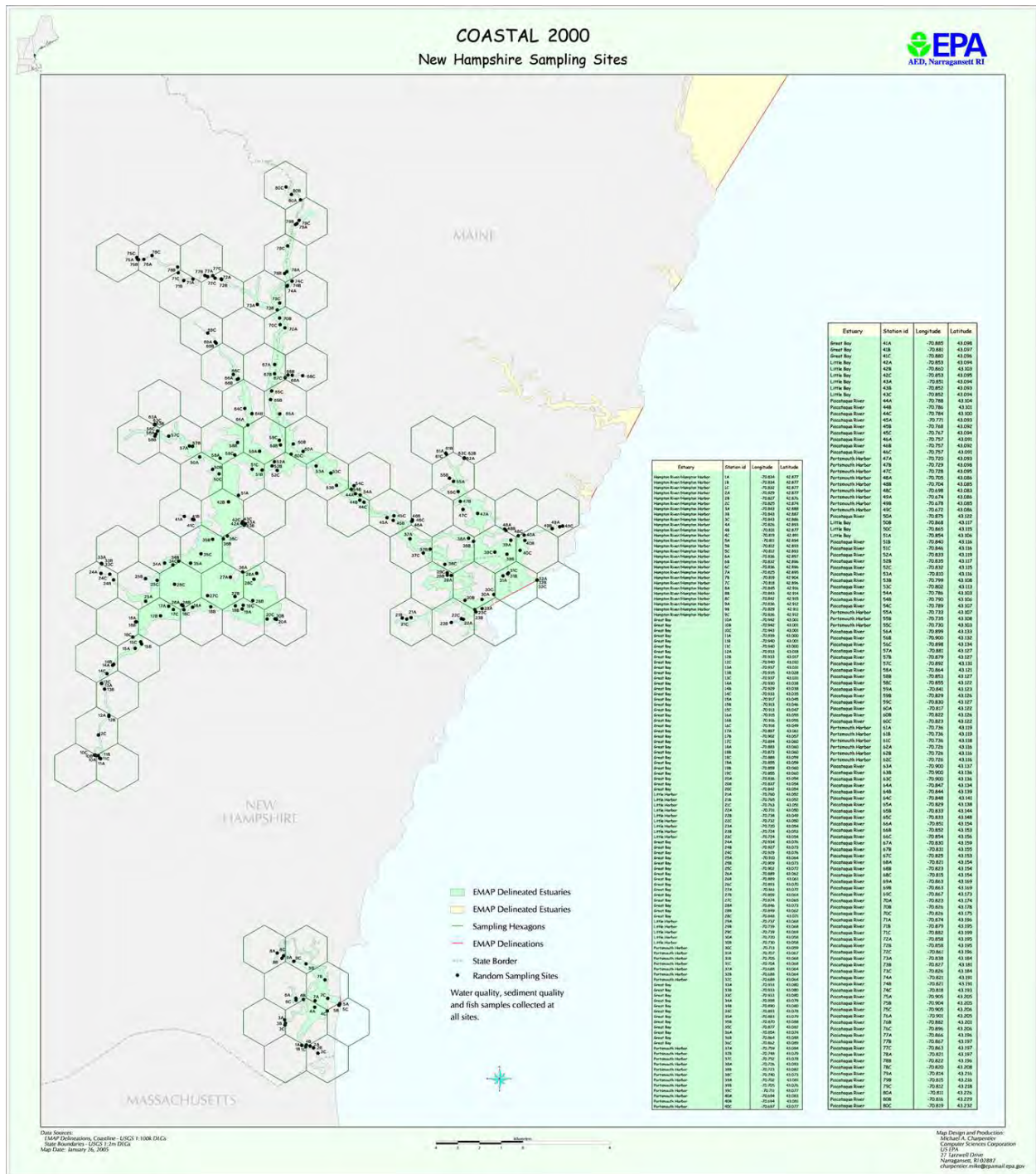
Benthic community conditions were considered poor if the B-IBI was less than 4.



**Figure 10. Examples of total abundance frequency distributions of the capitellid polychaete *Capitella capitata* and the brittle star *Amphiura filiformis* in relation to the expected number of species per 50 individuals (ES50) values for all samples in which they occur.**

Shaded areas indicate the 5% abundance distribution in relation to the lowest ES50 values (ES50.05); for *C. capitata* 1.5 and for *A. filiformis* 9.5. Tolerant species like *Capitella capitata* are by definition predominantly found in disturbed environments and they would mainly occur at stations with low ES50. In contrast, sensitive species like *Amphiura filiformis* occur in areas with no or minor disturbance and would then be associated with high ES50 (Rosenberg et al. 2004).

These three benthic variables (B-IBI, Sediment TOC and grain-size), plus salinity, are a start for the weight of evidence approach to assess benthic conditions relative to nitrogen concentration and low DO. Additional variables that would be required included season and year. From the DES 2009 Report, it is not possible to determine the quantity of data that went into investigating nutrient thresholds for the protection of the benthic invertebrate community, dissolved oxygen, and eelgrass. As stated, benthic data from approximately 130 station visits in the Great Bay Estuary collected by the National Coastal Assessment from 2000 through 2005 were used. From examining available data for Great Bay Estuary over this time period, it is not possible to determine how the data were condensed into the 11 or 12 assessment region points in figures 19 to 23. Which of the stations listed by the National Coastal Assessment for the region in figure 4 were used in the DES 2009 Report? More detail on which assessment regions ended up with and without data is needed. Also are the sediment and water column samples synoptic and from the same location? Combining datasets collected for differing objectives is difficult and must be done with clear statement of strengths and limitations.



**Figure 11. Location of National Coastal Assessment stations in the Great Bay region.**

The dissolved oxygen standard established by rule in Env-Wq 1703.07 that DO must be at least 5 mg O<sub>2</sub>/L at all times and that the daily average of dissolved oxygen saturation should be at least 75% is certainly protective for benthic invertebrates. While impacts from low DO occur over a broad range of oxygen concentrations, for benthic invertebrates, sublethal and behavioral responses to low DO are not obvious above 3 mg O<sub>2</sub>/l (Diaz and Rosenberg 1995, Vaquer-Sonyer and Durate 2008). Based on the DO

data used in the DES 2009 Report, between 2000 and 2012 the minimum DO concentration was 5 mg O<sub>2</sub>/l or less a total of 20 times in eight of the 22 assessment zones. It therefore seems unlikely that low DO is a controlling factor for benthic community structure.

## **KENWORTHY RESPONSE**

Yes, a “weight of evidence” approach is a reasonable means of selecting final thresholds for areas with eelgrass impairment as per EPA technical guidance (EPA 2009, EPA 2010a). The EPA documents provide specific guidance and recommendations on using multiple assessment methods with quantitative metrics, different data sets, and rigorous analytical statistical techniques. Unfortunately, in the case of the DES assessment in Great Bay, these guidance documents post-date the DES studies and the 2008 and 2009 DES reports. DES could not directly benefit from recommendations and guidance provided by these documents; however, it is my opinion that DES could improve their weight of evidence approach by implementing the recommendations made by EPA in these more recent guidance documents. This may require additional data collection, analyses of more recent water quality and eelgrass data, and the incorporation of mechanistic models into their assessment.

## **RECKHOW RESPONSE**

In a general sense, “weight of evidence” is always a reasonable approach. In a specific sense, it depends on the evidence and on how the evidence is interpreted.



**b) Does the “weight of evidence” (i.e., an assessment of available data and studies for this estuary) support the conclusion that excess nitrogen was the primary factor that caused (1) the decline of eelgrass populations or inability of eelgrass to repopulate specific areas, and (2) low DO in the tidal rivers?**

## BIERMAN RESPONSE

I defer to Drs. Diaz, Kenworthy and Reckhow.

## DIAZ RESPONSE

The use of static indices like the B-IBI, in which the sensitivity to stressors does not account for possible shifts in sensitivity of species along natural environmental gradients, to assess any one individual stressor, such as DO is questionable. This is even more difficult given the limited range of DO conditions reported for Great Bay. The evidence presented that links B-IBI to total nitrogen concentration is not convincing. The DES 2009 Report properly interprets the complexity of the relationship between co-varying factors, B-IBI, and nitrogen, but it fails to follow through with a similar evaluation relative to B-IBI and DO. This leads the DES 2009 Report to set a total nitrogen concentration for keeping DO above the standards of 5 mg O<sub>2</sub>/L at all times and daily average saturation at least 75% that is not supported by either a stressor-response or weight of evidence approach.

Relative to weight of evidence, the data presented are likely sound but are not properly applied to linking benthic conditions with low DO and subsequently to linking low DO with total nitrogen concentrations. Much of the problem is with the analysis approach being limited to simple linear regressions, which do not properly evaluate the influence of co-varying factors that confound conclusions regarding total nitrogen concentration as being the causal factor for DO and benthic conditions.

## KENWORTHY RESPONSE

The DES 2009 Report explicitly states; *“The nitrogen threshold for the protection of eelgrass was derived using a weight of evidence approach which included the thresholds for macroalgae proliferation, regressions between total nitrogen and the light attenuation coefficient, offshore water background concentrations, reference concentrations in areas of the estuary which still support eelgrass, and the thresholds that have been set for other New England estuaries.”* Based on my responses to question #1 it is my opinion that the DES “weight of evidence” does not support the conclusion that excess nitrogen was the primary factor that caused the decline of eelgrass and the inability of eelgrass to repopulate specific areas.

## RECKHOW RESPONSE

The PREP 2009 report provides additional years of data than available in the 2009 Numeric Nutrient Criteria (NNC) report. With more years reported, the PREP report shows more downward trend in

eelgrass coverage than does the NNC report. The two figures shown here based on the NNC report indicate the limited basis for eelgrass trends determination.

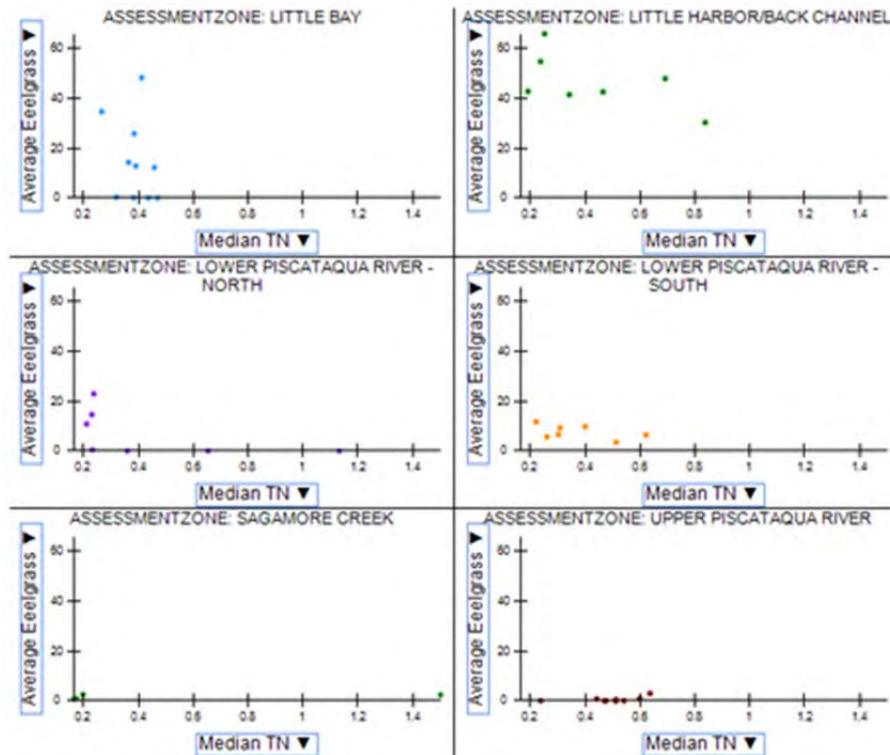


Figure 12. Eelgrass – TN relationship at monitoring stations

The NNC data for Little Harbor/Back Channel provide the best evidence for a downward trend in eelgrass coverage. However, the next two figures do not present a very strong case for eelgrass response to TN changes.

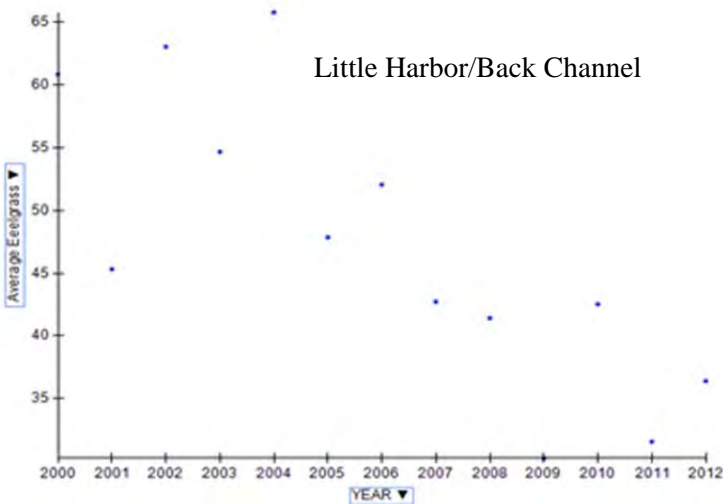
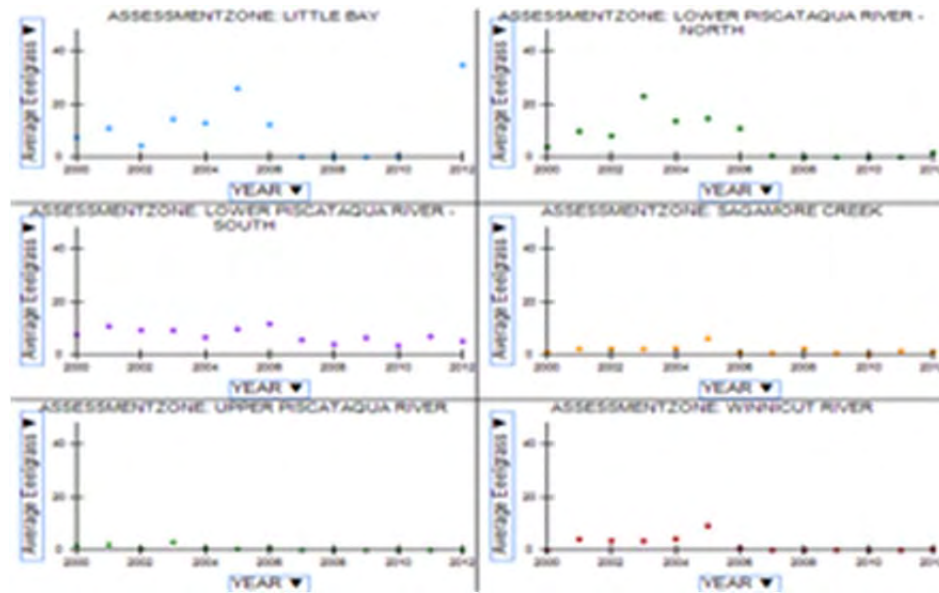
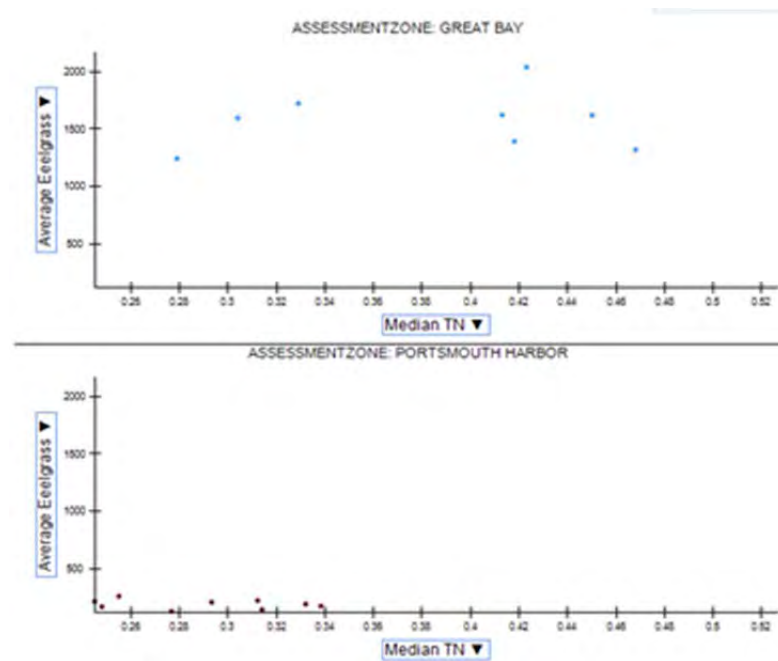


Figure 13. Downward trend in eelgrass coverage for Little Harbor/Back Channel

Scientific knowledge indicates a causal linkage between TN and DO, due to the growth and decomposition of algae. However, as I indicated in my response to Question 1d, my data analysis does not support this TN-DO linkage in the NH DES data.



A)



B)

Figure 14. Time trends for eelgrass at monitoring stations

**c) Does the DES 2009 REPORT and/or subsequent data reasonably assess the potential reasons for eelgrass loss besides cultural eutrophication in the various areas?**

**BIERMAN RESPONSE**

I defer to Dr. Kenworthy.

**DIAZ RESPONSE**

I defer to Dr. Kenworthy.

**KENWORTHY RESPONSE**

The answer to this question is no, as explained in my response to question #1. In particular, many of the potentially confounding factors known to affect eelgrass growth, reproduction, abundance, distribution and survival were not adequately ruled out as reasons for eelgrass declines. Furthermore, eelgrass cover data subsequent to the DES 2009 report (Table 1) indicates eelgrass is declining in locations (reference locations) where the nitrogen concentrations are similar to the proposed criteria; hence other factors must be operating to affect the changes in eelgrass cover.

