Introduction

The federal Clean Water Act requires states to identify and prioritize water bodies that do not meet water quality standards. For these water bodies, the states must develop a total maximum daily load (TMDL) for the responsible pollutants and set a level to achieve water quality standards. Once the maximum level of the pollutant that allows the water body to achieve standards (load capacity) is established, the states allocate the amount that can come from nonpoint and each point source. Reductions in nonpoint loading are voluntary and generally employ best management practices (BMPs). Reductions in point sources are mandatory and are numerical limits in National Pollutant Discharge Elimination System permits. Exceedances of NPDES limits can result in heavy financial penalties and potential incarceration.

Two assessment units in the Lower Boise River have been determined not to meet water quality standards due to phosphorus. Accordingly, Idaho Department of Environmental Quality (IDEQ) prepared a TMDL in cooperation with the Lower Boise Watershed Council to resolve phosphorus concerns. The TMDL employed a sophisticated mathematical model to determine how much total phosphorus (TP) can be discharged by individual point sources and how much can run off from nonpoint sources to achieve desired goals These models are state-of-the-art calculations that simulate the myriad physical, chemical, and biological processes at work in the aquatic environment. Since some of these processes are poorly understood, or difficult to perfectly simulate, some degree of error can be expected. To more fully address the phosphorus concerns the IDEQ prepared the Lower Boise River TMDL Total Phosphorus Addendum.

Model calculations were aimed at 1) achieving a target of 0.07 mg/l total phosphorus (TP) in the Boise River near Parma, and 2) achieving a maximum periphyton standing crop of 150 mg/m^2 chlorophyll *a* in the lower 2 assessment units. To meet these targets Nampa would be required to reduce its TP discharges by 94% during October 1 – April 30, and 98% during May 1 – September 30. Nampa is currently spending $38 million to reduce its TP discharges 90% to 0.5 mg/l. In Phase II Nampa is scheduled to spend $189,900,000, of which $38 million is to reduce TP to the EPA mandated 0.1 mg/l. The question then becomes if the model yields results that are sufficiently robust to form decisions on the finest scale that require tens of millions of dollars to hopefully achieve desired environmental goals. Consideration of a number of factors helps us understand the confidence we can place in the precision and accuracy of this best guess.

The Model

I am not proposing that the researchers applied the wrong model, nor that they erred in any way. As best I can determine they selected an appropriate model and were professional and diligent in their efforts. It is just a fact that a number of considerations need to be kept in mind when modeling and interpreting model results. Following are some factors that warrant consideration:

Selection of Model: There are a variety of models used in TMDLs. It is certain that the various models would produce different results. The Lower Boise River TMDL used AQUATOX, a widely accepted model. The importance of model selection can be demonstrated by considering projected hurricane paths in the Atlantic Ocean. The Weather Channel may show the results of 20 different "accepted" models. Some may show the hurricane staying in the Atlantic, others show it going up mainland Florida and still others show it in the gulf. These models project a few days out in advance with models that have been used and refined for decades and have wide acceptance. These models are simulating strictly physical conditions. It is not difficult to envision that models simulating physical, chemical and biological processes and interactions and projecting over a time frame of years could vary substantially.

Evolution of Model: Often when a model is selected it goes through an evolutionary process where new versions are offered with refinements and enhancements. AQUATOX version 2 was released in late 2003, 3.1 in late 2013 and 3.1 Plus in May of 2014. I assume that each of these updates were supposed to yield more accurate results. I am not sure which version of AQUATOX was used for the Lower Boise River TMDL, but what kind of results would have been generated with one of the other versions? Will AQUATOX 4.0 yield even better results?

Assumptions: It is necessary in all models to make assumptions. Assumptions may be used because insufficient data exists to formulate a more accurate estimate, a process may be poorly understood, or it would require inordinate time or money to elucidate the answer. But every assumption suggests there is an opportunity for error. In the Lower Boise River TMDL Addendum they have lists of assumptions on pages 76 and 102, but other assumptions are scattered throughout the study. Each of these assumptions usually leads to a more conservative (requiring lower discharge limits) result. What is the cumulative effect of all these assumptions on model results? We don't know, but likely considerable.

