Stream Nutrient Aquatic Life Criteria Technical Advisory Committee Meeting

September 29, 2010, 9:30 AM - Noon

3rd Floor Conference Room, Wallace Building, 502 East 9th St., Des Moines

TAC members present: Connie Dou, Greg Gelwicks, Tom Isenhart, Chris Jones, John Olson, Clay Pierce, Keith Schilling, Mary Skopec, Mark Tomer, Gary Welker, Tom Wilton

Absent: Mike Birmingham, Ed Brown, Mike Burkart, Peter Jacobson, Steve Kalkhoff, Kurt Pontasch

Tom Wilton (TW) began the meeting with introductions and a brief review of the meeting agenda. He said that the main focus of the meeting would be the nutrient-biological response data analysis. Using a PowerPoint presentation available at the Google Groups TAC web site[1] and provided to the TAC in a hand-out. TW reviewed some of the information discussed at the April meeting, including: TAC mission, objectives and process, technical agenda issues/questions, and EPA nutrient criteria guidance (Slides 3-6).

Work Progress Discussion

Regarding work progress (Slide 7), TW mentioned that approximately 16 stream sites are being monitored by the State Hygienic Laboratory (SHL)[2] as part of IDNR's annual biological monitoring work plan. The goal of the monitoring is to link biological sampling data with nutrient data. The project targets high quality streams (i.e., Outstanding Iowa Waters and reference streams) where nutrient monitoring data is generally lacking. High water conditions during most of the 2010 summer season, however, have interfered with this sampling, and TW cautioned the data may not be representative of a typical sampling year; however, the data should be available later this year to assist with development of nutrient criteria recommendations. Information on the on-line discussion/information forum (Google Groups), data analysis, and documentation was also presented. When the TAC was asked for questions regarding work progress, the following TAC members responded:

Connie Dou asked whether the monitoring at the 16 stream sites was targeted toward base flow conditions. TW said that is mostly true; however, there is no strict requirement that samples must be collected under base flow conditions. He added that because some of the sampling activities require wading in the stream (e.g., periphyton collection, biological sampling), this pretty much prohibits sampling under high flow conditions. Tom Isenhart noted that high stream/river flows this summer would prevent expression of nutrient impacts. He added that one of his student's stream nutrient research plans have been negatively impacted by the prolonged flooding and high flows extending into the fall season. Stream conditions were just now reaching a level where more typical stream nutrient responses might be seen. Wilton also indicated that TMDL monitoring plans had been substantially affected by equipment losses and monitoring had been cancelled in some flood-impacted streams.

Mark Tomer asked about discussion postings at the on-line forum. TW mentioned that John Olson and Connie Dou added their comments related to stream classification and Iowa's aquatic life use designations (TAC agenda questions 1-3). Olson's comments emphasized regional patterns in water quality and nutrient levels, which he believes should be considered in developing nutrient criteria recommendations. He attached a file with his comments, which contained graphs illustrating regional differences in ambient levels of N & P. Dou commented that Iowa's aquatic life use designations are not ecologically based, and they may need to be revised to include the connection between nutrient levels

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[1] *TAC web site: http://groups.google.com/group/iowa-stream-nutrient-tac/*

[2] *SHL formerly known as the University of Iowa Hygienic Laboratory (UHL)*

and biological responses. She noted the designated uses encompass a wide range of stream types and conditions across the state. For toxics, IDNR has predominantly adopted national standards so a regional approach has not been used. Nutrient standards, however, are different because the development process involves looking at stressor-response relationships that are likely to vary from region-to-region within the state. Dou suggested that in order to approach nutrient criteria development like toxic parameters, we will need to find the species that are most sensitive to nutrient impacts. TW responded this type of approach may not work because nutrient impacts are usually measured in terms of impacts to biological assemblages (e.g., trophic guilds) rather than at the level of individual species.