**RECKHOW RESPONSE**

I defer to Dr. Kenworthy.

**d) Are the selected TN criteria for eelgrass protection consistent with (1) data/studies available for this estuary and (2) TN levels found to be protective in other northeast estuarine systems?**

## **BIERMAN RESPONSE**

I defer to Drs. Kenworthy and Reckhow.

## **DIAZ RESPONSE**

I defer to Drs. Kenworthy and Reckhow.

## **KENWORTHY RESPONSE**

On page 3 the DES 2009 Report explicitly states that numeric nutrient criteria have been established for relatively few estuaries and they typically fall between 0.35 and 0.49 mg N/L, but they do not cite any specific reports or publications to document these values. DES refers to a total nitrogen criterion (0.49 mg N/L) adopted for Pensacola Bay in Florida, but this is a subtropical seagrass system with very different species and would not necessarily apply to eelgrass in the Great Bay estuary. As a precedent for eelgrass and total nitrogen criteria, DES explicitly identified the Massachusetts Estuaries Project (MEP) and the similarity between the range of values determined by MEP (0.30 – 0.38 mg N/L) and the proposed DES nitrogen criteria.

DES was correct in considering the MEP program as precedent because; 1) eelgrass is the primary species of interest, 2) eelgrass declines are well documented, 3) nitrogen is implicated as a stressor causing the declines, and 4) many of the bio-physical characteristics of the coastal ecosystems are similar. However, DES failed to acknowledge the relevance of some very important differences between the MEP program's approach and the DES approach. Also, important differences in some the physical characteristics of Great Bay and the embayments of Massachusetts were not acknowledged, implying that DES did not consider the relevance of the differences and how they could affect interpretation of water quality monitoring data. Furthermore, by making a simple comparison to the MEP program without a comprehensive evaluation of the status of that program, DES was irresponsible in making the comparison and implying that it supports total nitrogen criteria proposed for the Great Bay. None-the-less, consideration of the MEP program can inform DES in revising and improving their approach to setting nitrogen criteria.

The MEP program developed nitrogen criteria using two of the three approaches recommended in the most recent EPA guidance; 1) reference condition (DES refers to this as sentinel sites) and 2) mechanistic modelling. The MEP approach correctly recognized that because of the wide range of biophysical characteristics in coastal MA, as well as the different features of the watersheds, they could not set one criterion for all 89 embayments in MA. The MEP proposed assessing and modelling each embayment's hydrodynamics, watershed and nitrogen processes separately. MEP has completed assessments and modelling in a subset of the 89 embayments. Since it has been determined that the primary driver for eutrophication and eelgrass loss in many of the MA coastal embayments on Cape Cod, the Elizabeth Islands and Buzzards Bay is nitrogen enrichment from groundwater, the MEP linked watershed

embayment models address this process as well as other nitrogen transformations to model nitrogen criteria indicated by “healthy eelgrass” growing at reference stations. The approach has gone through scientific peer review and the initial stages of the implementation of nitrogen TMDLs for a small subset of the 89 individual embayments and achievement of the total nitrogen criteria has been initiated. The implementation of TMDLs and achievement of nitrogen criteria is at a very early stage in MA. It will take years, perhaps even decades, to finance and make the necessary infrastructural changes to modify the delivery of nitrogen to the groundwater. Even when that is accomplished the legacy of nitrogen already in the groundwater of many of the watersheds will take several years to decades to be depleted and eventually to detect improvements in the conditions of the embayments. By no means has the modeled and proposed nitrogen concentrations and expected eelgrass responses been tested and validated by MEP in any of the MA embayments.

It is my opinion that a simple comparison of total nitrogen values derived in the MEP cannot support the nitrogen concentration proposed by DES. To the best of my knowledge, I am unaware of any other northeast State that has total nitrogen criteria intended for the protection of eelgrass. None-the-less, DES could benefit from a more comprehensive evaluation of the MEP program and adopting at least some of the basic principles of the approach for the Great Bay assessment. For example, MEP recognized the distinct biophysical and chemical differences between watershed/embayment systems and assessed them separately.

The principle ‘no one suit fits all’ was applied appropriately in MA. This resulted in some embayments having different nitrogen criteria in MA, and recognition that no one concentration value will fit for all of the different systems. Although DES explicitly recognizes different segments of the Great Bay estuary, in order to discover nitrogen criteria the method DES used failed to consider potentially important differences that could affect nitrogen, symptoms of nitrogen loading, and the eelgrass response. For example, the lower salinity tributaries of Great Bay have distinctly different biophysical characteristics and much tighter coupling to the watersheds than further downstream which is more coupled to oceanic influences. There may in fact be some situations upstream in lower salinity where phosphorus is a controlling factor. It is also clear from the eelgrass cover data that some portions of the Great Bay should be considered largely a restoration problem (e.g., Winnicut, Squamscott, Lamprey and Oyster Rivers), while other locations would be considered primarily a maintenance and conservation problem (e.g., Great Bay, Portsmouth Harbor). It is likely that the eelgrass water quality requirements (light especially) and nitrogen criteria could be different in these locations. Restoration site selection criteria described by Short et al. (2002) suggest a number of factors that should be considered in the assessment of the different zones of Great Bay.

Considering the MEP approach identifies another very important deficit in the DES 2009 Report. With the exception of what was considered as the oceanic boundary conditions in the Gulf of Maine, DES did not take into account the inputs of nitrogen (loads and sources) and the potential variability of these inputs into the Great Bay estuary, better yet, different inputs in the various zones. Loading models would be very informative for the process of establishing achievable nitrogen criteria.

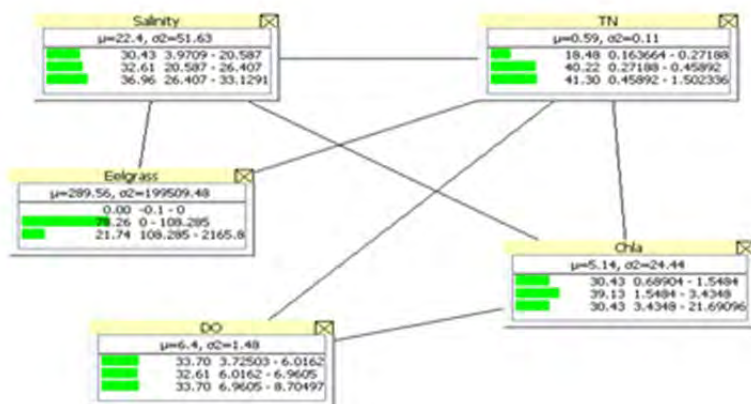


To the best of my knowledge, only one system wide level study of the relationship between total nitrogen and eelgrass status has been published in the scientific literature (Wazniak et al. 2007). This study was conducted in the coastal bays of Maryland and Virginia and examined the long-term record for trends in eelgrass abundance and total nitrogen concentrations, chlorophyll a, total phosphorus, and dissolved oxygen). This study is informative for DES because it demonstrates statistically that in locations where total nitrogen concentrations exceeded 0.65 mg/l eelgrass was declining. The proposed DES total nitrogen criteria in Great Bay (annual median of 0.25 – 0.30 mg total nitrogen) are about half the threshold concentration identified by Wazniak et al. (2007), so it appears that the DES criteria are more conservative and potentially more protective of eelgrass than identified for the Maryland coastal bays.

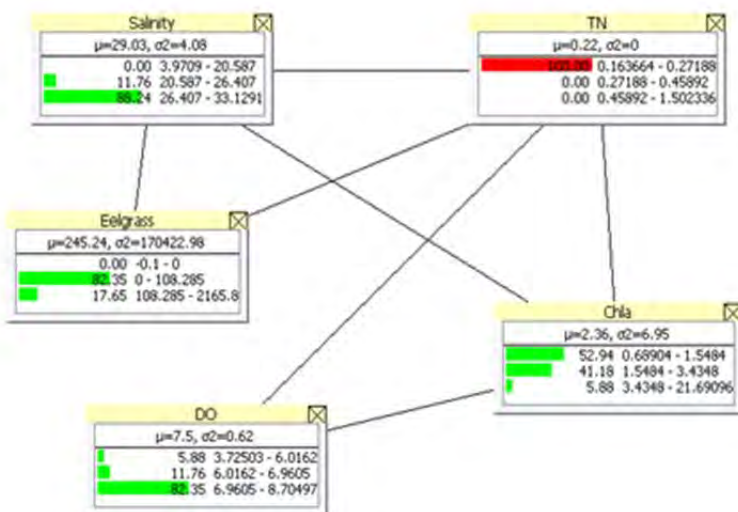
To help better identify the potential total nitrogen criteria for Great Bay, DES should also consider the results of a recent study conducted in collaboration with the MEP program in Massachusetts (Bensen et al. 2013). This study identified; 1) healthy and stable eelgrass beds as locations with long-term total nitrogen concentrations (2000-2010) of 0.45 mg/l and, 2) degrading or lost beds with concentrations of  $\approx$  0.55 and 0.65 mg/l, respectively (see Figure 2 in Bensen et al. 2013). These results corroborate values reported by Wazniak et al. (2007) discussed above, indicating that concentrations on the order of about 0.6 mg/l total nitrogen correspond with degrading eelgrass beds. However, as indicated above in my responses to questions #1 and #2, even where lower total nitrogen values in Great Bay are lower than 0.6 mg/l and are at the proposed DES criteria concentrations, eelgrass is declining. Again, suggesting the likelihood that other factors are affecting eelgrass distribution, abundance and survival in Great Bay.

## RECKHOW RESPONSE

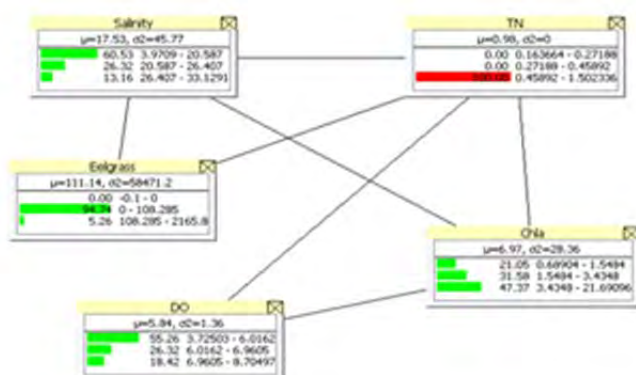
Looking at only the pooled site/date NH DES data, I developed the Bayes network in the next figure. The cutoffs for the “bins” for the TN variable were selected based on the proposed TN criteria. To assess the impact of the proposed TN criteria, we should compare the changes in the three eelgrass bars from the “base” case in the first figure below to the eelgrass bars in the next two figures. In the second figure, I examined the impact on eelgrass of  $TN < 0.27$  (indicated by the red bar); note that the change in eelgrass coverage from the base case is a relatively small improvement, as the middle category for eelgrass increases from 78% to 82%. In the third figure, I examined the impact on eelgrass of  $TN > 0.45$  (indicated by the red bar); note that the change in eelgrass coverage from the base case is actually counterintuitive, as the middle category for eelgrass increases from 78% to 94%. Note however, that the changes in DO and chlorophyll **are** consistent with scientific understanding. Taken together, these findings underscore the weak link between TN and eelgrass in the NH DES data; this is consistent with other analyses I have presented.



A)



B)



C)

Figure 15. The predicted effect of the one of the proposed TN water quality criterion

**e) Does the available information demonstrate that, for the protection of eelgrass habitat, the annual median total nitrogen concentration should be less than or equal to 0.25-0.30 mg N/L, depending on the eelgrass restoration depth? Will attaining these values achieve the desired restoration depth for transparency?**

## **BIERMAN RESPONSE**

I defer to Drs. Kenworthy and Reckhow.

## **DIAZ RESPONSE**

I defer to Drs. Kenworthy and Reckhow.

## **KENWORTHY RESPONSE**

First of all, there is compelling scientific evidence that eutrophication of estuaries and coastal embayments and loss of eelgrass can be caused by either the loading or delivery of high concentrations of different forms of inorganic, organic, and total nitrogen (e.g., Taylor et al. 1995, Short et al. 1995, Short and Burdick 1996, Kemp et al. 2004, Burkholder et al. 2007, Krause-Jensen et al. 2008, Vaudry et al. 2010, Latimer and Rego 2010, Benson et al. 2013). Several of these studies also make a direct link between nitrogen concentrations, nitrogen loading and water transparency. Likewise, eliminating point source wastewater discharges and reducing nitrogen loading reversed eelgrass losses in a shallow coastal embayment on Long Island Sound, Ct (Vaudry et al. 2010). Lending credence to the argument that nitrogen management can improve water quality conditions (e.g., water transparency) for the protection and restoration (Dennison et al. 1993, Krause Jensen et al. 2008, Vaudry et al. 2010). None of these studies actually specify any threshold concentrations of total nitrogen, and most either directly address concentrations of inorganic nitrogen (ammonium, nitrate/nitrite, phosphorous), or nitrogen loading.

DES was correct in considering measurements of water transparency, because it is a very important symptom of eutrophication and one of several factors controlling eelgrass distribution and abundance. As explicitly stated in the 2009 Report, DES quantified transparency as the light attenuation coefficient ( $K_d$ ) derived from a number of data sources, presumably all using similar methods. To predict the presence or absence of eelgrass in different zones of the Great Bay estuary DES adopted a modelling approach suggested by Koch (2001) which incorporates the effects of tide range and assumed a fixed eelgrass light requirement (22%). The model was derived from a published empirical study of eelgrass depth distribution in Long Island Sound (Koch and Beer 1996) and DES used eelgrass light requirements (22%) adopted by the Chesapeake Bay Program. I am unaware of any studies which have rigorously tested or applied the Koch (2001) model for deriving nitrogen criteria; however, the model is based on sound physical principles, was derived in a relatively similar northeastern coastal environment (Long Island Sound) and should have practical value in the Great Bay estuary.

The assumption that seagrass light requirements for a species are constant, even in different environmental conditions, has come under scrutiny in several studies (Kenworthy and Fonseca 1996,

Duarte et al. 2007, Kenworthy et al. 2013). Light requirements may vary as a function of optical water quality (turbidity, transparency), sediment organic matter content (sulfide toxicity, oxygen demand) and water temperature. A recent study in coastal Massachusetts indicates that eelgrass minimum light requirements can range from as low as 9.6% in a pristine embayment to as high as 29.7% in a nitrogen impaired site (Kenworthy et al. 2013), suggesting it may be necessary for DES to evaluate the strength of the assumption of a fixed light requirement for eelgrass in Great Bay. DES should also consider what factors might affect their assumption (e.g., sediment organic matter, water turbidity, CDOM) and whether there is uncertainty in the assumed constant. DES should also explain why they depended on a value derived from the Chesapeake Bay Program, but neglected to specifically cite the results of a very relevant local empirical study by Short and Burdick (1995).

In a controlled mesocosm study at the University of New Hampshire Lab on Great Bay, Short and Burdick (1995) examined the effects of eutrophication and shading on eelgrass. This is an important study because, to a large extent, the results were not confounded by other factors that cannot be controlled in field surveys. This study identified a minimum eelgrass light requirement ranging between 11% and 21%. In the 21% light treatment, eelgrass densities were “steady” near the end of the experiment while at 11% they were still declining. The authors concluded that at the lowest level of light (11%) eelgrass could not be sustained. However, at values above 21% eelgrass growth and density increased. Based on this study, it would seem that 22% is a reasonable estimate of a “minimum” light requirement, but the plants grow and reproduce at higher light levels. The study is informative because it demonstrates that using a designated minimum value as a target may be a risky proposition, should some other factors stress the plants. In the experiment, at 21% the plants were surviving but were poised at a tipping point where they might be nudged to decline with less light or increase with more light, depending on what other stressors might affect them (e.g., temperature, nutrients, sediment organic matter).

A more recent mesocosm study conducted at the University of New Hampshire facility on Great Bay in collaboration with another study at the University of Rhode Island on Narragansett Bay also indicates that the light requirements of eelgrass may be higher than 22% (Short et al. 2012). In this study, plants grown at 50% of ambient light in Great Bay water exposed to high organic matter sediments (8%) and temperatures elevated 2<sup>o</sup> and 4<sup>o</sup> C above ambient Narragansett Bay water displayed significantly greater stress responses compared to plants grown at ambient light and temperature (e.g., depressed shoot growth, slower asexual reproduction rate). These empirical studies suggest that eelgrass light requirements are not constant and important interactions between other factors that affect eelgrass growth and reproduction should be considered in order to establish an accurate and protective light requirement for the plants.

It would also make sense that, in order to have a protective target value, it should be greater than the minimum. Most of the data supporting a 20-22% minimum value are derived from field studies at the deep edge of established eelgrass beds and the correspondence between the percentages of surface light reaching those edges. In many cases, these studies have been conducted in relatively healthy eelgrass beds where the plants are reproducing and clonal integration between plants is supporting growth at the deep edges. This is especially relevant because several of the tributaries in Great Bay have lost all or most of their eelgrass and it is generally understood that eelgrass light requirements in recovery conditions (e.g., a restoration or by natural seed recruitment) will be higher than at the edge of an established and healthy

meadow. DES acknowledged this possibility in the 2009 report, but it was not addressed directly and 22% was assumed for the entire system. Just as they did for setting the nitrogen concentration criteria values, DES should consider the uncertainty in eelgrass light requirements and the fact that a minimum may not be conservative enough to protect and restore the plants. DES should consider building in a “margin of safety” by assuming a higher value that would better ensure the growth, reproduction and expansion of eelgrass, and not just survival at a minimum threshold. Based on the studies cited above, it is also probable that eelgrass light requirements could vary in the different segments of the Great Bay estuary, especially since many areas are going to require restoration and not just maintenance. DES acknowledges these issues pages 56 and 57 of the 2009 Report, but they do not make any effort to address their implications.