System Complexity: The lower Boise River is an extremely complex ecosystem. The TMDL Addendum notes on Page 50 that "the movement of TP through the watershed and the interrelationships among the complex plumbing, water reuse, agricultural drains and tributaries, groundwater, and other biogeochemical processes are not well known." In a complex system like this with many processes poorly understood, model results would be expected to have a significant degree of uncertainty.

Sample Error: In environmental studies it is not uncommon to encounter sample error. Sampling error is when for one reason or another your sample may not be truly representative of conditions you are trying to study. This sample error can contribute to uncertainty.

Analytical Error: In spite of the sophistication of analytical methods and machines, errors can occur during analyses. The main focus of the TMDL was total phosphorus (TP), but considerable interest was in orthophosphorus (OP) the biologically active fraction of TP. Obviously, since (OP) is one fraction of TP, you can't have more OP than you have TP. However, in Figure 14 of the TMDL Addendum showing OP to TP ratios relative to instantaneous river discharge it shows about 6 samples where the OP was higher than TP. The only way this can happen is analytical error. Additionally the researchers stated two potential outlier data points were deleted due to disproportionate influence on the analysis. Analytical errors are not unique to this study, they are likely ubiquitous in large, complex environmental studies. How much total analytical error is there? We don't know, but once again it could be considerable.

Data Gaps: Data gaps can lead to assumptions and potential errors. On page 31 of the TMDL Addendum the researchers state "This TMDL identifies several data gaps that, if eliminated, could help produce a more robust assessment of the effects of TP and periphyton on beneficial uses. The best available data were used to develop the current TMDL. However, DEQ acknowledges that additional questions warrant investigation." They continue "Subsequent information developed through these efforts may be used to appropriately revise portions of the TMDL and adjust implementation and control measures."

Intent: The findings of a study can be heavily influenced by the intent. The TMDL stated repeatedly that they were pursuing a conservative approach, meaning they would prefer to over-regulate phosphorus. The model includes an implicit "margin of safety" to assure the model is sufficiently conservative. The TMDL states "Because of uncertainties about quantifying loads and the relation of specific loads to attaining water quality standards, the rules regarding TMDLs…require a margin of safety be included in the TMDL". In addition, a number of assumptions are made throughout the report and in each instance the researchers selected the most conservative approach, sometimes admitting they know it's wrong. One important example relates to how bioavailable orthophosphate is from various sources. They state, "For this TMDL, DEQ maintains the assumption that total phosphorus from all sources is completely bioavailable and will be analyzed and modeled as such for a conservative approach." Later on the same page they state "Additional research shows that all orthophosphate may not be equally available for algal and plant uptake and growth". These layers of conservative assumptions and decisions can significantly increase the unjustified burden on dischargers to reduce their discharges.

The Point Versus Nonpoint Problem

The Idaho Department of Environmental Quality (IDEQ) has determined that in the Lower Boise River 62% of the total phosphorus comes from agriculture and only 30% from wastewater treatment plants. While point sources are addressed by permits that impose expensive and onerous numerical limits that can involve heavy penalties for exceedances, regulators by law take a much more benevolent approach to nonpoint pollution. There is no timetable established for agriculture or other nonpoint sources. Participation is voluntary and somewhat dependent upon funding and willing partners. There is little certainty about how successful various control strategies will be. In fact, IDEQ recognized "the many uncertainties in achieving the agricultural and other nonpoint sources load allocations over the long-term, an adaptive management type approach" should be used. Adaptive management type approach is a scientist's way of saying trial and error. The likelihood of nonpoint reduction targets being met under these conditions is remote.

The Concentration Problem

The TMDL mandates TP concentrations no higher than 0.07 mg/l in the Boise River near Parma, based on the Snake River – Hells Canyon TMDL. This target is even lower than the EPA Gold Book Standard of 0.1 mg/l. The Gold Book sets standards that are believed to be fully protective of aquatic life; so it would seem that 0.1 mg/l TP at Parma would be sufficient to guarantee environmental quality and protective of downstream environments.

