Chatfield Watershed Authority

6795 S. Elati Street Littleton, CO 80120
Tel: 303-795-5925

MEMORANDUM

To: Chatfield Watershed Authority Board

From: Chatfield Watershed Authority TRC

Subject: Updated Issues and Concerns for 2008 RMH as of April 16, 2008

Date: April 16, 2008

We have updated this "Tracking Memo," which describes unresolved issues, unanswered questions, and additional work necessary regarding the Division's proposals for the upcoming Chatfield Reservoir Water Quality Standards and Control Regulation rulemaking hearing before the Water Quality Control Commission ("Commission"). The Tracking Memo reflects questions and discussions raised during the Division's presentations. This Tracking Memo was substantially revised in January 2008 to consolidate, reduce and focus the issues, and now incorporates issues raised subsequently. On April 10th, in a memo from Tammy Allen, the WQCD presented a draft template of how recommendations from the technical review may be represented through changes to the regulatory language.

> The Division is pleased to have the opportunity to clarify and expand on the technical issues that have been the focus of our review. The "tracking memo" concept was implemented early in the review process as a means of collecting questions that arose in the course of the review. The scope and organization of topics in the memo has evolved considerably during the review process. The memo produced in January, for example contained less than two pages of text, whereas the most recent version, produced in mid-April has been expanded to six pages. It is not surprising that the document has evolved as participants have more time to consider the technical issues and develop additional questions.
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> A broad array of issues is covered in this memo, and those issues are presented as a mix of assertions and questions. In the interest of responding quickly and in the hope of focusing attention on the options that the Division has presented, we will not attempt to correct assertions with which we do not agree. Instead, it will be our aim to indicate where points of disagreement exist and to address questions to the best of our ability.

PREVIOUSLY IDENTIFIED ISSUES

- **Chlorophyll and Total Phosphorus Relationship**

The Division's proposal is based on a response ratio (of chlorophyll to Total Phosphorus) combined with concentration/load translators. The simple ratio in conjunction with a translator approach is being suggested to calculate the allowable load.

The relationship between the phosphorus and chlorophyll concentration is not well described by the ratio model being proposed. The response ratio approach removes the statistical correlation aspect between the two variables, while maintaining a slope component of traditional regression approaches using a zero intercept. This approach assumes chlorophyll is primarily dependent upon phosphorus and does not consider other factors that may affect the chlorophyll response.

The Division views the preceding two paragraphs as an incomplete characterization of information presented in the following documents: 1) 'Chatfield Reservoir Chlorophyll Phosphorus Relationship.doc' and 2) 'Creating a Concentration Translator to Link Chlorophyll and Nutrients.doc' distributed previously to the TRC.

1. The Authority encourages the Division to evaluate and incorporate into the modeling other potential "suppressor" factors that may affect algal response (e.g. flow, flushing rate, biology).

2. The Authority requests an explanation of how the uncertainties described in the papers addressing the translators have been resolved.

3. Dr. Saunders' analyses described in great detail how poor the fit was between phosphorus and chlorophyll. How has this discrepancy been resolved?

4. Have there been any sensitivity analyses completed on the assumptions made in preparing the draft proposal? In particular, if a range of assumptions are made about "suppressor" factors, does that influence the in-lake concentration disproportionately? If so, how will such sensitivity be considered in the final revisions to Regulation 73?

The main question concerning the relationship between chlorophyll and phosphorus seems to be: *How can the response ratio account for the observed variability in*

the chlorophyll-phosphorus relationship as it relates to refining the linkage between the chlorophyll goal and the phosphorus standard? Although the topic is discussed at length in two documents already distributed, and there has been considerable discussion in TRC meetings, it may be helpful to reiterate some of the key points.

When a large set of lakes is examined, there is a strong relationship between the average concentrations of chlorophyll and total phosphorus. When linear regression is applied to the log-transformed data, the phosphorus concentration "explains" a large proportion of the variability *among lakes* in the chlorophyll concentration. Although the relationship was developed to explain variation among lakes, it is often used to predict what will happen to chlorophyll within one lake if the phosphorus concentration is manipulated.