DES was correct in using the  $K_d$  values to help determine a target depth for eelgrass bed maintenance and restoration in the different zones of the Great Bay estuary. This general approach has frequently been used by scientists and resource managers to establish goals for seagrass conservation (Orth et al. 2010 a, b). However, a more useful and quantitative approach would also take into account the; 1) actual distribution of eelgrass with respect to depth, and 2) the potential eelgrass distribution with respect to depth (see Wazniak et al. 2007) . By simply setting a target depth based on  $K_d$  and not having any information of the estuary’s bathymetry, it is impossible to determine what the implications of the target depth criteria will be with respect to the distribution and abundance of eelgrass. Without information on bathymetry I don’t know if and where those water depths occur in a zone, and how much of the zone would actually be suitable for eelgrass growth. The assessment approach should also include spatially articulated estuarine bathymetry information. Another assumption DES makes in their approach, but fails to address, is whether the target depth will support eelgrass. Are the substrate and environmental conditions at the proposed target depths throughout a zone suitable for eelgrass growth? This is an important question that should be acknowledged and addressed by DES before anyone can fully understand and predict the implications of the proposed criteria.

## RECKHOW RESPONSE

See my response to part d above.

**QUESTION 3. THE DES 2009 REPORT ESTABLISHED THRESHOLDS FOR. . . TN concentrations. In this estuary, is TN the correct form of nitrogen on which to focus to address cultural eutrophication? Assuming that the excessive growth of macroalgae and/or epiphytes is one of the primary concerns, what form of nitrogen should be the focus, given detention times in the system? Is the form of nitrogen that should be controlled the same for great bay, the Piscataqua River and Portsmouth Harbor? Based on the available evidence, is it likely that dissolved organic nitrogen is converted to dissolved inorganic nitrogen to a significant degree within this estuary and watershed?**

### **BIERMAN RESPONSE**

Yes, TN is the correct form of nitrogen on which to focus to address cultural eutrophication.

I am in agreement with this statement from EPA (2010b):

*“Regardless of their source, N and P are present in three main forms: dissolved organic N and P, dissolved inorganic N and P, and particulate N and P (Chapra 1997). These compounds frequently cycle between forms, transforming and reacting between dissolved and particulate fractions. Only dissolved organic and inorganic forms are taken up by microbes and primary producers, and this uptake capacity and rate varies among taxa and environmental conditions.”*

*“For P, soluble reactive phosphorus (e.g.,  $PO_4$ ) is the form most readily available to plants and algae (Correll 1998). Although soluble  $PO_4$  concentration can be measured directly, it is taken up by plants or converted to other forms quickly in the environment, and measurements of soluble  $PO_4$  may not provide an accurate indication of available P. Therefore, total P (TP) is commonly measured and used as an indicator of the amount of P available to the system. Estimates of P loading have also been combined with lake retention time and P settling rates to model observed chl a concentrations (Vollenweider 1976).”*

*“For N, inorganic N in the forms of ammonia ( $NH_3$ ) and nitrate ( $NO_3$ ) are preferred by plants and algae. Like  $PO_4$ , it is often difficult to measure  $NH_3$  and  $NO_3$  frequently enough in most state sampling programs to capture nutrient-plant dynamics. Thus, total N (TN) is commonly used to represent the amount of N in the system and its relationship to primary production.”*

For Great Bay Estuary it is not possible to answer the question about the influence of detention times on conversion of nitrogen from unavailable to available forms within the watershed or estuary. To answer this question, a load-response mass balance model would be required that incorporates estuarine hydrodynamics, and nitrogen cycling in the water column and bedded sediments. Such a model does not presently exist for Great Bay Estuary.



## DIAZ RESPONSE

The nitrogen cycle is complex with many forms that are biologically active and readily transformed. Processes responsible for the transformation, retention, or removal of nitrogen in shallow coastal systems are diverse and include uptake, release, and mineralization by primary producers and microbes, burial, denitrification, and transport to the coastal ocean.

For managing nutrient driven eutrophication the most important forms are ammonia, nitrate, and nitrite, which when summed represent dissolved inorganic nitrogen (DIN). This is what the DES 2009 Report considers to be DIN. Other fractions considered were dissolved organic nitrogen (DON), nitrogen in phytoplankton, and nitrogen in all other particulate organic matter. The report also states that total nitrogen (TN) is the sum of all dissolved nitrogen plus all particulate nitrogen.

It is generally thought that macroalgae growth is related primarily to DIN loads or concentrations, so a strategy that focused on all forms of DIN might seem appropriate. However, bioavailable compounds in the DON pool, such as amino acids and urea, can make up significant portion of the DON pool and contribute to macroalgal production (Tyler and McGlathery 2006). In addition, labile organic compounds may represent an important source of N for both heterotrophic and autotrophic microorganisms, as well as for benthic plants (Tyler et al. 2001). For the Great Bay system TN is about 38% DIN, about 39% DON, and about 23% PON (from Table 3 in DES 2009 Report). Given that DON and PON can be converted to DIN and taken up directly by macroalgae, a key question with regards to which fractions of nitrogen to control would be: How much of the DON and PON fractions within Great Bay are converted to DIN and how much is taken up directly as DON? Based on the information in the DES 2009 Report, it is not possible to determine the rate of conversion of organic nitrogen to DIN or direct uptake.

Relative to excessive macroalgal production, the timing of availability of DIN and DON would be important as macroalgae occur seasonally. During the times of year that macroalgae are not present, what other species take up the TN fractions?

## KENWORTHY RESPONSE

Yes, total nitrogen is the correct and most robust form of nitrogen to use as an indicator of nitrogen status in an estuary. Normally, the transformations of inorganic forms of nitrogen to organic forms and the metabolism of primary producers and microorganisms which process inorganic and nitrogen are extremely rapid. The dynamics are so rapid, and the variability in concentrations so high, standard water quality monitoring programs cannot adequately capture and statistically describe the variability in the inorganic forms of nitrogen (Wazniak et al. 2008, Benson et al. 2013). Unless there was demonstrable evidence that an excessive abundance of recalcitrant forms of organic nitrogen are delivered to the Great Bay estuary, there is no reason to be concerned that measuring total nitrogen is incorrect.

Detention times for the individual segments and the entire system of Great Bay are not quantitatively addressed in the DES 2009 Report, so it is impossible to answer that portion of the question. However, it is well documented that water residence time is an important factor in considering nitrogen loading and eutrophication in coastal systems (Krause Jensen et al. 2008, Latimer and Rego 2010, Benson et al. 2013).

Water residence times and hydrodynamics are important centerpieces of the MEP nitrogen modelling program in Massachusetts and it would be informative for DES to consider incorporating these factors into their assessment.

The information provided in the DES 2009 Report is insufficient for determining if the forms of nitrogen are different in the Great Bay, Piscataqua River and Portsmouth Harbor.

## **RECKHOW RESPONSE**

I think that TN is the best measurement of nitrogen to set as a water quality criterion and for a TMDL to control eutrophication. We know that algae preferentially take up inorganic nitrogen forms (nitrate and ammonium), and over short time scales inorganic nitrogen forms provide the best indicator of near-term future algal growth (if N is limiting). Recently, some scientists have reasoned that since nitrogen is a component of algal cells, then the use of the TN – chlorophyll relationship as a basis for nitrogen control decisions is wrong due to spurious correlation (Lewis and Wurtsbaugh 2008). I think this conclusion is flawed when it is cited as the basis for not using TN to set water quality criterion, since we know that TN reductions can be expected to lead to chlorophyll reductions. In addition, since transformations of nitrogen from one form to another do occur in surface waters, it does not make sense to me to have a (long-term) water quality criterion or TMDL for nitrogen based on any other parameter except TN.

**QUESTION 4. THE DES 2009 REPORT WAS PUBLISHED NEARLY FIVE YEARS. . . Ago. To ensure ongoing protection of estuarine resources and water quality based on the latest scientific understandings, the des 2009 report may be updated in the future.**

**a) If you were charged with updating the DES 2009 Report, what approach would you take given the information now available?**

## **BIERMAN RESPONSE**

My answer to this question assumes that the goal of an updated DES 2009 Report is to refine/revise the numeric nutrient criteria based on new data, models and information that has become available since publication of the original document. A caveat to my answer is that improvements in water quality/ecological health in Great Bay Estuary can only be obtained by controlling nutrient loads, not by simply setting numeric nutrient criteria. Such criteria may be beneficial in cases where only narrative criteria exist and progress on nutrient load controls is held hostage to endless arguments over how to translate narrative criteria into quantitative criteria. In my opinion, however, numeric nutrient criteria are a solution to a regulatory problem, not a water quality problem. They are one link in a causal chain that must eventually connect nutrient loads to water quality and/or ecological endpoints in order to develop controls on nutrient loads in the form of TMDLs and/or NPDES permits.

The U.S. EPA itself took this approach in their use of process-based mass balance models by Scavia et al. 2004 and Cerco et al. 2010 to develop nutrient load reduction goals for the Gulf of Mexico (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008) and the nutrient and sediment TMDLs for Chesapeake Bay (EPA 2010c). These process-based models are load-response models, not empirical stressor-response models, and hence they obviate the need for numeric nutrient criteria because they directly link nutrient loads to response variables that represent water quality impairments (e.g., dissolved oxygen, chlorophyll-a, water clarity and acreage of submerged aquatic vegetation). This reasoning applies not only to process-based mass balance models but can also apply to empirical models. Empirical statistical models were developed for the Gulf of Mexico (Scavia and Donnelly 2007; Turner et al. 2008) and Chesapeake Bay (Hagy et al. 2004). These models are also load-response models and none of them involves numeric nutrient criteria.

To update the DES 2009 Report for the purpose of revising/refining the numeric nutrient criteria, I would use a comprehensive “weight of evidence” approach based on the “triad” of methods discussed above in my response to Question 2a:

- Reference condition approach
- Empirical (statistical) stressor-response analysis
- Process-based (mass balance) models.

I would follow the guidance in EPA (2001) for the reference condition approach, in EPA (2010b) for empirical stressor-response analysis, and in Bierman et al. (2013) for process-based mass balance models.

In following the guidance in EPA (2001), I would conduct a comprehensive and systematic review of site-specific data for other representative marine/estuarine systems in the New England and mid-Atlantic regions. I would place emphasis on spatial classification and segmentation of each system, including Great Bay Estuary, into zones with similar flushing times, bathymetry and sediment physical-chemical characteristics. I would use this information base to develop target thresholds for total nitrogen concentrations for each of the distinct water quality/ecological zones in the Great Bay Estuary. In following the guidance in EPA (2010b), I would place emphasis on fully investigating the influence of the co-varying/confounding variables in my response to Question 1a, and address all of the concerns expressed in my response to Question 1e.

In following the guidance in Bierman et al. (2013), I would select a process-based mass balance model from the Nutrient Modeling Toolbox (NMT) that represents the water quality/ecological endpoints of concern in Great Bay Estuary, and which is compatible with the available data for model set-up, inputs and calibration. There are numerous process-based models that would be appropriate for nutrients, chlorophyll-a and DO, but only a limited number of complex models for submerged aquatic vegetation (eelgrass). A viable alternative would be to use a hybrid approach in which a process-based model would link nutrient loads to chlorophyll-a, DO and underwater light attenuation, and an empirical component would be used to link these process-based outputs to eelgrass. This empirical component would need to be developed using results from the reference condition and empirical stressor-response approaches. See Bierman et al. (2013) for a more complete discussion of hybrid models.

There would be three major benefits to using a process-based mass balance model. First, all of the relevant stressor, response and confounding variables could be represented within the same internally consistent mass balance framework. Second, numeric nutrient criteria could be extracted from load reduction simulations with the calibrated model that achieve the desired water quality/ecological endpoints. Finally, load reduction simulations with the calibrated model could be used directly to develop controls on external loadings in the form of TMDLs and/or NPDES permits.

## **DIAZ RESPONSE**

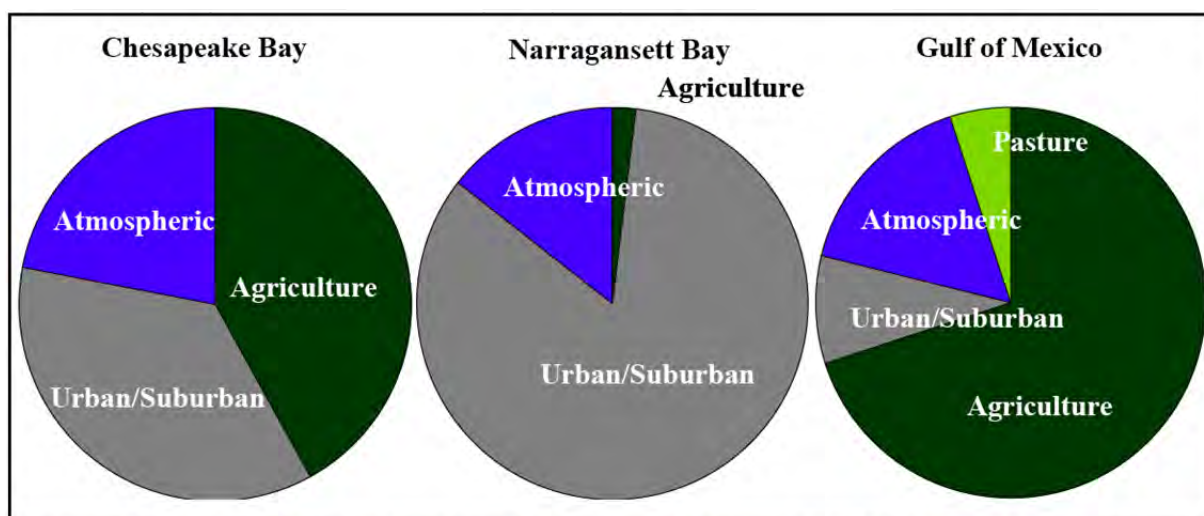
Given that the DES 2009 Report is five years old, its authors did a good job finding and compiling data for the Great Bay system for nutrients and water quality from January 2000 to December 2008. Any approach to an update would start with a compilation of nutrient and water quality data on Great Bay collected from January 2009 to the present, and integration of new data with previous data compilations. The same data update would be needed for sediments and benthic invertebrate communities.

In parallel with the data updates, DES should evaluate the guidance now available from EPA for applying response-stressor and weight of evidence approaches to setting numerical nutrient criteria. Particular attention needs to be given to the conceptual models used to support regulation of nitrogen.

While it is widely understood that nitrogen is typically limiting in marine systems, it is important to consider phosphorus and develop a two-nutrient control strategy. Recent thinking about restoring the Baltic Sea, and other marine systems, has shifted to a two nutrient solution (Conley et al. 2009). Any

update of the DES 2009 Report should include more detailed assessment of how changes in nutrient ratios will affect the ecosystem.

While the DES 2009 Report is focused on setting numerical criteria for total nitrogen, some consideration needs to be included for what are the sources of nitrogen to the Great Bay system, and which are controllable vs. which are uncontrollable. This becomes important in assessing success of any nitrogen reduction strategy. For example, the sources of nitrogen driving eutrophication in Chesapeake Bay, Narragansett Bay, and northern Gulf of Mexico are different and would require tailored approaches to nutrient reduction (Figure 16, CENR 2010). Basically, are there sufficient pools of controllable nitrogen that can be reduced to meet any set numerical criteria for total nitrogen?



**Figure 3. Comparison of the relative contribution of major sources of nitrogen pollution in three coastal ecosystems experiencing hypoxia.** Urban/suburban includes both point (industrial and sewage effluent) and nonpoint sources (residential run off). Data sources: Chesapeake Bay: Chesapeake Bay Program; Narragansett Bay: Nixon et al. 2008, Moore et al. 2004; Gulf of Mexico: Alexander et al. 2008.

**Figure 16. Variation in sources of nitrogen for three US systems. From CERN (2010). Absent from consideration were oceanic sources, which may be an important sources for systems such as Great Bay.**

## KENWORTHY RESPONSE

First of all, DES should be complemented for their effort to establish nitrogen criteria in the Great Bay estuary. DES has compiled a complicated, long and very large data set from a wide range of sources to conduct their assessment and to begin addressing nitrogen management and resource protection in the Great Bay estuary. There is compelling scientific information that has identified this problem in many coastal ecosystems, including Great Bay (see citations noted in my responses above). There is also considerable management experience which supports a need for responsible resource agencies and the public and private stakeholders to control nutrient enrichment for the protection of sensitive, productive and valuable estuarine environments. Large scale attention to this problem and the cooperation of scientists and managers, along with public and private financing, has paved a promising path for the protection and restoration of seagrasses in several coastal ecosystems (e.g.; Tomasko et al. 2005, Greening and Janicki 2006, Steward and Green 2007, Orth et al. 2010a; Bensen et al. 2013, Massachusetts Estuaries Project at <https://www.google.com/#q=Massachusetts%20estuaries%20project>).

Along with new and emerging scientific information (locally, nationally and globally) and several comprehensive evaluations of the results of nutrient management programs (see for example Orth et al. 2010 a, b, Greening and Janicki 2006, Tampa Bay National Estuary Program at <http://tbep.tech.org/>), there are also relatively new EPA guidelines (USEPA 2010a, b) recommending more comprehensive approaches to assessing nutrient enrichment and setting criteria. DES was well into their assessment as this new and important scientific information emerged, the recent experiences of other state program were evaluated, and new guidelines were proposed. So it is now possible for DES, the Great Bay estuary stakeholders and the responsible parties in the region to benefit from this new information by a thorough and critical re-evaluation of the approach. The new scientific information, preliminary indications from the applied science, and management experience all strongly suggest there is potential for considerable improvements to be made without sacrificing the data and information already collected and compiled by DES and its' collaborators. The DES 2009 Report would benefit from significantly modifying the approach and collecting new information as per my recommendations discussed below and suggestions made by my fellow panel members.