In order for the TP concentration at Parma to not exceed 0.07 mg/l, EPA is placing TP discharge limits at the Nampa Wastewater Facility of 0.35 mg/l for 1 October – 30 April, and 0.1 mg/l for 1 May – 30 September. Nampa is currently spending $38 million to reduce its average daily TP discharge of total phosphorus from 718 pounds per day to 75 pounds per day. This reduction of 643 pounds achieves 0.5 mg/l TP and equates to $59,098 for every pound removed. To get to the 0.1 mg/l mandated by the EPA would require a reduction of another 60 pounds of total phosphorus requiring an additional expenditure of $38,000,000. This equates to $633,333 for every pound of TP removed. However, since IDEQ estimates that only 23% of the phosphorus discharged reaches Parma, the actual reduction at point of interest is 13.8 pounds. That means for every pound of phosphorus not reaching Parma, Nampa is investing $2,753,623.

What is the benefit of a reduction of 13.8 pounds of TP at Parma? Likely undetectable. Modeled results show mean monthly TP concentrations at Parma during the period of interest (May through September) to range from 0.04 to 0.08 mg/l (Table D-4). Allowing Nampa to maintain its discharge at 0.5 mg/l would certainly result in TP concentrations at Parma well below the Gold Book standard of 0.1 mg/l.

On page 86 of the TMDL Addendum it states "A detailed approach was used for analyzing and selecting the allocations…" "Considerations included equitable cost, cost effectiveness, and credit for prior efforts…" Nampa paying $2,753,623 for every pound TP reduced at Parma seems neither equitable nor cost effective.

The Periphyton Problem

The second target selected in the TMDL is for periphyton (attached algae). This target differs from the concentration target in two ways. First, it applies throughout the impaired areas rather than at a point near confluence with the Snake River. Second, the target applies year round. IDEQ, has determined that that periphyton is a nuisance aquatic growth when the chlorophyll *a* exceeds 150 mg/m^2. This is not a federal standard but a level that was determined in consultation with the Lower Boise Watershed Council, a working group with broad representation. It could be argued that a different group of people could have come up with a different amount of chlorophyll *a* that would be considered nuisance, but this seems in line with numbers reported in the literature. This 150 mg/m^2 is thus a numeric target for an aesthetic goal.

There is little in the TMDL that suggests that periphyton (primarily diatoms) is controlled by phosphorus. Figure 22 shows benthic chlorophyll a values collected between 1995 and 2013. The figure states some value differences may reflect different sampling methodologies. The figure does not show which values were collected in what year, or by what methodologies. Based on these considerations these data are of limited value. However, several broad conclusions can be drawn. First, there appears to be a strong seasonal trend with maxima noted in October, November and December, and minima noted April through August when the river would experience heaviest seasonal use. Second, all sampling stations except Eckert Road exceeded the 150 mg/m^2 standard with regularity.

Contrast this with Figure 32 which models mean monthly periphyton under existing conditions. In segments 9 – 13 (the TP-impaired assessment units) the mean monthly standard was exceeded less than 12% of the time. The TMDL Addendum states on page 62 that “algal biomass may be influenced by human and environmental factors other than TP alone (e.g., flow, water temperature, other nutrients)”. The impropriety of this target is highlighted by comments on page 116: “Although brief periods of elevated periphyton may occur during August in model segment 10 and September in segment 11…these are likely due to growth of low-nutrient diatoms that can proliferate under low nutrient and other habitat conditions.” In other words, if we do lower the TP concentrations it is possible that we would be exchanging high-nutrient diatoms for low-nutrient diatoms. Finally, on page 1 of the comments IDEQ states “limited exceedances above 150 mg/m^2 target may be acceptable, so long as they do not impair the beneficial use”.

Figure 32 also highlights extreme annual variation. In four months sampled in common on successive years, the differences are extreme and almost totally reversed.