It has been known for many years that the linear regression lines developed to explain variation among lakes perform poorly when applied to the task of explaining variation *among years* within one lake. This should come as no surprise in view of the many factors that can affect the accumulation of algal biomass (i.e., chlorophyll) within a lake. The factors, in addition to phosphorus, affecting growth rates of algae and the factors affecting the loss rates of algae are numerous, and each may vary seasonally in one lake.

In concept, all factors might be measured and a mechanistic model might be developed to incorporate all of those factors in a predictive framework for a single lake. Usually this is done in a research context. In practice, however, there is little hope that enough money and technical expertise would be available to measure enough variables with sufficient frequency for long enough to calibrate such a model. The Division continues to believe that a research effort of that magnitude is neither practical nor necessary for the purpose of developing a useful linkage between chlorophyll and phosphorus in Chatfield Reservoir.

Instead of engaging in a fruitless search for a straight line correlation, the Division has turned to the concept of a response ratio, which figured prominently in analyses of the National Eutrophication Survey performed during the 1970s. The simple ratio

of chlorophyll to phosphorus on any sampling date is an estimate of the responsiveness of the resident algal community to the phosphorus in the water column. When growth rates are high and loss rates are low, the ratio of chlorophyll to phosphorus will be high. When growth rates are low and loss rates are high, the ratio will be low. It is not necessary to know why growth rates or loss rates are high or low in order to define the typical responsiveness of the algal community in Chatfield Reservoir.

Generally, the algal community in Chatfield Reservoir accumulates 1 ug/L of chlorophyll for every 3 ug/L of total phosphorus. The response is variable, as indicated in supporting documents, but this is the central tendency. This is considerably less responsive than originally thought; having a chlorophyll goal of 17 ug/L and a phosphorus standard of 27 ug/L implied that the algal community is twice as responsive (about 2 ug/L chlorophyll per 3 ug/L phosphorus) as it really is.

The response ratio aggregates the variability in the chlorophyll-phosphorus relationships without attempting to explain the source of variation. By retaining the observed variability of the response ratio in the probabilistic modeling approach (as outlined in the previously distributed document 'Estimating Allowable Phosphorus Load in Chatfield Reservoir.doc'), the range of conditions expected for the linkage between chlorophyll and phosphorus in Chatfield can be reflected appropriately.

- **<u>Establishment of Chlorophyll a goal/standard at 17 ug/l</u>**

The WQCD proposes to change from a chlorophyll goal to a standard for chlorophyll.

1. How do chlorophyll concentrations relate to the beneficial uses of Chatfield Reservoir?

2. What are the upper bounds for chlorophyll impairment as related to the beneficial uses of the Reservoir? What is the potential effect on the TMAL?

3. Why would both a chlorophyll *a* standard and a phosphorus standard be necessary?

As indicated during the April 23rd Board meeting, the Division believes that the abundance of algae (as

reflected by the chlorophyll concentration) has a direct effect on uses. Accordingly, our efforts to develop lake nutrient criteria statewide have focused largely on selecting thresholds for chlorophyll concentration. At the same time, we recognize that implementation efforts (especially discharge permit limits) will depend on having a target value for phosphorus. Because the Control Regulation exists for implementation of the established TMDL, it makes sense to designate the phosphorus concentration as a standard.

The chlorophyll concentrations observed during the Chatfield Reservoir Clean Lakes study were judged by the Commission to be protective of uses. The chlorophyll goal was set slightly higher in order to accommodate anticipated growth. The untested assumption was that uses would remain protected at the higher chlorophyll level. In fact, there has been no opportunity to test the assumption because chlorophyll levels have remained consistently well below the concentrations observed during the Clean Lakes study. If uses are not currently considered impaired, we should be asking if that condition can be preserved if chlorophyll levels are allowed to rise much above present levels.