I would recommend a complete re-evaluation of the updated eelgrass cover data for all of the individual zones in the Great Bay Estuary (see my response to question #1 and Table 1). This re-evaluation would more closely align eelgrass status with the contemporary water quality monitoring data and improve the correspondence analysis between eelgrass, optical water quality, nutrients and environmental conditions in the Great Bay estuary. I would also recommended treating eelgrass status and corresponding water quality data independently for each distinctive zone. This would recognize potential differences in the biophysical characteristics of the zones, as well as the sources of nutrients (loadings), and result in a “zone specific” approach that could be more easily adapted to changing conditions and new information. It is highly likely that this would require the addition of more water quality monitoring stations in each zone as well as a more comprehensive evaluation of the temporal and spatial variability of the different biological, chemical and physical factors affecting the delivery of nutrients to Great Bay, the response of the symptom factors (chlorophyll-a, turbidity, CDOM,  $K_d$ ) and the corresponding growth, abundance and distribution of eelgrass.

By taking this approach, DES would also benefit by formally addressing eelgrass status in the Great Bay estuary as two different problems. One is a very difficult and uncertain restoration problem in the tributaries that have lost all or most of their eelgrass and the second is a maintenance and conservation problem in the areas where most of the eelgrass resource exists, but is still declining. DES should consider establishing priorities for protecting the largest extent of the resource and adapting the assessment approach to these priorities instead of treating the system with one nitrogen concentration criterion and the expectation that eelgrass will be protected and restored throughout a very complex estuarine ecosystem.

## RECKHOW RESPONSE

I would use the methods that I applied in my review of the DES 2009 Report; these methods are described in my responses to Question 1 and Question 2.



**b) Would a reference waters approach to establish a TN threshold based on various eutrophic responses such as macroalgae growth, low dissolved oxygen, and eelgrass loss be appropriate and feasible for the great bay estuary? If so, how would you recommend such an approach be developed?**

## **BIERMAN RESPONSE**

Yes, but only as one part of a “triad” of methods. See my response to Question 4a.

## **DIAZ RESPONSE**

Approaches that use reference conditions for defining impairment or impact can provide some of the strongest statistical evidence for impairment or impact. These approaches are commonly applied in assessments that use benthic invertebrate communities. When the impact has not yet occurred the designs are known as before-after, control-impact (BACI) study designs. If the impact has occurred, the approach to the assessment changes and requires spatial comparisons between impacted vs. unimpacted sites (Green 1979). Unimpacted sites would provide the control or reference conditions.

There are limitations to a reference waters approach for setting total nitrogen criteria. The first would be the lack of cause-effect between similarities or differences at the reference and impaired sites. Strong stressor-response relationships would still be required and they would have to be applicable to all sites evaluated.

For DES to switch to a reference waters approach to set nitrogen criteria in Great Bay region the following steps need to be followed:

- Identification of impaired waters within the Great Bay region in order to establish the degree of impairment.
- Identification of unimpaired reference waters within the Great Bay region in order to establish reference conditions. If there are no unimpaired waters, can minimally impaired waters be used?
- Given that Great Bay is a relatively small system and watershed (Figure 1), there may be no regions/stations that have sufficient spatial separation for establishing impaired vs. unimpaired waters. Are stations far enough apart but still similar enough for comparison? If this is the case, can unimpaired waters be found outside the Great Bay region that would serve as reference waters?
- Matching of impaired and unimpaired waters to characterize conditions for the primary (Chlorophyll-a and macroalgae) and secondary (benthic invertebrates, sediment quality, DO, and eelgrass) indicators DES will use for setting total nitrogen numeric criteria.
- Establish the stressor-response relationship between total nitrogen and primary and secondary indicators.

If these five points can be adequately addressed, then a reference waters approach may be possible.

## KENWORTHY RESPONSE

As per the EPA guidelines and my detailed response to questions #1 and #2, a reference approach should be considered as part of a broader effort that also includes consideration of; 1) nitrogen sources, loading, and hydrodynamic modeling (mass balance modelling), 2) empirical determinations of eelgrass response to selected eutrophication stressors, and 3) empirically ruling out other factors which affect eelgrass growth, abundance and distribution in the Great Bay estuary. Most importantly, DES **should not** consider one reference site for the entire Great Bay estuary. But rather, each zone, or the aggregation of a few zones, should have their own reference condition established depending on the bio-physical similarities and dissimilarities between zones.

## RECKHOW RESPONSE

I know that the USEPA has promoted the reference waters approach. I am not a proponent of this strategy as the single basis for setting a water quality criterion. If a reference waters approach is to be used as a basis for TN criteria for the Great Bay, it should be considered as only one of several “lines of evidence” that are needed.

**c) Are there other approaches that you would recommend as alternatives for setting site specific nutrient criteria for the tidal Piscataqua and Cocheco rivers?**

**BIERMAN RESPONSE**

The “triad” approach recommended in my response to Question 4a would also be appropriate for the tidal Piscataqua and Cocheco Rivers. To the extent that these assessment zones are more strongly influenced by different physical factors (e.g., flushing rates) than portions of the Great Bay Estuary located further downstream, the process-based mass balance modeling approach might provide a stronger line of evidence than the reference condition or empirical stressor-response approaches.

**DIAZ RESPONSE**

The approaches followed in the DES 2009 Report for setting total nitrogen concentration criteria rely on stressor-response and weight of evidence methodologies framed and guided by two conceptual models of nutrient enrichment and eutrophication (see Question 1 response). Other approaches would involve numerical modeling or shifting to total nitrogen load as the criteria.

**KENWORTHY RESPONSE**

According to the DES 2008 report, *“Eelgrass is not known to have been present in the Cocheco River. The historic sources did not map and current eelgrass maps do not show eelgrass in this zone. Available chlorophyll-a data indicate compliance with the chlorophyll-a criterion. Since there are no chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.”* Based on this assessment, I would recommend that the Cocheco River be treated very differently from the tidal Piscataqua which still has eelgrass present, but declining. With respect to eelgrass, it has never been documented in the Cocheco, so it would be irresponsible to set criteria for eelgrass based on any other segments of the Great Bay estuary.

**RECKHOW RESPONSE**

I would use the methods that I applied in my review of the DES 2009 Report; these methods are described in my responses to Question 1 and Question 2.

**d) Do you have any recommendations for the long-term (10-year) monitoring and evaluation of the estuary to assess changes in conditions over time?**

**BIERMAN RESPONSE**

Long-term monitoring and evaluation of the estuary should be conducted within the larger context of an overall decision support system. An adaptive management framework should be used for this decision support system, and should be a framework for integrating continued monitoring, data analysis and process-based mass balance model to improve scientific understanding and reduce uncertainties. A relevant example would be the recommendations in the Massachusetts Estuary Project (MEP) Linked Watershed Embayment Model Peer Review (Scientific Peer Review Panel 2011).

**DIAZ RESPONSE**

Irrespective of which set of methods DES follows in setting limits on total nitrogen, additional data are needed to link total nitrogen to total ecosystem functioning of the Great Bay system. Before launching into data collection, consider that it is well-established dogma that estuarine ecosystems are complex and are driven by a complex combination of top-down, bottom-up, internal, and external factors. Cloern (2001) captures much of this complexity in Figure 17. Basically, there are no simple cause-effect relationships, it is all interactions. Therefore to focus limited resources on what is essential for setting nitrogen criteria within Great Bay, a detailed conceptual model of all sources of nitrogen entering Great Bay and interactions of ecosystem components with nitrogen would be needed. Evaluation of data gaps within this overall model framework combined with best professional judgment will guide both which linkages are most important, and which short-term and long-term datasets are needed.

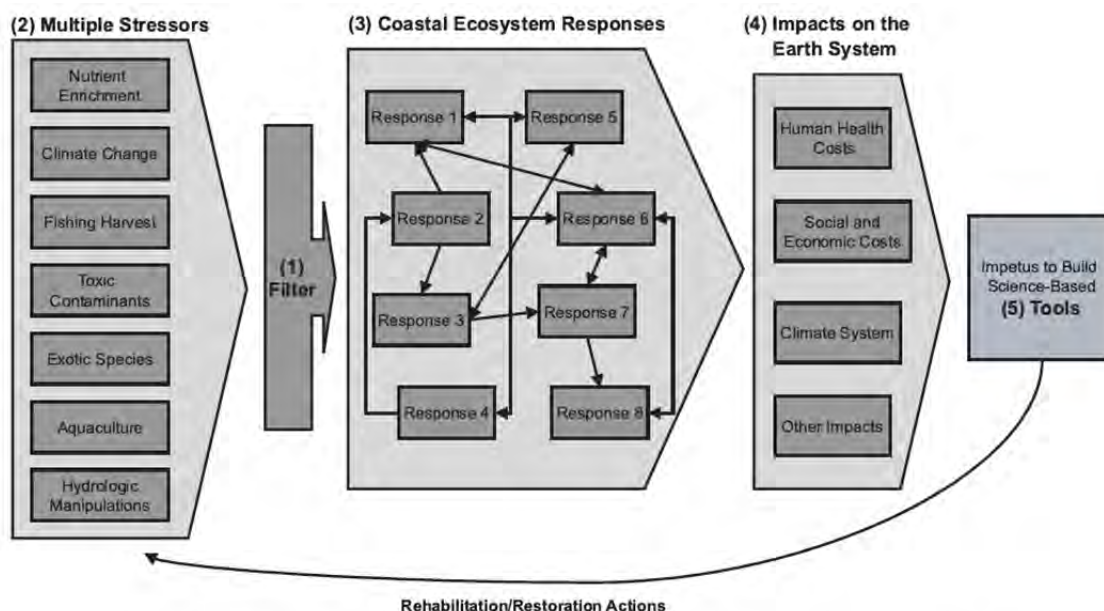


Fig. 24. One view of the next (Phase III) conceptual model of coastal eutrophication, organized around 5 basic questions concerning: (1) the system attributes that act as a filter to modulate the responses to nutrient enrichment; (2) nutrient enrichment as 1 of many interacting stressors; (3) the complex linkages between responses to multiple stressors; (4) impacts of change in coastal ecosystems on the Earth system, including aspects that influence sustainability of the human population; and (5) the application of a deeper and broader scientific understanding of coastal eutrophication to produce a set of tools for building rational management strategies and action plans for ecosystem rehabilitation/restoration

**Figure 17. Conceptual model for complexity of interactions within estuarine systems.**

From Cloern (2001).

## KENWORTHY RESPONSE

I would urge DES to follow the recommendations I have suggested in my responses above to questions #1, 2 and 3 and the specific recommendations made by the other members of this review panel. To summarize the most important points I will briefly re-iterate that DES should: 1) incorporate the more recent eelgrass data (Table 1) into their assessment and align these data more closely in time and space with a more rigorous analysis of the water quality and light attenuation data; 2) follow the most recent guidelines by EPA and its' expert panel reviews which recommend a broader approach to the assessment process by incorporating stressor response analyses, appropriate reference conditions, and process based modelling; 3) consider addressing the different zones in the Great Bay estuary independently for the assessment of eelgrass, water quality status, and reference condition; 4) improve the assessment by quantitatively recognizing and treating the status of eelgrass and eutrophication in the different zones as either a conservation and maintenance problem or a restoration problem; 5) incorporate more basic information and understanding of eelgrass biology (e.g., reproductive biology) and ecology as it pertains to eutrophication, eelgrass loss, and eelgrass recovery; and 6) review and evaluate the more recent basic and applied scientific literature cited in this review to gain a better understanding of the problem in Great Bay and refinements in the assessment process.

In addition to these specific recommendations, I also suggest that DES consider using a properly calibrated bio-optical water quality model to assess the effects of chlorophyll-a, turbidity, and CDOM on

light attenuation ( $K_d$ ) and eelgrass abundance and distribution (Gallegos 2001, Gallegos 2005, Gallegos and Kenworthy 1996, Biber et al. 2008, Kenworthy et al. 2013). As indicated earlier, the data used by DES from the Morrison et al. (2007) study show that all three monitored optical water quality components (chlorophyll-a, turbidity, CDOM) are contributing to light attenuation in the Great Bay estuary. Based on the 2009 assessment report, it appears that DES has undervalued the contributions of turbidity and CDOM and placed a disproportionate emphasis on chlorophyll-a. Distinguishing the relative importance or the effects of each one of these variables using linear regression (simple or multiple) analyses can be significantly improved by using a bio-optical water quality model to calculate  $K_d$  and having some knowledge about eelgrass light requirements (Gallegos 2001, Kenworthy et al. 2013). The bio-optical modelling approach recognizes that  $K_d$  is an “apparent” optical property and can be calculated by using inherent optical properties (absorption and scattering) which are additive and directly related to concentrations of regularly measured water quality parameters (chlorophyll-a, turbidity, CDOM).

A properly calibrated model can be used to directly evaluate the sensitivity of individual water quality parameters as well as the combination of parameters that are affecting  $K_d$  (see Figure 10 in Gallegos 2001 and Figures 6 and 7 in Kenworthy et al. 2013) and ultimately influencing the depth distribution and abundance of eelgrass. A bio-optical model recently calibrated in Massachusetts (Kenworthy et al. 2013) could be easily transferred for application to existing and newly collected optical water quality data in the Great Bay estuary with a minor amount of effort to calibrate the model. This model could be used to quantitatively calculate eelgrass restoration depths in each of the designated zones of the Great Bay estuary.

## RECKHOW RESPONSE

My analysis indicates that the available NH DES data provide a weak basis for setting TN criteria for the Great Bay Estuary. If you are making decisions that have substantial economic and societal consequences, then you want to be confident in your decision. I think that too often we spend too little on planning that informs decisions that have major consequences. To remedy this, I recommend that NH DES invest wisely in future water quality monitoring, assessment, and modeling.

I can go on at length as to how you might do this, but in brief, you first need to establish a water quality monitoring program that is not based on convenience sampling, but rather is focused on the major uncertainties, given your objectives to set numerical nitrogen criteria. While to some degree we know the answers, the key questions remain: (1) what are the designated uses that you are trying to protect? (2) What criteria are the best measurable indicators of attainment of the designated uses? (3) Over what space/time scales must you measure these criteria to achieve an acceptable error level for the determination of attainment/nonattainment? Answers to these questions, perhaps utilizing a water quality model, should provide the basis for a multi-year monitoring program that should provide more confidence in your decision on TN criteria.



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State of Minnesota  
Minnesota Pollution Control Agency

In the Matter of Proposed  
Amendments To Minnesota Rules  
Chapters 7050 and 7053 for Rule  
Amendments Governing Water  
Quality Standards- River  
Eutrophication, Total Suspended  
Solids and Minor Corrections.  
OAH Docket # 60-2200-30791,  
Revisor ID # 4104.

Staff Information for Reopened  
Administrative Record

March 28, 2014

MPCA Information for Reopened Administrative Record.

As stated in the Order reopening the administrative record, Minnesota Law requires an agency engaged in rulemaking to submit an additional notice plan to the Office of Administrative Hearings (OAH) for approval. Minnesota law also requires agencies to provide a copy of the proposed rule to the commissioner of agriculture in accordance with the conditions in Minn. Stat. § 14.111 if the proposed rule will affect farming operations.

*14.111 FARMING OPERATIONS.*

*Before an agency adopts or repeals rules that affect farming operations, the agency must provide a copy of the proposed rule change to the commissioner of agriculture, no later than 30 days prior to publication of the proposed rule in the State Register.*

*A rule may not be invalidated for failure to comply with this section if an agency has made a good faith effort to comply.*

This memorandum provides information on the Minnesota Pollution Control Agency's (MPCA) notice to the Commissioner of Agriculture during the rulemaking process for proposed amendments to Minn. Rules chs. 7050 and 7053. As detailed in this memorandum, the MPCA provided actual notice to the Commissioner of Agriculture at least 30 days in advance of publishing the proposed rules in the *State Register*.<sup>1</sup> In addition, the Commissioner of Agriculture reviewed the proposed rules and decided not to comment on the proposed rules.<sup>2</sup> This memorandum also provides information on MPCA's compliance with the additional notice plan submitted to the OAH.

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<sup>1</sup> Hearing Exhibit HE-5b: Notice of Hearing published in *Minnesota State Register*, Monday, November 18, 2013.

<sup>2</sup> Hearing Exhibit HE-8-25: March 27, 2014, letter to Honorable James E. LaFave from Matthew Wohlman, Assistant Commissioner, Minnesota Department of Agriculture (referred to herein as "March 27, 2014, MDA letter").

**A. The MPCA Provided Actual Notice of the Proposed Rulemaking to the Commissioner of Agriculture More Than 30 Days Prior to Public Notice of the Rule.**

The MPCA provided actual notice of the proposed rule to the Commissioner of Agriculture more than 30 days prior to the publication on November 18, 2013, of the proposed rule in the *State Register* and the Commissioner of Agriculture acted on the actual notice received.