Mary Skopec asked about the lack of reference conditions for larger streams/rivers and whether this might be a problem for recommending nutrient conditions. She wondered if it might be necessary to look outside of Iowa to establish such reference conditions. TW agreed the lack of reference conditions for large rivers is an issue and a source of uncertainty. He noted that many other states are also dealing with this issue because most bioassessment development work has focused on wadeable streams. Skopec also noted there can be suppression of chlorophyll-a due to high levels of suspended sediment. TW agreed and suggested that differences in nutrient response might be justification for additional stream classification. He noted that the stream bioassessment protocol distinguishes streams by habitat type (e.g., riffle versus non-riffle streams). Tom Isenhart noted that EPA guidance suggests that states classify waters by trophic state. TW agreed, but noted that the guidance on how to do it didn't seem very clear.

Mary Skopec asked whether we (TAC) know how EPA might react to what Iowa might propose for nutrient criteria and how much EPA will allow Iowa to deviate from the nutrient benchmarks established for Region 7 streams and rivers by U.S. EPA's regional nutrient technical assistance group (RTAG). Gary Welker (EPA Region 7) responded that the Region 7 RTAG was one of the few RTAGs nationally that has set nutrient benchmarks. He added that Region 7 realizes that these benchmarks were developed on a regional (four state) scale and that states may thus need to refine the benchmarks; however, state criteria "should be in the ball park" of the RTAG benchmarks. TW asked Welker about the status of documentation for the RTAG process for establishing the nutrient benchmarks; Welker responded that the reports for both lake and stream/river nutrient benchmarks are in "final draft" form but he could not give a definite date when these reports would be available for distribution.

Data Analysis Discussion

TW outlined the remainder of the TAC meeting in Slide 9; that is, context for the nutrient stressor/biological response relationship would be provided, a number of data analysis methods would be described, some of the preliminary results would be presented, and any questions/discussion regarding the methods or results would be welcome.

Context for the nutrient stressor/biological response relationship: Using Slide 10, TW presented the concepts of "biocondition gradient" (BCG) and "tiered aquatic life uses" (TALU). Four examples of biological condition thresholds were described – roughly equivalent to: 1) natural/pristine (biological integrity); 2) optimal biological conditions in contemporary terms; 3) biological conditions that are representative of aquatic life uses; 4) impaired – not consistent with Clean Water Act interim "fishable" goal. TW remarked that the TAC might not yet have a clear understanding of what the biological goal should be for Iowa's rivers and streams from the standpoint of developing nutrient criteria recommendations. The biological condition goal can be influenced by both science and by public opinion and this decision will ultimately affect the setting of nutrient criteria.

Chris Jones mentioned that he had seen a presentation by Dr. Kenneth Lubinski, USGS in which a similar kind of aquatic ecosystem condition gradient was discussed. Based on Jones' recollection of the presentation, Lubinski indicated that most people prefer and like to know that waters exist at the level of "ecosystem health"; however, they will usually accept a somewhat lower ecosystem condition where socio-economic factors might affect them personally. Slide 16 of Lubinski's presentation that Jones provided to the TAC following the meeting contains a four-tier paradigm of ecosystem conditions ranging from "no life" through "degraded" to "ecosystem health" and finally "ecosystem integrity."

In Slide 11, TW presented a conceptual model of stream nutrient enrichment. That is, nutrients feed stressors such as aquatic habitat quality, the food web, water quality (e.g., ammonia and turbidity), and D.O. flux. The data analysis examples presented at the meeting specifically address the pathway whereby increased nutrients lead to increased seston algae levels, resulting in an altered trophic/food web and changes in the composition and structure of the benthic macroinvertebrate assemblage. TW said thus far he has looked at the connection between seston chlorophyll-a levels and the benthic macroinvertebrate community; however, relationships involving other nutrient response variables (e.g., benthic algae, d.o. flux) and biological assemblage indicators (i.e., fish IBI) will also be examined.