As part of the statewide effort to develop nutrient criteria for lakes, considerable attention has been paid to relationships between chlorophyll and other water quality parameters. For example, when seasonal chlorophyll concentrations are higher than about 6 ug/L, significant depression of deep water dissolved oxygen concentrations can be expected. The Division believes that Chatfield is on the cusp in terms of chlorophyll concentrations. Dissolved oxygen concentrations in the metalimnion often fall below the standard of 6 mg/L. In terms of the national perspective, EPA has recommended (304a criteria) chlorophyll concentrations in the vicinity of 2 ug/L in order to protect uses.

The Division's options are based on the assumption that we should be respectful of regulatory precedent of the Commission regarding the site-specific nutrient criteria that have already been adopted for Chatfield Reservoir.

- **Exceedance Frequency**

According to the Division, the "…exceedance frequencies are derived empirically by applying percentiles of the response ratios to data from various Colorado lakes." This only provides the number of exceedance based on distributional characteristics of the data – not the level that is acceptable. It is critical that the recommendation for exceedance frequency be based upon science and experience at Chatfield Reservoir (even if the recommendation is retaining the status quo).

The Division is puzzled by the implication that an empirical derivation is somehow not scientific. The Authority has quoted a passage from a document describing how response ratios could be used for Colorado lakes in general. We refer the Authority to the document on estimating allowable loads for a description of the manner in which exceedance frequencies were determined specifically for Chatfield Reservoir (see pages 12-13 of 'Estimating Allowable Phosphorus Load in Chatfield Reservoir.doc'). The distinction is important because the approach was tailored to the wealth of data available for Chatfield.

1. What basis was used for the proposed exceedance frequency of one in five years (which is the result of using the median flow)?

2. What flow would be used if the one in ten year exceedance frequency was used?

3. How would that affect the proposed standards and TMAL?

The existing statement of the standard (or goal) for Chatfield is not accompanied by an exceedance frequency, and the Division believes it should be. Indeed, the Basic Standards specify that Numeric Standards will include appropriate averaging periods and appropriate frequencies of allowed excursions (see 31.7(1)(b)). The hydrologic scenario (Q10) used to develop the existing TMAL demonstrates an intent to provide a once-in-10-year exceedance frequency (more later about what it actually accomplishes). The Division is not opposed to formal incorporation of a once-in-10-year frequency, as has been applied to Cherry Creek Reservoir.

The Division's preference is for a more flexible approach involving a once-in-5-year exceedance frequency, which is in line with our thinking about statewide nutrient criteria for lakes. Application of 10-y instead of 5-y would make the standard about 20% more restrictive as shown in Table 2 of the document

'Estimating Allowable Phosphorus Load in Chatfield Reservoir.doc', which was distributed previously to the TRC.

UNCERTAINTIES WITH MODEL INPUTS

- **Phosphorus Load Translator**

During the phosphorus load translator presentation by the Division, the Division's comments indicated that they were not satisfied with the performance of the Vollenweider or Dillon-Rigler models used to link in-lake phosphorus concentrations with the load, and further, that this translator could still change. The materials provided by the Division on the Chatfield Reservoir Phosphorus Load Translator indicated: "[t]he relatively poor performance of the Vollenweider model stimulates interest in an alternative."

The Division went on to assess the Dillon-Rigler model, which it deemed "better than the Vollenweider model, but still not very satisfying" and that "greater accuracy would be preferable."

Therefore, the Authority was extremely surprised when presented on April 10, 2008 with a "probabilistic approach," which was "developed from the Vollenweider mass-balance model" that was previously rejected by the Division.

The Division disagrees with the characterization of the translator and especially with the statement that the Division had rejected the mass-balance model. Nevertheless, it is apparent that we could have done a better job of explaining our concerns and how they were resolved.

1. Upon what evidence / data did the Division rely in returning to the Vollenweider model? How has it been refined to make it more predictive?