- The Commissioner of Agriculture has staff assigned to monitor proposed MPCA water quality rules.<sup>3</sup> These staff are delegated responsibility for tracking and participating in rule development stakeholder meetings on the proposed amendments to Minn. Rules ch. 7050 and 7053. In this case, Mr. Robert Sip, State Policy Analyst for the Minnesota Department of Agriculture (MDA) in the Pesticide and Fertilizer Management Division was the Commissioner's delegate for the proposed rulemaking.
- As part of his duties, Mr. Sip received notices on the proposed rule amendments through the GovDelivery message service from at least December 27, 2011, including a message on June 7, 2013, which provided an electronic link to a draft of the proposed rule amendments.<sup>4</sup> A copy of the June 7, 2013, GovDelivery message is included as proposed Hearing Exhibit HE-18.
- Mr. Sip met regularly with MDA senior management, including representatives from the MDA commissioner's office, to discuss pending rulemaking activities. The proposed amendments to Minn. Rules ch. 7050 and 7053 were discussed at these meetings and the MDA decided not to comment on the proposed amendments.<sup>5</sup>
- In addition to Mr. Sip, MPCA sent rule notices to at least 8 other MDA staff through the GovDelivery message service.<sup>6</sup>

The intent of Minn. Stat. § 14.111 is to provide notice to the Commissioner of Agriculture with sufficient time and specificity to provide an opportunity for review and comment on proposed rule changes that may affect farming operations. MPCA provided actual notice to the Commissioner of Agriculture that met the spirit and intent of the notice requirement in Minn. Stat. § 14.111.

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<sup>3</sup> March 27, 2014, MDA letter. See also, Proposed Exhibit HE-17: Affidavit of Jean Coleman.

<sup>4</sup> Id. See also, Proposed Hearing Exhibit HE-16: Affidavit of Carol Nankivel. MPCA sent the following notices to Mr. Sip through GovDelivery message service:

- Notice of Request for Comments (3rd) 6/11/12 (Hearing Exhibit HE-1c)
- Notice of Water Quality Standards Activities 8/20/12
- Notice of Availability of pre-proposal draft rule language 6/7/13
- Notice of Hearing 11/18/13 (Hearing Exhibit HE-5a)
- Notice of Extended Rebuttal Period 2/13/14
- Notice of Re-opened Comment period 3/26/14

<sup>5</sup> March 27, 2014, MDA letter. See also, Proposed Exhibit HE-17: Affidavit of Jean Coleman.

<sup>6</sup> See Proposed Hearing Exhibit HE-16: Affidavit of Carol Nankivel.

## **B. The MPCA Complied With Its Approved Additional Notice Plan**

Notwithstanding the fact that the MPCA provided the Commissioner of Agriculture with multiple notices concerning the proposed rulemaking and with a draft of the rule more than 30 days prior to public notice, MPCA also complied with its approved Additional Notice Plan (Plan). The MPCA submitted its Plan to the Office of Administrative Hearings (OAH) on July 5, 2013. The Plan did not state that the MPCA would provide a copy of the rule to the Commissioner of Agriculture pursuant to Minn. Stat. § 14.111. Attachment 2 to the Plan included an excerpt from the Statement of Need and Reasonableness (SONAR)<sup>7</sup> addressing MPCA's proposed public notice activities. MPCA stated on page 5 of Attachment 2 to the Plan that it would provide notice to the Department of Agriculture at the time the proposed rules were published. Notice at the time proposed rules are published is not Minn. Stat. § 14.111 notice. The MPCA believes that its proposed Plan did not intend or provide for Minn. Stat. § 14.111.

The MPCA does not believe that the proposed rules affect farming operations and attempted to explain why in its SONAR and Attachment 2 to the Plan. The MPCA's SONAR, page 20, and Attachment 2, states:

*Minn. Stat. § 14.111 requires an agency to provide a copy of the proposed rule changes to the Commissioner of Agriculture no later than 30 days prior to publication of the proposed rule in the State Register if the proposed rules will affect farming operations. The amendments relating to eutrophication and total suspended solids may have a limited effect on agricultural practices, through programs that identify voluntary measures to implement Best Management Practices to reduce erosion and runoff. However, adoption of these standards does not create new regulatory authority affecting agricultural discharges. The MPCA will provide notice to the Department of Agriculture when the proposed rules are published.*

The MPCA intended to convey that the adoption of new or modified water quality standards does not result in an effect on farming operations because water quality standards, in and of themselves, do require any party to act. In addition, any effect on farming operations would be entirely voluntary. Through various MDA programs,<sup>8</sup> farming operations could voluntarily agree to implement Best Management Practices that, among other benefits, improve water quality. These programs, however, are not linked to water quality standards promulgated by MPCA. Voluntary practices undertaken by farming operations to improve water quality are not required to meet water quality standards. The MPCA concluded that because any potential effects of the proposed rule on farming operations were limited to voluntary, indirect effects it would not provide notice to the Commissioner of Agriculture pursuant to Minn. Stat. 14.111. The phrase "may have a limited effect on farming operations" could be

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<sup>7</sup> Hearing Exhibit HE-3.

<sup>8</sup> See MDA water protection programs at <http://www.mda.state.mn.us/protecting/waterprotection.aspx>, and MDA Pesticide and Fertilizer Management Division programs summarized at <http://www.mda.state.mn.us/about/divisions/pfmd.aspx>.

read to mean that the proposed rule would have a mandatory, direct effect on farming operations, however limited, but MPCA did not intend to convey that meaning.

**C. Any Error Concerning Notice to the Commissioner of Agriculture is Harmless Error.**

Minn. Stat. § 14.15 gives the administrative law judge the discretion to disregard any error or defect in a rule proceeding upon a finding that a procedural requirement imposed by law “(1) did not deprive any person or entity of an opportunity to participate meaningfully in the rulemaking process; or (2) that the agency has taken corrective action to cure the error or defect so that the failure did not deprive any person or entity of an opportunity to participate meaningfully in the rulemaking process.” MPCA’s actions did not deprive the commissioner of agriculture of an opportunity to participate meaningfully in the rulemaking process.

In 1999, the OAH considered the question of harmless error in a rule hearing where the Environmental Quality Board (EQB) failed to provide Minn. Stat. § 14.111 separate notice to the Commissioner of Agriculture prior to publication of the proposed rule in the *State Register*. The Administrative Law Judge decided that because the Commissioner of Agriculture sat on the EQB and staff from the Department of Agriculture were involved in drafting the rule, the Board’s failure to formally notify the Department of Agriculture of the proposed rule prior to publication was a harmless error.<sup>9</sup> Although the Commissioner of Agriculture and MDA staff were not involved in the same manner in this rulemaking, their involvement was similar enough to support a finding of harmless error. MPCA’s proposed Hearing Exhibit 16 demonstrates that the MPCA notified MDA staff delegated by the Commissioner of Agriculture to participate in MPCA rulemaking throughout the rule development process. The March 27, 2014, MDA letter shows that the Commissioner of Agriculture knew of the rule, had the necessary information to make a decision on whether to comment on the proposed rule and decided not to comment. As a result the error, if any, is harmless.

If the MPCA’s conclusion that the proposed rules do not affect farming operations because any potential effects are indirect and voluntary is error, the error is harmless.

**CONCLUSION**

The MPCA provided actual notice to the Commissioner of Agriculture more than 30 days prior to publication of the rule, although it was not Minn. Stat. § 14.111. The MPCA did not provide notice under Minn. Stat. § 14.111 because it reasonably concluded that the statute did not apply to this rule which has at most, only voluntary, indirect impacts on farming operations. As provided for in Minn. Stat. § 14.15, the proposed rule amendments should not be invalidated based on MPCA’s failure to provide the specific Minn. Stat. § 14.111 notice which resulted in harmless error.

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<sup>9</sup> Hearing Exhibit HE-19: Office of Administrative Hearings, IN THE MATTER OF THE PROPOSED AMENDMENTS TO RULES GOVERNING THE ENVIRONMENTAL REVIEW PROGRAM RELATING TO THE APPLICATION OF PROVISIONS ON CONNECTED ACTIONS TO ANIMAL FEEDLOTS, MINN. RULES, CHAPTER 4410, 1999 WL 194069 (Minn.Off.Admin.Hrgs.)

1999 WL 194069 (Minn.Off.Admin.Hrgs.)

Office of Administrative Hearings

State of Minnesota

IN THE MATTER OF THE PROPOSED AMENDMENTS TO RULES GOVERNING THE  
ENVIRONMENTAL REVIEW PROGRAM RELATING TO THE APPLICATION OF PROVISIONS  
ON CONNECTED ACTIONS TO ANIMAL FEEDLOTS, MINN. RULES, CHAPTER 4410

**\*1 Minnesota Environmental Quality Board**

6-2901-11995-1

March 1999

REPORT OF THE ADMINISTRATIVE LAW JUDGE

The above-entitled matter came on for hearing before Administrative Law Judge Allan W. Klein on January 21, 1999 in St. Paul; January 25 in North Mankato; January 26 in Morris; and February 4 with a video conference involving persons in St. Paul, Rochester, and Thief River Falls. At each of the locations, there was both an afternoon and an evening session, except for the first day in St. Paul, which was morning only. Each hearing session continued until all interested persons, groups and associations had an opportunity to be heard concerning the proposed rules.

This Report is part of a rulemaking proceeding held pursuant to Minn. Stat. §§ 14.31 to 14.20 (1998), to hear public comment, to determine whether the Minnesota Environmental Quality Board (hereinafter "the Board") has fulfilled all relevant substantive and procedural requirements of law applicable to the adoption of rules, whether the proposed rules are needed and reasonable, and whether or not modifications to the rules proposed by the Board after initial publication are impermissible, substantial changes.

Alan Mitchell, Assistant Attorney General, 445 Minnesota Street, 900 NCL Tower, St. Paul, Minnesota 55101, appeared on behalf of the Board. Greg Downing, Environmental Review Coordinator, Minnesota Environmental Quality Board, 658 Cedar Street, St. Paul, Minnesota 55155, presented the Board's position and answered questions at each of the hearings.

The record remained open for the submission of written comments until February 19, 1999. During the initial comment period, the ALJ received numerous written comments from interested persons and the Board. Pursuant to Minn. Stat. § 14.15, subd. 1, five working days were then allowed for the filing of responsive comments. During the responsive comment period, interested persons replied to the Board's comments, and the Board also replied to written comments. The record closed for all purposes on February 26, 1999.

**NOTICE**

The Board must wait at least five working days before taking any final action on the rules; during that period, this Report must be made available to all interested persons upon request.

Pursuant to the provisions of Minn. Stat. § 14.15, subd. 3 and 4, this Report has been submitted to the Chief Administrative Law Judge for his approval. If the Chief Administrative Law Judge approves the adverse findings of this Report, he will advise the Board of actions which will correct the defects and the Board may not adopt the rule until the Chief Administrative Law Judge determines that the defects have been corrected. However, in those instances where the Chief Administrative Law Judge identifies defects which relate to the issues of need or reasonableness, the Board may either adopt the Chief Administrative Law Judge's suggested actions to cure the defects or, in the alternative, if the Board does not elect to adopt the suggested actions, it

must submit the proposed rule to the Legislative Coordinating Commission for the Commission's advice and comment.

\*2 If the Board elects to adopt the actions suggested by the Chief Administrative Law Judge and makes no other changes and the Chief Administrative Law Judge determines that the defects have been corrected, then the Board may proceed to adopt the rule and submit it to the Revisor of Statutes for a review of the form. If the Board makes changes in the rule other than those suggested by the Administrative Law Judge and the Chief Administrative Law Judge, then it shall submit the rule, with the complete record, to the Chief Administrative Law Judge for a review of the changes before adopting it and submitting it to the Revisor of Statutes.

When the Board files the rule with the Secretary of State, it shall give notice on the day of filing to all persons who requested that they be informed of the filing.

Based upon all the testimony, exhibits and written comments, the Administrative Law Judge makes the following:

### **FINDINGS OF FACT**

#### **Procedural Requirements**

1. On July 13, 1998, the Board published a request for comments concerning these rules at 23 State Register 211. Ex. 1.
2. On July 16 and 17, 1998, the Board mailed a request for comments to its rulemaking list, its mailing list for notice of board meetings, its list for notice of activities relating to the Generic EIS on Animal Agriculture, and to the Department of Agriculture's Feedlot and Manure Management Advisory Committee. Ex. 2.
3. On October 26, 1998, the Board authorized the issuance of a Notice of Intent to Adopt Rules after Holding a Public Hearing. This resolution was signed by Chair Rodney W. Sando and Board Member Gene Hugoson. Ex. 3.
4. On November 18, 1998, the Revisor of Statutes certified a copy of the proposed rule amendments. Ex. 4.
5. On November 23, 1998, Chair Sando executed the Board's Statement of Need and Reasonableness.
6. On November 25, 1998, the Board filed a copy of a Proposed Notice of Hearing, a copy of the proposed rules, and the Statement of Need and Reasonableness with the Office of Administrative Hearings. On that same date, the Board requested the scheduling of hearings in St. Paul, North Mankato, and Morris. Finally, on that date, the Board requested prior approval of the additional notice plan described on pages 9 and 10 of the Statement of Need and Reasonableness.
7. On December 4, 1998, the Board was given oral approval for its additional notice plan, and by letter dated December 8, 1998, the Board was given written approval.
8. On December 15, 1998, the Board filed a copy of the Statement of Need and Reasonableness with the Legislative Coordinating Commission. Ex. 6.
9. On December 21, 1998, the Board published the Notice of Hearing in the State Register at 23 State Register 1412. This notice announced the hearings in St. Paul, North Mankato, and Morris. It also indicated that additional days of hearing would be scheduled if necessary. Ex. 7.
10. On December 18, 1998, the Board mailed a copy of the Notice of Hearing and the proposed rules to all persons on its statutory rulemaking list, to all persons who submitted comments in response to the request for comments, and to all persons (roughly 1300) on its mailing list for the Generic Environmental Impact Statement



on Animal Agriculture. In addition, on that date the Board also mailed to roughly 24 state legislators involved in legislation affecting the Board's rulemaking authority and special legislation requiring that this particular hearing be held. Ex. 9 and 11.

\*3 11. On December 28, 1998, the Board published a copy of the Notice for Hearing at 22 EQB Monitor 39. Ex. 10.

12. Prior to the start of the public hearings, the Board decided to add an additional hearing date to provide an easier opportunity for persons in the southeast and northwestern portions of the state to participate in the hearing process. On January 19 and 20, 1999, the Board mailed a Notice of Additional Hearing to its statutory rulemaking list, all persons who submitted comments in response to the request for comments, and to those persons on the Board's mailing list for the Generic EIS on Animal Agriculture who had mailing addresses in the south central, southeast, north central, and northwest portions of the state. This notice announced the February 4 video hearing sessions involving sites in St. Paul, Rochester, and Thief River Falls. Ex. 12.

13. On January 21, at the start of the public hearings, the Board introduced the above-numerated documents into the record, as well as introducing copies of public comments received up to January 20 (Ex. 13); a copy of the special legislation requiring this rulemaking (Ex. 14); as well as a number of background exhibits describing animal feedlots, connected actions, and the environmental review process. The Board also filed a Certificate of Mailing List Completeness as of December 18, 1998. Ex. 18.

14. On February 1, 1999, the Rochester Office of the Minnesota Pollution Control Agency issued a press release, reminding persons of the February 4 video conference.

15. On February 19, 1999, the Board filed comments in response to the testimony and written materials which had been supplied by the public and by other agencies during the hearing process. In response to comments, the Board proposed a number of modifications to its original proposals.

16. On February 26, 1999, the Board filed an additional responsive comment, which contained two additional modifications, both in response to comments which had been filed by the MPCA staff. Finally, on February 26, the Board filed a final response to comments from the Turkey Store Company which had been filed the previous day.

All of the above documents have been available for inspection at the Office of Administrative Hearings from the date of filing.

### **Standards of Review**

17. In a rulemaking proceeding, an administrative law judge must determine whether the agency has established the need for and reasonableness of the proposed rule by an affirmative presentation of facts.<sup>1</sup> An agency need not always support a rule with adjudicative or trial-type facts. It may rely on what are called "legislative facts" - that is, general facts concerning questions of common sense, policy, and discretion. The agency may also rely on interpretations of statutes and on stated policy preferences.<sup>2</sup> Here, the Board prepared a SONAR setting out a number of facts, statutory interpretations, and policy preferences to support the proposed rules. It also supplemented information in the SONAR with information presented both at the hearing and in written comments and responses placed in the record after the hearing.

\*4 18. Inquiry into whether a rule is reasonable focuses on whether the rulemaking record establishes that it has a rational basis, as opposed to being arbitrary. Minnesota law equates an unreasonable rule with an arbitrary rule.<sup>3</sup> Agency action is arbitrary or unreasonable when it takes place without considering surrounding facts and circumstances or disregards them.<sup>4</sup> On the other hand, a rule is generally considered reasonable if it is rationally related to the end that the governing statute seeks to achieve.<sup>5</sup>

19. The Minnesota Supreme Court has defined an agency's burden in adopting rules as having to "explain on

what evidence it is relying and how the evidence connects rationally with the agency's choice of action to be taken.<sup>76</sup> An agency is entitled to make choices between different approaches as long as its choice is rational. Generally, it is not proper for an administrative law judge to determine which policy alternative he thinks would be the "best" approach, since making a judgment like that invades the policy-making discretion of the agency. Rather, the question for an administrative law judge is whether the agency's choice is one that a rational person could have made.<sup>7</sup>

20. In addition to ascertaining whether proposed rules are necessary and reasonable, an administrative law judge must make other decisions - namely, whether the agency complied with the rule adoption procedure; whether the rule grants undue discretion to the agency; whether the agency has statutory authority to adopt the rule; whether the rule is unconstitutional or illegal; whether the rule constitutes an undue delegation of authority to another; and whether the proposed language is not a rule.<sup>8</sup>

21. When an agency makes changes to proposed rules after it publishes them in the *State Register*, an administrative law judge must determine if the new language is substantially different from what the agency originally proposed.<sup>9</sup> The legislature has established standards for determining if the new language is substantially different.<sup>10</sup>

### **Nature of the Proposed Rules**

#### **Impact on Farming Operations**

22. Minn. Stat. § 14.111 imposes an additional notice requirement when rules are proposed that affect farming operations. The statute requires that the agency provide a copy of the proposed rule changes to the Commissioner of Agriculture at least 30 days prior to publication of the proposed rule in the State Register. In this particular case, the Board failed to provide separate notice to the Commissioner of Agriculture prior to publication in the State Register. However, as noted above, the Commissioner of Agriculture is a member of the EQB Board (*see* Finding 3), and staff from the Department of Agriculture were involved in drafting the rule. Transcript of January 21 hearing, at pp. 21-28 and letter dated January 5 from Sharon Clark, Acting Commissioner. In this letter, Acting Commissioner Clark states that the Department of Agriculture did have adequate advance notice of the rule and urged the Administrative Law Judge to treat the matter as a harmless error. The Administrative Law Judge finds that, under the circumstances noted above, the Board's failure to formally notify the Department of Agriculture of the proposed rule prior to publication is a harmless error.