Analysis methods & data: In Slide 13, TW listed the various analytical methods he has used so far to investigate the connection between seston chlorophyll-a levels and benthic macroinvertebrate responses. He apologized for the cumbersome list of abbreviations in Slide 14, which were necessary for efficient performance of data management/analysis tasks. TW provided a brief description of the data used in the preliminary analysis (Slides 15-17). For now, the data from the IDNR/SHL sampling conducted on warmwater streams for the REMAP and biocriteria reference site projects will serve as the primary basis for investigating the connections between nutrient levels and aquatic life responses. He said there are other data sets that could be used, but the REMAP data offers the advantages of being a random survey and having integrated nutrient, nutrient response, and biological assemblage data.

<Meeting Break>

Results of analysis of biological responses to seston chlorophyll-a: Slides 18-20 illustrated relationships between stream watershed size, aquatic life designated uses, and seston chlorophyll-a. In particular, the slides highlighted a pattern of increasing chlorophyll-a levels with increasing stream size. This pattern is also reflected by the former and current designated uses. Isenhart asked about the scale of stream sizes used in the analysis. TW responded that initially, nutrient-biological relationships are being looked at across the entire spectrum of stream size and designated uses. He invited suggestions on how to stratify streams to improve the analysis, and went on to mention that data from coldwater streams had been excluded from this analysis for two main reasons: 1) little or no seston chlorophyll-a was found in CW streams; 2) the benthic macroinvertebrate (BMIBI) metrics used as the aquatic life use indicators are only appropriate for warm water streams.

Isenhart questioned the nature of the “seston”; i.e., whether seston was only phytoplankton or might include dislodged benthic chlorophyll, and whether there was any way to tell how much was one versus the other. TW responded he did not know of any way to tell from the available data what proportion originates as benthic versus planktonic growth. He mentioned some research had been done at Iowa State University[3] some time ago that found a relationship between suspended algal levels and the area of wetted stream bottom upstream from the sampling point. The authors concluded that a substantial amount of the suspended algae in Iowa streams comes from benthic growth. They stated there is probably a point in the stream network where the suspended algae in large river segments is dominated by true planktonic algae; however, they did not suggest where that point might be. TW remarked that from a functional standpoint, in terms of the benthic macroinvertebrate assemblage response to increased suspended algal biomass, where the algae originates from may not matter.

Greg Gelwicks suggested that on-stream impoundments, which provide conditions conducive to excessive algal growth, may be influencing the high seston chlorophyll-a values seen in flowing rivers. This might be an important thing to take into account with respect to classification. Regarding super-high levels of seston chlorophyll-a that are sometimes seen in small streams, TW noted that such levels can occur because of discharges from wastewater lagoons, ponds or stormwater basins. He noted that the timing of sampling in relation to boom-bust cycles in benthic algal growth may also influence the levels of seston chlorophyll-a measured. Skopec suggested that regional differences in stream/river seston

[3] *Swanson, R.D. and R.W. Bachmann 1976. A model of algal exports in some Iowa streams. Ecology 57:1076-1080.*

chlorophyll-a should be considered. TW responded that the IDNR/SHL ambient stream/river monitoring data will be useful for looking at these regional differences because of the many sites around the state where monthly nutrient and chlorophyll-a monitoring is conducted. Dou asked whether REMAP sampling includes impaired waters. TW responded that due to its random design, REMAP sampling results should represent close to the entire range of Iowa's stream conditions, from impaired to high quality.

Clay Pierce raised several issues related to the use of LOWESS lines such as that displayed in the seston chlorophyll-a/drainage area graph in Slide 18. He cautioned that by changing the data smoothing specifications, the LOWESS line can be "tuned" to suggest a number of breakpoints in the data. It can potentially show many small changes in the bivariate relationship that may or may not be meaningful. TW agreed and indicated he does not plan to use LOWESS for breakpoint analysis for that very reason. He explained that the graph in Slide 18 is based on the default settings and was only intended to display a general pattern in the relationship between the two variables. He went on to describe steps taken to review the statistical distributions of regression model variables and residuals for normality before accepting r-squared values and significance test results.