2. Has the Division evaluated other models, and if so, what are the general conclusions about this translator?

3. Have modifications to the Vollenweider equations been tested? If so, what results?

It appears that there is confusion about the purpose of mass-balance models. The Vollenweider and Dillon-Rigler models are simply mass-balance equations. For those equations to be useful for forecasting phosphorus concentrations in the reservoir, there must be a means of establishing how much phosphorus is retained in the reservoir. That is the function of the retention coefficient (or sedimentation rate). When predictive models for the coefficient failed to

perform adequately, the Division chose to apply a probabilistic approach in which the full range of observed values for the coefficient are used rather than depending on predictions of one or more empirical relationships.

Probably the most efficient way to clear the confusion is to refer to page 9 of the aforementioned document - 'Estimating Allowable Phosphorus Load in Chatfield Reservoir.doc'. It defines the relationships as they are used in probabilistic modeling.

- **Sedimentation Coefficient**

The sedimentation coefficient is a key component for the phosphorus load to in-lake concentration translator.

1. How does this sediment coefficient respond when future scenarios are modeled? Such as varying hydrologic conditions? Or operational and storage changes proposed for the Chatfield storage reallocation? Given the proposed changes in reallocation and hydraulic retention times how might this component change under a revised TMAL?

2. Current assumptions presented about the coefficient are inconclusive in correlating the two factors.

3. A significant amount of sediment (and phosphorus) is 'decanted' out of the South Platte River as the flows are detained in Strontia Springs and Cheesman Reservoirs, upstream. So the sediment that remains in the water flowing to Chatfield appears different than in a natural system. Is the sediment finer and remaining suspended longer? Is it more likely to be flushed out of the reservoir?

4. Has the Division reviewed the data and effects on Chatfield when Denver flushes sediment from upstream Reservoirs? What are the effects on sediment when Denver flushes sediment from the upstream Reservoirs?

5. Is there a proposal to prove (or disprove) the apparent abnormal characteristics of the sediment from the South Platte River? How will the sedimentation coefficient be adjusted to account for the sediment characteristics for the load from the South Platte River?

There seems to be some confusion about the connection between the phosphorus sedimentation (=retention) coefficient and the nature and origin of sediment carried in the tributaries. There is none. The phosphorus sedimentation rate, also called a retention coefficient, defines the trapping of phosphorus in the reservoir without identifying the mechanism.

The Division concurs that quantifying the retention of phosphorus in the reservoir is central to the linkage between phosphorus load and the concentration of phosphorus in the lake. As the Division has pointed out, there is unexplained variation in the observed values of the retention coefficient (see 'Chatfield Reservoir Phosphorus Load Translator.doc'). Our approach to dealing with that variation is to incorporate all of it in the probabilistic model (see 'Estimating Allowable Phosphorus Load in Chatfield Reservoir.doc'). We have measured values in each year for the coefficient, and believe they are representative of conditions that can be expected in the future. If the Authority has evidence to show that the coefficient will change in the future, we would be glad to discuss it. Our current analysis shows that the relationship between the retention coefficient and hydrology explains little of the variation, suggesting that it is largely insensitive to the kinds of changes mentioned by the Authority.

Issues concerning the nature and sources of sediment in the watershed are beyond the scope of the technical review. They would be logical topics to include on the schedule of work to be undertaken if the Commission adopts the Division's proposal.

- **<u>Hydrology</u>**

1. What scientific justification exists to completely exclude 5 years of data because of high flows in Plum Creek?

2. How does excluding 1/5 of the data affect the predictability, and likelihood of exeedances, for the proposed exceedance frequency?

3. In developing the proposed revisions, Dr. Saunders excluded 5 years of data in which flows from Plum Creek exceeded 20,000 AF. The justification is that "the resulting model will perform better in most years, and it will be conservative with respect to the anomalous years." (pg. 10). This justification is unacceptable. We respectfully request that further analysis be done to include the 5 years and that the sensitivity analysis requested above be performed using the 5 years and excluding the 5 years.

4. How will the proposed median hydrology scenario for the TMAL acknowledge the increased uncertainty of in-lake phosphorus concentration predictions during years where the flow from Plum Creek exceeds 20,000 AF?