#### **Statutory Authority**

\*5 23. Minnesota Statutes § 116D.04, subd. 2a(a) (1998) provides:

The board shall by rule establish categories of actions for which . . . environmental assessment worksheets shall be prepared as well as categories of actions for which no environmental review is required under this section.

This grants the EQB the authority to define which actions will or will not trigger mandatory environmental review via an environmental assessment worksheet. The EQB properly invoked Minn. Stat. 116D.04 as a source of its rulemaking authority. *See* SONAR p. 2.

24. During the 1998 session, the Minnesota legislature enacted the following directive:

The environmental quality board, in consultation with the pollution control agency, shall study and adopt rules pursuant to Minnesota Statutes, chapter 14, to revise and clarify Minnesota Rules, part 4410.1000, subpart 4, as it applies to connected actions on animal feedlots and the need for environmental review.

Laws of Minn. 1998, ch. 401, § 54.

25. Opponents of the proposed amendments challenged the authority of the EQB to eliminate the connected actions provision. Opponents view the language of the Act (directing the EQB to "revise and clarify") as proof

of the legislature's intent that the concept of connected actions to environmental review of feedlots *not* be eliminated. They reason that elimination of connected actions is beyond the authority of the EQB because to do so is beyond legislative intent. *See* Transcript vol. 3A, p. 40. The Administrative Law Judge finds their reading of the Act to be too strained. The Act does not preclude elimination of the concept of connected action. Moreover, the authority of the Board granted by Minn. Stat. §116D.04 is broader than that provided by the 1998 Act. The EQB has the authority to specify which categories of actions require an EAW. The proposed rule revises the categories of actions that require an EAW. It is concluded that the EQB is acting within its authority to propose the elimination of connected actions and to create new categories of actions that require EAWs.

### **Cost and Alternative Assessments in SONAR**

26. Minn. Stat. § 14.131 provides that state agencies proposing rules must identify classes of persons affected by the rule, including those incurring costs and those reaping benefits; the probable effect upon state agencies and state revenues; whether less costly or intrusive means exist for achieving the rule's goals; what alternatives were considered and the reasons why any such alternatives were not chosen; the cost that will be incurred complying with the rule; and differences between the proposed rules and existing federal regulations.

27. In the SONAR, the Board addressed each of these requirements.<sup>11</sup> The Administrative Law Judge finds that the Board has complied with the requirements of the statute.

### **Performance-Based Regulation**

28. Minn. Stat. § 14.002 directs all agencies, whenever feasible, to develop rules that emphasize superior achievement in meeting the agencies' regulatory objectives and a maximum flexibility for the regulated public in meeting those goals. It also requires agencies to describe in the SONAR how they considered this policy. The Board stated in its SONAR that it did not believe the statute applied to these rules because they did not relate to a "regulatory program".

\*6 29. The Administrative Law Judge disagrees. The setting of precise thresholds, distances and other specifics, which is done in these rules, is the type of rulemaking which the legislature intended to address by the statute. However, in this case the record does contain numerous suggestions from the public for changes to the rule, including changes that offer increased flexibility in meeting the underlying program goals. The public has had a full opportunity to address these issues. The Administrative Law Judge finds the Board's error to be a harmless error.

### **History of the Proposed Rule**

30. The use of multisite animal feedlots as a method of producing farm animals is becoming more common, especially for raising hogs. *See* SONAR, p. 3. In the multisite production method for hogs, the animals are born at one site, and then transported one or more times to other sites to be raised to an appropriate body weight before slaughter. *See* Exhibit 16. The individual sites may vary substantially in distance from one another. Regardless of distance or size, under current rule, the individual sites of a multisite project are often treated as a "connected action" under Minn. R. 4410.0200, subp. 9b. *See* Transcript vol. 1A, p. 21 and Exhibit No. 20, *Pope County Mothers and Others Concerned for Health v. Minn. Pollution Control Agency*, Pope County District Court File No. C1-98-76 dated September 15, 1998. The issue of whether it is appropriate to apply the concept of "connected actions" to determine if multisite animal feedlots should be subject to environmental review is in dispute. *See* SONAR, p. 3. The Minnesota legislature considered this issue in 1998, but did not change existing law. Instead, it directed the EQB to "revise and clarify" the application of the concept of connected actions to environmental review of animal feedlots.

31. In response, the EQB solicited proposals for alternative ways to apply the concept of connected actions to feedlots. *See* SONAR, pp. 1-2; Transcript vol. 1A, p. 23. Some commenters suggested only repealing or retaining the connected actions concept. *See* Transcript vol. 1A, p. 24. Others suggested the repeal of connected actions and use of animal density per unit of land area as an alternative. The EQB considered these views and

formulated five options; none was “strongly supported.” The EQB convened a stakeholders group to solicit additional ideas. The proposed rules resulted from proposals made at the stakeholders’ meetings. However, there was no vote or consensus position which was supported by all of the participating stakeholders. *See* Transcript vol. 1A, p. 25; SONAR, p. 2. Some of the stakeholders and other people that commented on the proposal were opposed to removing the connected actions without having some kind of compensating lowering of thresholds for mandatory EAWs. That “compromise” was the genesis of these proposals.

#### **Related Proceedings: The GEIS and the MPCA Ch. 7020 Rules**

\*7 32. The timing of this EQB rulemaking proceeding was dictated by the legislative directive noted in Finding 24 above. In order to comply with the legislative schedule, this rulemaking had to be conducted at this time. However, there are two other proceedings which relate to feedlots and animal agriculture that may affect the content of these rules. First, the MPCA is about to propose a wide-sweeping update of its feedlot rules, Minn. Rules Ch. 7020. Public hearings for the MPCA project were tentatively scheduled for the spring of 1999, but have now been postponed until June. While the precise details of the MPCA’s proposed amendments are not yet public, MPCA (and others) did submit comments suggesting the likely content of some of the rules particularly pertinent to these EQB rules. (*See* letter dated February 19 from Lisa Thorvig, Acting Commissioner, and draft rules submitted by MCEA). Secondly, the EQB is in the process of preparing a generic EIS on animal agriculture, including feedlots. (SONAR, p. 9). This document is expected to provide new data on a number of the issues raised by these rules. The generic EIS has been scoped, but it is not expected to be finalized until 2001. A number of commentators suggested that this EQB rulemaking effort was poorly timed, because (1) the GEIS was expected to generate data that would assist with the decisions here and because (2) the MPCA rules were far more comprehensive than these rules, and it made no sense to proceed with this partial set now until the status of the MPCA rules was finalized, so that there would be a minimum of conflict and confusion.

33. In addition to those two specific actions, this is a time of increasing scrutiny and discovery of the environmental impacts of large-scale feedlots. For example, it was in May of 1998 that Greg Pratt of the MPCA released his study of cumulative impacts from feedlot air emissions. Ex. 23. The *Hancock Pro-Pork* decision was released in September of 1988. Ex. 20. The MPCA issued its Guidance Document on Cumulative Effects of Feedlot Air Emissions in January of 1999. Ex. 36. As we learn more, we can write “better” rules, in the sense that we can more precisely target the problems to be avoided and the best solutions for them. Any efforts at this time must be viewed as only temporary solutions, which ought to be re-examined within a few years.

#### **Rule by Rule Analysis**

##### **Connected Actions**

34. Multiple projects that are “connected actions” must be considered in total when determining the need for an EAW, preparing the EAW, and determining the need for an EIS. They must be considered in total when determining whether various thresholds have been met, thus triggering various types of environmental review.

35. Connected actions with respect to environmental review are defined in Minn. Rule 4410.0200, subp. 9(b): Two projects are “connected actions” if a responsible governmental unit determines they are related in any of the following ways:

\*8 A. one project would directly induce the other; B. one project is a prerequisite for the other; or

C. neither project is justified by itself.

36. The proposed rule eliminates the application of connected actions provision to determine whether proposed multisite animal feedlots must prepare an EAW.

37. Proponents and opponents of the proposed rules attacked the reasonableness of either retaining or

eliminating the connected actions provision.

38. Opponents of removing the “connected actions” provision expressed concern about potential or actual environmental effects of multisite feedlots on water and air quality. In their view, pollutants discharged from several individual feedlots *within some proximity* have cumulative effects on air and water. Many believed in the general need to assess potential cumulative effects on water and air. Commentors felt that there should be some mechanism to trigger mandatory environmental review of related projects to assess cumulative effects. They desired to retain the connected action provision in order to assess these cumulative efforts.

39. The cumulative effects of feedlot runoff on groundwater pollution may be significant. *See* Letter from Minnesota Project, p. 2 (Feb. 11, 1999). The cumulative effects of excess nitrate and phosphorus on soil and water is a major concern. *Id.*

40. Cumulative effects on air quality from volatile chemicals released from several individual animal feedlots may be significant. Hog facilities, for example, release hydrogen sulfide (H<sub>2</sub>S) and ammonia (NH<sub>3</sub>) gas into the surrounding air. The recent MPCA modeling study finds that heightened concentrations of these gases may result from the cumulative effect of several individual hog facilities in close proximity to one another. Ex. 23. The cumulative effects on air H<sub>2</sub>S concentrations may be apparent for up to 4.9 miles downwind from sources with high emissions. *See id.* The effect of NH<sub>3</sub> is evident up to 1.6 miles downwind from such sources. Thus cumulative effects on air quality may arise from closely situated, yet geographically distinct feedlots. Of course, cumulative air effects have nothing to do with any economic relationship between feedlots.

41. The Minnesota Pollution Control Agency is now requiring air emissions analysis for all EAWs for an area 5.5 miles around a proposed project. If the average AU density within that area exceeds 0.25 AU per acre, then cumulative air emission modeling using a sophisticated model is now required. Ex. 36. However, it is unknown at this time whether the MPCA, in the absence of an EAW, intends to require any sort of air quality modeling as part of its permit process under its new rules. *See* MCEA letter of February 19.

42. Several commentors believed that application of connected actions also served a useful purpose in simply identifying for the public projects which have multiple sites and share common owners. Disclosure to the public of a proposed project before it is constructed is another important function of the EAW. *See, e.g.,* SONAR at p. 3. The EAW process allows public inquiry into the project while still in the proposal stage. This is important to correcting errors in information and discovering problems of environmental importance that may lead to changes in the project or in the conditions of the feedlot permit. (*See, e.g.,* Transcript vol. 3A, pp. 32-33, 42, 46, 48, 76).

\*9 43. Opponents of eliminating connected actions for feedlots were concerned that feedlots currently subject to review as connected actions would no longer be reviewed under the proposed rule. Many individual hog facilities are built just below the 1000 AU threshold to avoid other permits. “There is no rational basis for eliminating the [connected action] rule and then not providing an approach which would capture the same facilities that are currently covered by an environmental review.” Transcript vol. 3A, p. 50.

44. Proponents of the rule change contend that the connected actions rule is itself irrational and thus its elimination is rational. *See* Transcript vol. 3A, p. 93, 3B, p. 18. The connected actions definition connects feedlots having economic relationships. These *economic* relationships may or may not reflect a relevant *environmental* relationship having potential for cumulative harm. *See* Letter from The Turkey Store, p. 1 (February 25, 1999); Exhibit No. 32, Comments of the Turkey Store, pp. 6-7. A connected action may reflect an economic relationship between geographically distant sites. At some distance, direct environmental relationships between the sites ceases to exist; at this point the connected actions relationship becomes meaningless for purposes of environmental review. In addition, the connected actions provision does not address environmental effects of neighboring feedlots that are not economically connected actions, yet are in close enough proximity to have potential cumulative environmental effects. Replacing connected actions with criteria that are more directly related to the potential for environmental harm from a project makes more sense. *See* Letter of Patricia Bloomgren, Director of Minn. Dept. of Health, p. 1 (February 26, 1999). The EQB agrees



generally with the foregoing analysis. *See* Letter of Gregg Downing, Environmental Quality Board (February 26, 1999).

45. So long as an EAW is required to be prepared, the cumulative effects of nearby feedlots will be addressed in the preparation of an EAW regardless of any economic relationship (*See* MPCA Guidance, Ex. 36). Connected actions is not a prerequisite for addressing cumulative effects.

46. Many livestock producers favored eliminating connected actions. Preparation of EAWs are bound to add unwanted costs to a feedlot proposal. Connected actions may penalize cooperative efforts of small farmers, by “connecting” their coordinated efforts to the point that an EAW is required. *See* Transcript vol. 4B at p. 26.

47. The proposed rules retain the phased action provision.<sup>12</sup> Individual feedlots that expand in stages are still covered. *See, e.g.,* Letter of John McIntosh regarding Metro Dairy, a phased and connected action.

48. Sometimes, the current connected actions provision identifies multiple sites that should be reviewed together because they pose cumulative environmental effects. However, at other times connected actions identifies sites that pose no cumulative environmental effects. Thus, the current connected actions provision is found to be a seriously imprecise method of determining whether the potential for cumulative environmental harms exist. The Administrative Law Judge finds that the Board has justified the need for, and reasonableness of, elimination of connected actions and its replacement by other criteria that more directly address the potential for environmental harm.

Lowering size threshold of a facility for triggering mandatory EAW from 2000 to 1000 animal units where the facility is not in a “sensitive area.”

\*10 49. The current rule requires an EAW for a construction or expansion of a proposed feedlot greater than 2000 AU<sup>13</sup> in size.

50. The proposed rule requires an EAW prior to construction or expansion of a feedlot greater than 1000 AU in size. The threshold applies to facility whether it is a confinement or nonconfinement type.

51. Farmers, agribusiness representatives and local public officials expressed concerns that lowering the threshold will make preparation of EAWs mandatory for more farmers. Their concerns were: 1) perceived high cost of EAW preparation; 2) lengthy time of preparation of EAWs, leading to costly delays in construction; and 3) administrative “logjams” at MPCA, leading to delays in completion of EAW and permitting decisions.

52. Some commentors suggested that a threshold of 500 to 750 AU is more appropriate than a threshold of 1000 AU. This view was based the observation of high concentrations in air pollutants by a few feedlots of that size. MCEA’s February 19 letter cited Ex. 22 for the proposition that of 24 facilities found to have violated the hydrogen sulfide standard during 1998 monitoring, eight were below 1000 AU. The single highest exceedance was from a facility with only 360 AUs.

53. Decreasing the threshold was also criticized on the ground that the threshold for permits for NPDES is 1000 AU. Since NPDES permits require “greater site specific environmental controls,” requiring an EAW was seen as unnecessary. *See* Letter of Gene Hugoson, Department of Agriculture (February 19, 1999). However, supporters of the 1000 AU threshold noted that it comports with the current requirements for various feedlot permits, such as the federal NPDES permit. *See* SONAR, p. 4; Letter of Patricia Bloomgren, Director of Minn. Dept. of Health, p. 1 (February 11, 1999); Letter from The Minnesota Project, p. 2 (February 11, 1999), and thus the cost of EAW preparation will not be as great because much of the material needed for the EAW will also be needed for the permit. Use of an animal population threshold is a rational test of the need for environmental review. Letter of Lisa Thorvig, MPCA (February 19, 1999).

54. Lowering the threshold will capture a few of the projects “lost” by the elimination of the connected actions provision. However, it will capture more projects which are not connected actions. It was part of the trade-off



for eliminating the connected actions provision. In general, it is fair to say that the more animal units, the greater the risk, *all other things (such as location) being equal*. There are other ways to assess risk, such as using the data from the Pratt study to set a distance guideline for EAW purposes. But AU numbers is also a reasonable measure for a threshold.

55. The Administrative Law Judge agrees with the MPCA that, ultimately, the amount of environmental review should depend upon a complex weighing of density of pollution sources of all kinds in an area, the proximity of residents and other sensitive receptors in the area, and other similar factors. But for now, the Administrative Law Judge finds that the Board has demonstrated a rational basis for its proposed 1000 AU threshold.

Increasing the threshold for exemption of feedlots constructed outside of sensitive areas from 100 to 300 AU.

\*11 56. The proposed amendments to Minn. Rule 4410.4600, subp. 19 raise the exemption threshold for construction of new animal feedlots from 100 to 300 AU. The threshold for expansion of existing feedlots remains at 100 AU. These exemptions apply only to feedlots located outside of enumerated sensitive areas. In addition, the modification of an existing feedlot where expansion is less than 300 AU is exempted if the modification is necessary to obtain a feedlot permit. If a project is exempt pursuant to this subpart, it is totally exempt from the entire program. The exemption applies to petitions as well; they are of no effect for exempt projects. Finally, the Board proposes to add a *de minimus* provision which would exempt the construction or expansion of a feedlot with a resulting capacity of less than 50 AU, regardless of location.