TW asked the TAC to consult Figure 9a in the draft data analysis report that was distributed to the TAC on September 15th[4]. Specifically, TW wanted to show examples of bivariate data plots that had been reviewed and to explain that "wedge-shaped" plots are suggestive of meaningful chlorophyll-a -biological response relationships. He noted, although this technique was useful for becoming more familiar with the data, it was not used to eliminate biological metrics from subsequent analysis. Several benthic macroinvertebrate data metrics (listed below) displayed a wedge-shaped pattern, in which the upper edge of the data might be interpreted as representing the limiting influence of chlorophyll-a over the biological response variable.

- standard habitat total taxa richness score (shttxscr);
- standard habitat Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa richness score (sheptxscr);
- standard habitat combined % abundance of top-3 abundant taxa score (shp3domscr)
- standard habitat % abundance scraper taxa score (shscrprscr)
- standard habitat % abundance of mayfly (Ephemeroptera) taxa score (shephmscr)
- standard habitat % abundance dominant functional feeding group score (shdffgscr)

Slide 25 contained a table summarizing simple linear regression (SLR) results for log-transformed seston chlorophyll-a and BMIBI index/metric scores. This table shows the 95%, 50%, and 25% metric scores for seven biological response variables used as example benchmark values, and the respective seston chlorophyll-a levels as derived from the SLR equations. The response variable standard habitat total taxa score (shttxscr) explained the largest percentage (~27%) of the variance in seston chlorophyll-a levels.

The next slide (26) displayed the relationship between seston chlorophyll-a and the shttxscr metric encompassing all stream sizes and use designations. Slide 27 was used to examine how the shttxscr / seston chlorophyll-a relationship might vary between former/current designated uses; i.e., B(LR)/WW2 calibrated, B(WW)/WW1 calibrated, B(WW)/WW1 uncalibrated, and general use uncalibrated. Calibrated streams are wadeable streams that are within the size range and designated use classifications represented by wadeable reference streams used to calibrate the benthic macroinvertebrate and fish IBIs. Clay Pierce asked whether these relationships (i.e., slopes) had been tested for statistically significant differences using analysis of covariance. TW indicated no they had not, but thought he could probably do that in the future. Mary Skopec had a question regarding the source of data used to build the figure in Slide 27; TW indicated it represented REMAP (random) stream sampling data only. TW noted that this slide suggests that optimal taxa richness can occur within all use designations and the general pattern of response was similar across the designated uses..

[4] *A copy of the draft report (Nutrient response analysis_draft.pdf) is available at the TAC web site: : http://groups.google.com/group/iowa-stream-nutrient-tac/*

Conditional probability: Slide 28 showed a conditional probability plot of the stressor (seston chlorophyll-a) and the biological response variable standard habitat total taxa score (shttxscr). To be consistent with the DNR's bioassessment protocol, the response variable cutoff score for shttxscr was set at the 25th percentile score (5.76) from reference site sampling. This plot represents what TW called a "forward view" of the conditional probability relationship where the plotted line shows the proportion of samples that fail to meet the total taxa benchmark when seston chlorophyll-a is equal to or greater than a given level along the stressor (seston chlorophyll-a) axis. TW noted the slide shows a pattern of increasing failure to meet the reference benchmark as seston chlorophyll-a levels increase. Slide 29 showed the "backward view" of the conditional probability relationship (i.e., proportion failing the biological benchmark when stressor is equal to or less than a given level). TW remarked that, although conditional probability is a helpful visual tool, it does not seem particularly useful for identifying specific breakpoints in the data.

Classification and regression tree analysis (CART): This method of data analysis was discussed using Slide 30. TW indicated the method was effective in finding breakpoints or changepoints in the seston chlorophyll-a (WCHLA) – benthic macroinvertebrate metric response relationships. For example, the CART analysis found a WCHLA breakpoint of 59 ug/l for the standard habitat percent abundance 3-dominant taxa metric (shp3domscr). He explained that once the CART response breakpoint had been identified, the mean scores for benthic macroinvertebrate metrics representing each split group were tested for significance using two-sample t-test methods. In each case, the mean difference was found to be statistically significant ($p< 0.05$). For each benthic macroinvertebrate metric tested, the mean score was below the respective reference 25th percentile benchmark for sites having WCHLA levels exceeding the WCHLA breakpoint, and the mean score was above the reference benchmark for sites that were below the WCHLA breakpoint.