The data were excluded for the reasons explained openly to the TRC and in the relevant document (see 'Estimating Allowable Phosphorus Load in Chatfield Reservoir.doc'). Nevertheless, in response to the questions, we ran the model again. Including those 5 years increases the variability of the predicted concentrations, without having much effect on central tendency. The net effect of the increased variability is to increase the frequency of exceedances for the same load compared to modeling conditions when those 5 years are excluded. Stated another way, the higher variability dictates a more restrictive standard, but only by a small amount. In other words, the decision to include or exclude those years has a relatively small effect on the outcome of the probabilistic modeling.

- **<u>Effect of Watershed Hydrology on Total Phosphorus, Chlorophyll</u>**

  - **Wildfires and Water Rights**

1. Please clarify how the increased phosphorus concentrations and resulting loads observed in recent years (last 5 years of the 20 year record) has been accounted for in the translator approach, especially when years were aggregated?

2. How does the use of and median values affect development of allowable loads? Does the fifteen previous years of data mask recent loading patterns?

3. Will the proposal to modify the TMAL outline a procedure for modifying the TMAL to accommodate impacts from upstream modifications, such as changes in hydrology due to water rights; wildfires; drought or flood?

There has been much speculation about the role for wildfires, and clearly it deserves attention when allocations are developed, but that is beyond the scope of present activities.

When loads were calculated, the last 5 years were aggregated as a group. Statistical testing showed that concentrations were not significantly different among those 5 years. The basis for the load calculations is explained in great detail in the following documented distributed previously to the TRC: 'Chatfield Reservoir Phosphorus Load Calculations.doc'.

  - **Unachievable Allowable Load**

It has been stated that it is possible the proposed revisions will present an allowable load that is unachievable or not economically feasible.

1. Why is it necessary to propose an allowable load before all aspects of the TMAL have been tested?

2. What protocols will exist for amending the allowable load if it is incorrect or not feasible?

3. How will the Division factor into their evaluation implementation of the TMAL, and costs for implementation?

4. Given that the Reservoir has met the chlorophyll *a* standard consistently, under what circumstances would radical changes in implementation requirements be justified?

There seems to be some confusion on the sequence of steps, which we hope was rectified during Sarah's presentation to the Board. In brief, the allowable load sets the stage for development of the TMAL. The allowable load is determined on the basis of the proposed standards and the linkages developed during the technical review. It is not possible to determine what load is achievable until after the TMAL has been developed and allocations are known. At that point, if it is determined that it is not feasible to meet the allocations, a revised standard could be considered on those grounds.

TIMING OF APPLICATION TMAL PROPOSAL

At the April 10th meeting of the TRC, Sarah Johnson, of the Division, described the timing for the Rule-making hearing. It is our understanding that the final proposal will likely be presented to the Authority in June 2008 The Authority may only have a matter of days or weeks to provide input on a proposal that has taken over a year to develop, before the Commission issues the Notice.

1. What is the justification for the shortened review time for the Chatfield Reservoir, especially in light of developing nutrient standards and the long period for Cherry Creek's development?

2. What steps will the Division take to include the Authority in the development of their proposal between now and the June release?

3. How will the Division address the issues in this memo, and when?

At the April 23nd Board meeting, the Division described the schedule in considerable detail and answered

numerous questions about process. We hope that was sufficient coverage.

COLLABORATION

It will be incredibly difficult to prepare meaningful comments to the entire proposal in the short time that will be allocated. If the process is to be truly collaborative, there should be very little or no controversy surrounding the TMAL proposal. Given the potentially short comment period, this outcome seems unlikely.

1. Why is the Division resistant to postponing the scheduled hearing, so the Authority and Division would have adequate time to work through these issues?

2. If the Chatfield proposals will be phased and sequential, what are the next steps?

3. What opportunities will exist to adjust approved proposals if they are subsequently shown to be incorrect or not feasible?

We believe these issues were addressed to a large extent during the April 23rd Board meeting.