57. The proposed changes were generally favored. Matching environmental review thresholds with permitting thresholds makes sense. The 300 AU threshold is currently a proposed permitting threshold in the MPCA's feedlot rule revision. *See* Letter of Lisa Thorvig, MPCA (February 19, 1999). Smaller feedlots are not considered have as much potential for significant environmental harm if sited outside of sensitive areas. *See* Letter of Patricia Bloomberg, Director of Minn. Dept. of Health, p. 3 (February 11, 1999). This change focuses limited staff time on environmental review for the larger feedlots that have the greatest potential for affecting air and water quality. Sufficient facts exist in the record to make the 300 AU threshold for exemptions reasonable.

58. A question was raised regarding the exemption of modification projects needed to obtain a feedlot permit. The question was whether that exemption was available for both sensitive and non-sensitive areas. The EQB staff indicated an intent that it apply to both. The Administrative Law Judge agrees that the wording of the subparagraph does not indicate any locational limitation, and thus the exemption is available anywhere.

Sensitive Areas

59. For construction or expansion in sensitive areas, the proposed rules have two main parts. Subpart 29 of 4410.4300 added additional facilities to the mandatory EAW list. Subpart 19 of 4410.4600 expands the number of facilities that were exempted from EAW requirements. Both changes are designed to better focus EAWs toward projects that have greater environmental risks.

60. In subpart 19, lines 14 through 18 added a new requirement for an EAW for *any* construction or expansion of a feedlot in certain sensitive locations. These are sensitive locations with respect to surface water or groundwater quality. Those sensitive locations are specifically listed and include:

- Shoreland
- Delineated floodplain
- State or federally designated wild and scenic river districts
- Minnesota River Project Riverbend area management district
- Mississippi Headwaters area management district

\*12 • Drinking Water Supply Management Area designated under Chapter 4720 of the State Health Department or

- Within 1000 feet of a known sinkhole

61. In the SONAR, EQB explained:

an EAW is required for any new construction or any expansion of a feedlot if it is situated in certain sensitive areas based on water quality concerns. All stakeholders consulted agreed that this revision was reasonable because feedlots in these areas clearly pose a potential threat to ground or surface waters. Although this threshold is low, it is unlikely to result in many EAWs because few producers will even attempt to build or expand feedlots in these recognized sensitive areas.

After the hearings, the Board proposed to modify this rule to allow smaller (300 and under) construction and expansion projects without requiring an EAW in every case. *See* Finding 78, below.

62. Some additional information on the regions included in the definitions of sensitive areas include:

<<square>> Shoreland -- means land located within the following distances from the ordinary high water elevation of public waters: (1) land within 1,000 feet from the normal high watermark of a lake, pond, or flowage; and (2) land within 300 feet of a river or stream or the landward side of a floodplain delineated by ordinance on the river or stream, whichever is greater. This is designated and regulated by the DNR.

<<square>> Delineated floodplain -- the land adjoining lakes and rivers which is covered by the “100 year” or “regional” flood. This flood is considered to be flood that has a one- percent chance of occurring in any given year. Typically governed by floodplain zoning ordinances.

<<square>> State or federally designated wild and scenic river districts - lands designated and subject to a plan for preservation developed by the DNR. It is an entire river or a segment of a river and adjacent lands that possess “outstanding scenic, recreational, natural, historical, scientific, or similar values”. The districts can include up to 320 acres of land per river mile on both sides of the river. The list of such rivers includes:

- Kettle River in Pine County
- Lower St. Croix from Taylor’s Falls to the Mississippi River
- Mississippi River from St. Cloud to Anoka
- North Fork Crow River in Meeker County
- Minnesota River from Lac Qui Parle dam to Franklin
- Rum River in Mille Lacs, Sherburne, Isanti, and Anoka Counties
- Cannon River from Faribault to the Mississippi River

<<square>> Minnesota River Project Riverbend area management district -- includes part of the counties of Renville, Redwood, Brown, Nicollet, Blue Earth, and Le Sueur. A board representing the counties is to develop and implement a comprehensive management plan for the preservation of the district.

<<square>> Mississippi Headwaters area management district -- area managed by a board consisting of member from the counties of Clearwater, Hubbard, Beltrami, Cass, Itasca, Aitkin, Crow Wing, and Morrison.

\*13 <<square>> Drinking Water Supply Management Area designated under Chapter 4720 of the State Health

Department relating to a recent program of the Department of Health designed to protect municipal and similar drinking water wells from contamination.

<<square>> Within 1,000 feet of a known sinkhole.

\* \* \*

These sensitive areas cover a significant portion of the state. The biggest sensitive areas are those located in 100-year flood plains<sup>14</sup> and those that contain sinkholes. From the comments, it is clear that these areas do contain a significant number of feedlots already that may seek to expand and are in farming communities that may attract new feedlot construction.

### **Karst Topography Areas**

63. Commentors on the subject of sensitive areas were mostly concerned with requirements to mandate EAWs for feedlots within 1,000 feet of a sinkhole. As several commentors pointed out, sinkholes can develop suddenly and unexpectedly. In Minnesota, there are at least three known cases where sinkholes have developed directly under existing sewage lagoons (*see* Finding 63, below). Other commentors pointed out that other karst features, such as near-surface caves, resurgent springs, disappearing streams, and karsted bedrock are as likely as sinkholes to lead to groundwater contamination. Other commentors pointed out that a problem with the existing proposal is that it requires feedlot operators to locate and self report sinkholes, which they may be reluctant to do.

64. Some southern Minnesota counties are dominated by karst geography. One commentator pointed out that in a survey of just two townships in Houston County there were 60 known sinkholes effecting 40 farms. Fillmore County has over 6,000 documented sinkholes, and the estimate is that the number should be closer to 10,000. There are 990 feedlots in Fillmore County and approximately 20 percent of them are within 1,000 feet of a known sinkhole. Rock County was estimated to have 535 sinkholes in 1984 and currently has approximately 732 feedlots.

65. As Dr. George Huppert, Professor of Geography and Earth Science at the University of Wisconsin-LaCrosse and chair of the department there testified:

Down here in southeast Minnesota, since 1974 there have been a collapse of three sewage lagoons: two at Altura, in 1974 and 1991, that's in Winona County; one in Lewiston in Winona County. I couldn't find a date on that, but it's fairly recent. And one in Bellechester, which is on the Goodhue-Wabasha County line, in 1992. These sinkhole - these lagoon collapses dumped literally millions of gallons of sewage, minimally-treated sewage into the groundwater system. Under the proposed rule of 1,000 feet setback to a sinkhole, all of these lagoons would have been approved, because on the maps around these sewage lagoons you will not find a sinkhole within a 1,000 feet. On the other hand, the reason for the collapse of these lagoons was the breaching and opening of a sinkhole beneath the lagoon (Tr. 4B, pp. 14-15).

\*14 66. Commentors such as the Minnesota Department of Health, Minnesota Department of Natural Resources, and Dr. Calvin Alexander, a Professor of Geology at the University of Minnesota and the state's expert on karst topography, all stated that other karst features are just as likely to lead to groundwater contamination as a sinkhole. The commentors recommended two alternatives: first, to require EAWs for any feedlot within a 1,000 feet of *any* karst feature including sinkholes, caves, resurgent springs, disappearing streams, karst windows, blind valleys, dry valleys, exposed bedrock and other karst features; or second, to use the county atlas maps and require EAWs for feedlots built in areas that have been mapped as being "high" or "moderate-high" probability of sinkhole development.

67. Commentors opposed to the requirement for EAWs in sensitive areas cited the costs and delays in obtaining an EAW as an unreasonable burden on small feedlot operators. They felt that the fact that counties such as Houston, Rock, and Fillmore have so many sinkholes, and so many feedlots, makes this an unfair and

unreasonable burden for the feedlot operators in their region.

68. In this karst region, the question of whether or not any given new or expanded facility has a significant potential to adversely affect the environment is truly a case-by-case question. The very first witness to testify at the first hearing session was the Houston County zoning administrator. He pointed out that the topography of portions of Houston County is such that it is entirely possible that a proposed feedlot within a thousand feet of a known sinkhole can be located, topographically, in such a way that it has no flowage to the sinkhole at all. Tr. 1A, pp. 40-41. Although he did not say so, the Administrative Law Judge believes that it is also possible to have a feedlot site located more than a thousand feet from a known sinkhole that does, in fact, have a direct hydrologic connection to groundwater near the sinkhole. In other words, the distance to a known sinkhole is no guarantee of groundwater protection (unless the distance chosen is very large, probably measured in miles, which is not reasonable). What is needed is a site-by-site evaluation. And that is what an EAW provides. But to avoid having to do an EAW on every site, the rule should separate out those with the potential for environmental harm from those without the potential. The persons and agencies who have done the greatest amount of study in this area universally suggest that the Board's proposal is inadequate. This includes Dr. Alexander (noted above), Dr. George Huppert, Chair of the Geography and Earth Science Department at the University of Wisconsin at LaCrosse (Tr. 4B, pp. 13-20 and letter dated January 24), the Minnesota Department of Health (letters of February 11 and February 26), and the Minnesota Department of Natural Resources (comments dated January 19). Each of them argues that in order to protect groundwater from contamination, what is needed is adequate depth of soil and slow percolation rates. They argue that while sinkholes are a visible and easily understood path for surface contamination to reach groundwater, they are not the only means. Instead, they are merely one indicia of karst geology.

\*15 69. In response to the comments, the EQB recommended against making any changes to the sinkhole language. They acknowledged that there were other factors to consider, such as the depth to groundwater or the existence of bedrock, but felt that the rule would be too difficult to draft and too uncertain to implement if all these factors were addressed in the rule.

70. The Administrative Law Judge finds that EQB's reason for including the requirement of EAWs within 1,000 feet of a sinkhole was to protect the groundwater of these regions. But, as was made clear by the comments, the current language fails in that goal. Requiring EAWs only for feedlots within 1,000 feet of a known sinkhole ignores the many other karst features that may directly lead to groundwater contamination. The EQB's reasoning that changing the language would be too difficult is not convincing. The use of the maps, although the best answer in the long run, is not feasible for all areas at this time. The maps are not available for all counties and their accuracy and timeliness may lead to other problems. The best alternative is to require an EAW for a feedlot within 1,000 feet of a known karst feature or locations with exposed bedrock. As recommended, the definition of a karst feature would include sinkholes, caves, resurgent springs, disappearing streams, karst windows, blind valleys, and dry valleys.

71. The proposed rule has not been shown to be reasonable. While it is simple, it is not a rational response to the problem. To cure this defect, the Board should adopt some combination of the map test and the list of karst features.

### **Wellhead Protection Areas**

72. Commentors were also concerned with the requirement that EAWs be prepared for projects in a "wellhead protection area designated under chapter 4720". The problem is that many of these areas have not yet been designated and so there is no certainty where or how extensive these areas might be.

73. EQB responded to this concern by adopting a portion of the Minnesota Department of Health's proposed solution, which was a change in the language to "drinking water supply management area delineated under chapter 4720". But similar problems arise with this language. As the Department of Health stated in their February 26 response, MDH has a ten-year goal of delineated all drinking water supply management areas. The process is not even half done yet. By only requiring EAWs for projects within those delineated protection areas,

the rule would ignore all of the ones that MDH has not delineated yet. MDH asked that the language include “for wells not yet delineated, a two mile radius for a community or nontransient noncommunity water supply well that the Minnesota Department of Health has determined is potentially vulnerable to contamination.” EQB responded by stating this language was “too unwieldy and will lead to disagreements and delays”. MDH replied that it has already faced this problem in connection with feedlots, underground storage tanks, and other contexts, and has worked out a procedure with MPCA to use the temporary two-mile radius for those wells which have not yet had their designated DWSMAs finalized. MDH staff are able to make reasoned judgments about the vulnerability of wells in undelineated areas because they have established criteria (Minn. Rule pt. 4720.5550, subp. 2) to guide them. MDH argues that since MPCA will likely be the RGU for feedlots in sensitive areas, there should be no problem with using the same process here.

**\*16** 74. The Administrative Law Judge finds that the EQB’s proposal, which would leave the undesignated wells without any protection, is unreasonable. This defect can be cured by adopting all of the language proposed by MDH in its letter of February 11, at page 2. If the Board feels uncomfortable with the discretion allowed by that language, it could add some limiting language referencing “the criteria contained in Minn. Rule pt. 4720.5550.”

#### **Definition of Expansion**

75. Several commentators pointed out the necessity to clarify the definition of “expansion”. EQB explained that expansion in case of all categories means an increase in whatever the parameter is used. In this case, expansion is measured with respect to the number of animal units. The Board intends to measure by expansion of permitted capacity, not just the addition of one animal unit. If the feedlot operator seeks to add AUs above the current permitted level, that is an expansion. The addition of AUs that does not exceed the facility permit capacity would not be considered an expansion.

76. Item B under subpart 19 allows modification without expansion of capacity of any feedlot of no more than 300 AUs if the modification is necessary to secure a Minnesota feedlot permit. This exemption was created to allow feedlot operators to make upgrades to their system, such as manure handling methods, that will allow them to come into compliance with the feedlot permit program. This exemption would apply whether the facility was located in a sensitive or non-sensitive area. Based on the revised language proposed by the EQB in their February 26 letter, this exemption would continue to apply even if there was an expansion that resulted in a facility with a capacity of less than 50 AUs. The Administrative Law Judge finds that the Board has justified both of these interpretations.

#### **Changes to the Proposed Rule**

77. Much of the concern over the EQB’s original proposals was in response to concerns about their impact on small farms. Many commentators noted the financial and time difficulties that the EAW could cause for construction and expansion of these facilities in areas such as the karst areas of southeastern Minnesota. And most commentators felt that the large, mostly commercial feedlot operations could absorb the burden of the EAW with less impact. EQB was receptive to these concerns and proposed several changes to the proposed language in their letters dated February 19 and 26.

78. One change to respond to the comments of those that want to protect small farms was to limit the *mandatory* EAW requirement in sensitive areas to construction of feedlot facilities of more than 300 AUs or expansion of an existing facility by no more than 100 AUs. As the EQB notes in their letter, this does not mean that small feedlots in sensitive areas are exempt from EAW review, only that it is not mandatory. An EAW could still be required by the county, PCA, or in response to a citizen petition.

**\*17** 79. EQB went a step further in their February 26 response by modifying Part 4410.4600, Exemption categories, Subpart 19 (A) to exempt, even in sensitive areas, construction or expansion of a feedlot with a resulting capacity of less than 50 AUs. This language was supported by the many of the comments from both individuals and agencies.

80. This change in language leads to the following breakdown for EAWs:

**EQB FINAL PROPOSAL<sup>15</sup>**

**CONSTRUCTION**

AUs	Not Sensitive Areas	Sensitive Areas
OVER 1001	Mandatory	Mandatory
301-1000	May Be Requested	Mandatory
UNDER 300	Exempt	May Be Requested
UNDER 50	Exempt	Exempt

**EXPANSION**

AUs	Not Sensitive Areas	Sensitive Areas
OVER 1001	Mandatory	Mandatory
301-1000	May Be Requested	Mandatory
100-300	May Be Requested	May Be Requested
50-99	Exempt	May Be Requested
UNDER 50	Exempt	Exempt

**Who Will Be the Responsible Governmental Unit?**

81. The EQB initially proposed that the PCA be the preparer of mandatory EAWs unless the county would issue the feedlot permit, in which case the county would be the RGU. This drew a few comments, particularly one from the MPCA. In its letter of February 19, the MPCA questioned whether it was a good idea for counties to be the RGUs, particularly in light of recent developments requiring air dispersion modeling of both the proposed facility and surrounding facilities when cumulative air impacts are at issue. This is the matter



discussed at Finding 41. The MCPA noted:

[T]he MPCA is currently working to develop tools and guidance to better assess the potential environmental impacts of feedlot operations, regardless of their size. As these tools and strategies are developed, the MPCA is planning to share that information with the counties that have delegated permitting authority, in order to provide them with the ability to conduct environmental review, as envisioned by this rule change. This effort, however, will take some time. As a result, the MPCA asks that the EQB consider “phasing in” the requirement for counties to take on the RGU designation for environmental review of feedlots for which they would issue a permit. (MPCA letter of February 19).

82. In response, the EQB noted that those county officials, including zoning and feedlot officers, who did comment during the hearing supported the idea of requiring fewer EAWs, but did not generally object to the concept of the county being the RGU responsible for preparation of the EAWs. The EQB agreed with the MPCA that some delay in transferring the RGU responsibility would be appropriate. The EQB recommended that an eighteen-month delay, to January 1, 2001, would be an appropriate time for the MCPA to develop and disseminate the necessary knowledge to assist counties in this task. Therefore, the EQB recommended that the language proposed for part 4410.4300, subp. 29, be amended to delay its application until January 1, 2001.

83. The Administrative Law Judge finds that this is a reasonable change. As noted earlier, recent developments will cause some EAWs to be more complicated to prepare than they have been in the past. It is appropriate that the agency with the greatest amount of staff expertise in air quality modeling, the MPCA, prepare guidance for others to follow. Delaying the transfer for 18 months is a reasonable way to accomplish that goal. This change does not result in a substantially different rule, and may be adopted.