<u>Quantile regression and logistic regression:</u> Slides 31 and 32 show examples of the quantile regression (QR) approach [note: the title of slide 31 is mislabeled; it should read "Method – Quantile Regression"]. TW explained that the upper percentile regression lines (e.g., 95%, 75%) are thought to come closer to modeling the true relationship between the stressor and response variables compared with the more conventional least squares mean regression line. In slide 32, TW noted the QR analysis was done using the biological response variable as the x-variable and seston chlorophyll-a as the y-variable, which is reversed from slide 31. TW remarked the QR results from this model configuration seemed more consistent insofar as predicting seston chlorophyll-a levels from the various benthic macroinvertebrate metric benchmarks. TW asked the TAC if there was a reason why the regression should not be done this way. Connie Dou noted this is not the typical way to construct a regression model – i.e., using the "dependent" variable to estimate the "independent" variable. Mark Tomer indicated that it was not necessarily wrong, and that ideally you would want the x-variable to have lower measurement error than the y-variable in predictive modeling.

Slide 33 was used to demonstrate how logistic regression can be used to investigate the relationship between seston chlorophyll-a and the biological response variable – in this case, the proportion of samples equaling or exceeding the 25%, 75%, and 95% reference benchmark levels for the *standard habitat percent three dominant taxa* metric score. TW explained that the various colored lines on the graph represented the LR predictions of the proportions of REMAP samples that would attain the respective reference benchmark levels at a given level of seston chlorophyll-a. The bars indicate the actual observed proportions that occurred within each seston chlorophyll-a division shown on the x-axis. Each division represents approximately 10% of the entire data range. TW noted that one of the advantages of using LR is that the biological response variable is transformed to represent a binary distribution from 0 to 1. Consequently, the regression will not predict a response level that lies outside the range of possible values (i.e., from 0 to 10 for benthic macroinvertebrate metric scores). TW remarked that the type of graph in Slide 33 seems like a useful way of modeling expected changes in the attainment levels of biological reference benchmarks in relation to a given nutrient stressor gradient.

Slide 34 contained a summary of the data analysis methods used and the resultant benchmark values for seston chlorophyll-a. TW noted the preliminary analysis found a wide range of potential seston

chlorophyll-a benchmarks that reflected the different data analysis methods and how the biological response goal was defined.

Slides 35 through 38 were presented as “teaser slides” that showed relationships between (1) total phosphorus and seston chlorophyll-a and (2) total nitrogen and seston chlorophyll-a. TW mentioned that once the appropriate chlorophyll-a level and/or other nutrient response variable levels had been defined by the TAC, it would be necessary to examine relationships between nutrient parameters and these response variables. Due time constraints, TW suggested that discussion of these slides should be postponed.

In Slide 39, TW emphasized several pressing questions regarding data analysis:

- What are the appropriate/desired/acceptable biological endpoints?
- Of the methods used thus far, what are the best methods of data analysis?
- Are there alternative methods that could/should be used?
- How do we address the issues of causation (vs. correlation) and the uncertainty in our ability to predict biological responses?

John Olson asked TW if he would eliminate any methods based on the results of this preliminary analysis,. TW responded he didn’t think that was necessary at this point. All the methods seemed potentially helpful and did not require a lot of extra time, and so he thought he would continue using them as he moved forward with analysis of other nutrient-biological response relationships.

The next steps for the TAC were summarized in Slide 40. The analysis of stressors and responses will continue with additional pathways and parameter being considered. Data for nutrient parameters will be reviewed to look for influences of flow, seasonality, and other sources of variation. An historical summary focusing on data analysis and a literature review will be prepared. TW said he understood that the information presented before and during the meeting was a lot to digest in a short amount of time. He emphasized that feedback from TAC members is welcome anytime. He thanked everyone for attending and said he will be keeping in touch with the TAC using e-mail and the Google group web site. No timeframe for the next meeting was identified. The TAC meeting closed shortly after 12:00 PM.