**\*18** Based upon the foregoing Findings of Fact, the Administrative Law Judge makes the following:

### CONCLUSIONS

1. That the Environmental Quality Board gave proper notice of the hearing in this matter.
2. That the Board has fulfilled the procedural requirements of Minn. Stat. §§ 14.14, subds. 1, 1a, 1b and 14.14, subds. 2 and 2a, and all other procedural requirements of law or rule, except as noted at Findings 22 and 29, which are both harmless errors.
3. That the Board has demonstrated its statutory authority to adopt the proposed rules and has fulfilled all other substantive requirements of law or rule within the meaning of Minn. Stat. §§ 14.05, subd. 1, 14.15, subd. 3 and 14.50 (i) and (ii).
4. That the Board has documented the need for and reasonableness of its proposed rules with an affirmative presentation of facts in the record within the meaning of Minn. Stat. §§ 14.14, subd. 2 and 14.50 (iii), except as noted at Findings 71 and 74.
5. That the amendments and additions to the proposed rules which were suggested by the Board after publication of the proposed rules in the State Register do not result in rules which are substantially different from the proposed rules as published in the State Register within the meaning of Minn. Stat. §§ 14.05, subd. 2 and 14.15, subd. 3.
6. That the Administrative Law Judge has suggested action to correct the defects cited in Conclusion 4 as noted at Findings 71 and 74.
7. That due to Conclusions 2 and 4, this Report has been submitted to the Chief Administrative Law Judge for his approval pursuant to Minn. Stat. § 14.15, subd. 3 or 4.
8. That any Findings which might properly be termed Conclusions and any Conclusions which might properly

be termed Findings are hereby adopted as such.

9. That a finding or conclusion of need and reasonableness in regard to any particular rule subsection does not preclude and should not discourage the Board from further modification of the proposed rules based upon an examination of the public comments, provided that the rule finally adopted is based upon facts appearing in this rule hearing record.

Based upon the foregoing Conclusions, the Administrative Law Judge makes the following:

### RECOMMENDATION

IT IS HEREBY RECOMMENDED: that the proposed rules be adopted except where specifically otherwise noted above.

Dated this \_\_\_\_\_ day of March 1999.

Allan W. Klein  
Administrative Law Judge

### Footnotes

<sup>1</sup> Minn. Stat. § 14.14, subd. 2, and Minn. Rule 1400.2100.

<sup>2</sup> Manufactured Housing Institute v. Pettersen, 347 N.W.2d 238, 244 (Minn. 1984); Mammenga v. Department of Human Services, 442 N.W.2d 786 (Minn. 1989).

<sup>3</sup> In re Hanson, 275 N.W.2d 790 (Minn. 1978); Hurley v. Chaffee, 231 Minn. 362, 367, 43 N.W.2d 281, 284 (1950).

<sup>4</sup> Greenhill v. Bailey, 519 F.2d 5, 10 (8th Cir. 1975).

<sup>5</sup> Mammenga v. Department of Human Services, 442 N.W.2d 786, 789-90 (Minn. 1989); Broen Memorial Home v. Minnesota Department of Human Services, 364 N.W.2d 436, 444 (Minn. Ct. App. 1985).

<sup>6</sup> Manufactured Housing Institute, *supra*, 347 N.W.2d at 244.

<sup>7</sup> Federal Security Administrator v. Quaker Oats Company, 318 U.S. 2, 233 (1943).

<sup>8</sup> Minn. Rule 1400.2100.

<sup>9</sup> Minn. Stat. § 14.15, subd. 3.

<sup>10</sup> Minn. Stat. § 14.05, subd. 2.

<sup>11</sup> Ex. 7, pp. 4-6.

<sup>12</sup> Phased actions are two or more projects undertaken by the same proposer, reasonably close in time that will impact the same geographic area.

<sup>13</sup> Animal unit“ is a unit of measure used to compare differences in the production of animal manures that employs as a standard the amount of manure produced on a regular basis by a slaughter steer or heifer. Currently, the equivalents are:

- A. one mature dairy cow, 1.4 animal unit;
- B. one slaughter steer or heifer, 1.0 animal unit;
- C. one horse, 1.0 animal unit;
- D. one swine over 55 pounds, 0.4 animal unit;
- E. one duck, 0.2 animal unit;

F. one sheep, 0.1 animal unit;

G. one swine under 55 pounds, 0.05 animal unit;

H. one turkey, 0.018 animal unit;

I. one chicken, 0.01 animal unit.

For animals not listed in items A to I, the number of animal units is the average weight of the animal divided by 1,000 pounds. Minn Rule pt. 7020.0300, subp. 5, applied to EAWs through Minn. Rule pt. 4410. 0200, subp. 3. The MPCA may be considering changes to these numbers in its upcoming rulemaking proceeding.

<sup>14</sup> The draft MPCA rules would appear to prohibit the construction or expansion of any feedlot within a 100-year floodplain. However, the MPCA is also considering an exception that would allow new feedlots to be constructed within the Red River Valley floodplain if they are at least 1,000 feet from the ordinary high water mark. The EQB may want to consider a similar exception for EAWs.

<sup>15</sup> To minimize complexity, this chart does not include special provisions for modifications necessary to obtain a feedlot permit.

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1999 WL 194069 (Minn.Off.Admin.Hrgs.)

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End of Document

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## Nankivel, Carol (MPCA)

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**From:** Minnesota Pollution Control Agency <mpca@public.govdelivery.com>  
**Sent:** Friday, June 07, 2013 9:01 AM  
**To:** Nankivel, Carol (MPCA)  
**Subject:** Water Quality Standards Rulemaking– Pre-proposal Draft of Rule Amendments Update

Having trouble viewing this email? [View it as a Web page.](#)

You are subscribed to Water Quality Standards for Minnesota Pollution Control Agency. This information has recently been updated, and is now available.

### Minnesota Pollution Control Agency

#### Update on Water Quality Standards Revisions

You are receiving this notice because you registered to be notified of Minnesota Pollution Control Agency (MPCA) rulemaking activities affecting the State Water Quality Standards.


In the next few months the MPCA will be proposing a set of rule amendments that include:

- New standards addressing eutrophication (algae growth) of rivers, streams, Mississippi River Pools and Lake Pepin
- Total Suspended Solids (TSS) standards that will replace the existing turbidity standards
- Several technical corrections and clarifications to Minn. R. chs. 7050 and 7053

The MPCA expects to hold public hearings for these amendments later this year. Notice of the hearings and of the official comment period will be sent to you at that time. However, in order to provide you with additional review time and the opportunity to contact MPCA staff with questions or comments, the MPCA posted the following materials at [Planned Amendments to Water Quality Standards](#):

- 1) Pre-proposal draft of the amendments being considered.



2) Detailed technical support documents, which provide background on the draft amendments. The technical support documents for the proposed standards have been available for review at this site for several years, but Minnesota Nutrient Criteria Development for Rivers, which supports the proposed eutrophication standards for rivers, was revised in January 2013.


You are invited to review these materials in advance of the official comment period and to contact Carol Nankivel at 651-757-2597  or by e-mail; [carol.nankivel@state.mn.us](mailto:carol.nankivel@state.mn.us) with questions or for further information.

The MPCA's mission is to work with Minnesotans to protect and improve the environment and enhance human life. The MPCA is committed to developing rules through a transparent and open process that fulfills our mission and meets federal and state requirements. The MPCA asked for and received comments from interested parties throughout the development of the proposed amendments. Three formal Requests for Comment were published, public informational meetings held and the technical support documents have been available for review throughout the rule development process. Providing a pre-proposal draft of the amendments is another way the MPCA works with the public and interested parties to meet our mission.

**(Note: Comments received during this pre-proposal period are important and will be considered by staff, but they are not part of the official rule record. In order for comments to be considered as part of the rule record they must be submitted during the official comment period. You will receive notice of the official comment period at a later date.)**

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 [Minnesota Pollution Control Agency](#)   [ [Contact us](#) ] 

[Unsubscribe](#) • [Preferences](#) • [Help](#) • This email sent using GovDelivery (800-439-1420 )

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This email was sent to [carol.nankivel@state.mn.us](mailto:carol.nankivel@state.mn.us) using GovDelivery, on behalf of: Minnesota Pollution Control Agency  
520 Lafayette Road North · Saint Paul, MN 55155 · 1-800-439-1420

**Minnesota Pollution Control Agency**

**CERTIFICATE OF GIVING ADDITIONAL NOTICE UNDER THE ADDITIONAL NOTICE PLAN**

**Proposed Rules Relating to the Classification and Standards for Waters of the State, Minnesota Rules, chapter 7050, and Relating to Effluent Limits and Treatment Requirements for Discharges to Waters of the State, Minnesota Rules chapter 7053; Revisors ID # 4104; OAH # 60-2200-30791**

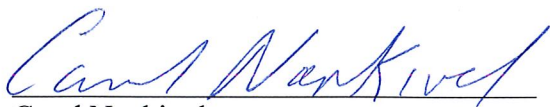
I certify that at St. Paul, Ramsey County, Minnesota, I gave notice according to:

- the Additional Notice Plan submitted by the Minnesota Pollution Control Agency (MPCA) on July 5, 2013 (including Attachments 1 to 3) and approved by the Office of Administrative Hearings (OAH) on July 15, 2013; and

-the revisions to the Additional Notice Plan submitted by the MPCA on September 18, 2013 and approved by OAH on October 2, 2013.

Specifically, I:

- Prior to the date of providing notice under Minn. Stat. §14.14, subd. 1a, I developed an extensive mailing list of parties requesting notice;
- On November 18, 2013 provided electronic notice to municipalities to meet the requirements of Minn. Stat. §115.44, subd. 7. The list of city administrators was obtained from the League of Minnesota Cities and was current and correct;
- On November 18, 2013 provided all required notifications identified in the MPCA's Additional Notice Plan approved by the Office of Administrative Hearings on July 15, 2013, including:
  - electronic Notice to interested parties as certified in the MPCA's Certificate of Mailing Notice;
  - electronic Notice to municipalities as required by Minn. Stat. § 115.44, subd. 7;
  - posting the Notice of Hearing, with links to the Statement of Need and Reasonableness (SONAR) and proposed rule language, on the MPCA's public notice website for the term of the public comment period;
  - posting the Notice of Hearing, SONAR and proposed rule language on an MPCA webpage established to provide information about the proposed amendments.



Carol Nankivel  
Minnesota Pollution Control  
Rule Coordinator



STATE OF MINNESOTA  
OFFICE OF ADMINISTRATIVE HEARINGS  
FOR MINNESOTA POLLUTION CONTROL AGENCY

In the Matter of Proposed Amendments To  
Minnesota Rules Chapters 7050 and 7053  
for Rule Amendments Governing Water  
Quality Standards-River Eutrophication,  
Total Suspended Solids and Minor  
Corrections

**AFFIDAVIT OF JEAN COLEMAN**

STATE OF MINNESOTA     )  
  ) ss.  
COUNTY OF RAMSEY     )

Jean Coleman, being duly sworn, testifies as follows:

1. I am Jean L. Coleman, staff attorney for the Minnesota Pollution Control Agency (MPCA). I have appeared for and on behalf of MPCA in the rule hearing for the above referenced OAH Docket.
2. As part of preparing the March 28, 2014, Staff Information for Reopened Administrative Record, I had cause to have a telephone conversation on March 26, 2014, with Mr. Daniel Stoddard, Assistant Director, Minnesota Department of Agriculture (MDA) Pesticide and Fertilizer Management Division.
3. The topic of my conversation with Mr. Stoddard was MDA's activities in tracking MPCA's rulemaking process for amendments to Minn. Rules chs. 7050 and 7053.
4. Mr. Stoddard informed me that the Commissioner of Agriculture has staff assigned to monitor proposed MPCA water quality rules; that these staff are delegated responsibility for tracking and participating in rule development stakeholder meetings; and that Mr. Robert Sip, State Policy Analyst for the Minnesota Department of Agriculture (MDA) in the Pesticide and

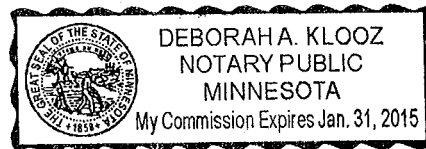
Fertilizer Management Division was delegated to participate in the rulemaking process for the proposed amendments to Minn. Rules ch. 7050 and 7053.

FURTHER AFFIANT SAYETH NOT.

  
Jean Coleman

Subscribed and sworn to before me on  
this 28<sup>th</sup> day of March, 2014.

  
NOTARY PUBLIC



STATE OF MINNESOTA  
OFFICE OF ADMINISTRATIVE HEARINGS  
FOR MINNESOTA POLLUTION CONTROL AGENCY

In the Matter of Proposed Amendments To  
Minnesota Rules Chapters 7050 and 7053  
for Rule Amendments Governing Water  
Quality Standards- River Eutrophication,  
Total Suspended Solids and Minor  
Corrections.

**AFFIDAVIT OF CAROL NANKIVEL**

STATE OF MINNESOTA    )  
  ) ss.  
COUNTY OF RAMSEY    )

Carol Nankivel, being duly sworn, testifies as follows:

1. I am Carol Nankivel, rule coordinator for the Minnesota Pollution Control Agency (MPCA), and I work in the Resource Management and Assistance Division of the MPCA.
2. As rule coordinator I have responsibility for handling the administrative proceedings aspects for the development of the rule in the above referenced OAH Docket.
3. As part of preparing the March 28, 2014, Staff Information for Reopened Administrative Record, I reviewed MPCA maintained records for each Govdelivery message service notice sent to document delivery. The records I reviewed included a list of addresses of persons who received Govdelivery message service notification for each of the following notices sent for this rulemaking.
  - Notice of Request for Comments (3rd) sent on 6/11/12
  - Notice of Water Quality Standards Activities sent on 8/20/12
  - Notice of Availability of pre-proposal draft rule language sent on 6/7/13
  - Notice of Hearing sent on 11/18/13
  - Notice of Extended Rebuttal Period sent on 2/11/14
  - Notice of Re-opened Comment period sent on 3/26/14

4. The full lists of notice addresses, including Mr. Sip's address, for each of the above notices, will be provided on request.

5. I verified the date on which Mr. Robert Sip, State Policy Analyst for the Minnesota Department of Agriculture (MDA), registered in the MPCA's Govdelivery system to receive notice of rulemaking relating to water quality standards. Mr. Sip registered in the MPCA's GovDelivery system on December 27, 2011, with the e-mail address rob.sip@state.mn.us.

6. I verified that MPCA sent GovDelivery notices on the following dates and Mr. Sip (rob.sip@state.mn.us) was on the GovDelivery list for each of the notices listed in item 4 of this Affidavit.

7. None of the notices to the e-mail address for Mr. Sip were returned as undeliverable.

8. I also verified that other MDA staff, in addition to Mr. Sip, received rule notices through the GovDelivery message service. The number of other MDA staff are noted in the following list.

- Notice of Request for Comments (3rd) sent on 6/11/12(sent to 8 additional MDA staff)
- Notice of Water Quality Standards Activities sent on 8/20/12 (sent to 9 additional MDA staff)
- Notice of Availability of pre-proposal draft rule language sent on 6/7/13 (sent to 10 additional MDA staff)
- Notice of Hearing sent on 11/18/13 (sent to 12 additional MDA staff)
- Notice of Extended Rebuttal Period sent on 2/11/14 (sent to 14 additional MDA staff)
- Notice of Re-opened Comment period sent on 3/26/14 (sent to 14 additional MDA staff)

9. The additional MDA staff that received rule notices through the GovDelivery message service were:

Annie.felix-gerth@state.mn.us

Christine.yaeger@state.mn.us

Dan.stodddard@state.mn.us

David.miller@state.mn.us

Gregg.regimbal@state.mn.us

Jeffrey.berg@state.mn.us

Jingrong.wang@state.mn.us

Joseph.zachmann@state.mn.us

Joshua.stamper@state.mn.us

Katie.rasmussen@state.mn.us

Luan.johnsrud@state.mn.us

Luke.stuewe@state.mn.us

Mark.dittrich@state.mn.us

Matthew.ribikawskis@state.mn.us

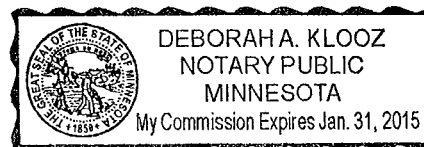
Rob.sip@state.mn.us

FURTHER AFFIANT SAYETH NOT.

  
Carol Nankivel

Subscribed and sworn to before me on  
this 28<sup>th</sup> day of March, 2014.

  
NOTARY PUBLIC





## Minnesota Pollution Control Agency

520 Lafayette Road North | St. Paul, Minnesota 55155-4194 | 651-296-6300

800-657-3864 | 651-282-5332 TTY | [www.pca.state.mn.us](http://www.pca.state.mn.us) | Equal Opportunity Employer

March 28, 2014

The Honorable James LaFave  
Administrative Law Judge  
600 North Robert Street  
P.O. Box 64620  
Saint Paul, Minnesota 55164-0620

RE: MPCA Submittals for Reopened Administrative Record for Rule Amendments Governing Water Quality Standards - River Eutrophication, Total Suspended Solids and Minor Corrections and Clarifications to Minn. R. chs. 7050 and 7053.  
(OAH Docket # 60-2200-30791, Revisor's # 4104)

Dear Judge LaFave:

The Minnesota Pollution Control Agency (MPCA) requests that you please accept the enclosed affidavits and information relating to OAH Docket # 60-2200-30791 in response to the Order Reopening Administrative Record for Limited Period, dated March 25, 2014.

Enclosed are:

1. Affidavit of Carol Nankivel (HE-16), MPCA staff;
2. Affidavit of Jean Coleman (HE-17), MPCA attorney;
3. Certificate of Giving Additional Notice (HE-7a) (amended from submittal on 3/27/14);
4. Copy of the MPCA's Govdelivery notice sent 6/7/13 (HE-18);
5. HE-19 Copy of OAH Decision 1999 WL 194069 (Minn. Off Admin Hrgs.); and
6. MPCA staff information for reopened Administrative Record.(HE-20)

Please contact me at 651-757-2597 if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Carol Nankivel".

Carol Nankivel  
Planner Principal  
Environment & Energy Section  
Resource Management & Assistance Division

Enclosures