The fact that mean monthly periphyton standards are exceeded less than 12% of the time under “existing” conditions, the fact that there has already been a substantial decrease in TP concentrations from “existing” conditions, the fact there is little evidence that TP controls periphyton levels in the study area, the fact that high-nutrient diatoms may be replaced by low-nutrient diatoms, and the fact that limited exceedances are permissible suggests there is little justification for the Nampa facility to reduce its TP discharge to ameliorate periphyton conditions.

The Dollar Problem

As mentioned previously the costs associated with meeting mandated levels are staggering. Financial projections indicate if the bond referendum fails the average monthly rates for residential customers would increase to between \$59.90 and \$111. These rates would represent between 1.7% and 3.5% of the median household income for Nampa residents, far exceeding the EPA’s definition of affordability for wastewater service. The costs will heavily burden Nampa’s fixed and low income residents in a community where the poverty rate exceeds 22%. Fortunately, IDEQ is planning for low interest clean water state revolving loans for the city of Nampa to help constrain user rates for services. These 1.68% low interest rates for 30 years are very helpful and should bring the rates to about 1.5% of average income, the upper limit of EPA's definition of affordable. These loans are applicable only if the bond passes.

Where Are We Now?

There is a recent report on the progress of lowering total phosphorus loading in the Lower Boise River. On September 25, 2017 Lauren Perreault with the USGS posted a report "Monitoring Shows Progress Towards Reducing Boise River Phosphorus Levels". The report notes "From 2012 to 2013, the average wastewater phosphorus load from Boise, Meridian, Nampa and Caldwell was about 1387 pounds per day (lb/day). During 2015 to 2017, this load decreased by about 50% to 644 pounds per day." The report adds "in the past two years, total phosphorus (for clarification they are talking about near Parma which is their primary reference point) has declined by almost half of the amount needed to achieve the water quality target which is 0.07 mg/l." All of this predates the reductions of a number of the wastewater treatment facilities discharging into the river. Additionally, we are in the very early stages of implementing nonpoint controls. This suggests that Nampa could discharge TP at 0.5 mg/l and still meet the Gold Book standard at Parma.

Where To From Here?

Nampa shares the concern of the USEPA and IDEQ about the water quality of the Lower Boise River. In a significant commitment Nampa is spending $38 million to decrease its discharge of total phosphorus into the river system from 718 pounds per day to 75 pounds per day. This reduction of 643 pounds equates to $59,098 for every pound removed. The USEPA is demanding a reduction of another 60 pounds of total phosphorus per day, which would result in 13.8 less pounds of TP reaching Parma. This would require an additional expenditure of $38,000,000. This equates to $2,753,623 for every pound of TP not reaching Parma. This begs the question: can such large monetary expenditures be justified for what would likely be an imperceptible environmental benefit? To answer that question consider the following facts:

1) The IDEQ states in its report that "All models are mathematical approximations of a true system, with some uncertainty being an inherent component of model results".

20 The model, as applied, was conservative (over estimating needed total phosphorus reductions) with numerous assumptions, all which favored additional conservatism.

3) There is some obvious analytical error. The impact of these errors on model results is unknown.

4) There are numerous data gaps in the analysis and an statements by researchers that filling these gaps would likely lead to more robust results.

5) The TMDL assumes that all point sources will be discharging at the maximum permit limits. In order to limit liability, most facilities will, in fact, discharge less than the maximum permitted.

6) The lower Boise River is already showing significant improvement in just 2 years. Completion of Phase I at the Nampa facility, along with upgrades at other waste treatment plants and installation of Best Management Practices at nonpoint sources will result in even more improvement.

7) Phase II, requiring the expenditure of $38,000,000 would remove 60 pounds of TP per day, or 13.8 lb/day TP at Parma. Historically, daily TP loads at Parma have been in the range of 1190 lb/day. This means that the investment by Nampa would likely result in about a 1% reduction of TP in the lower Boise River. Given the uncertainty that IDEQ recognizes in the model, this would appear to be a huge misappropriation of public funds.

Models can be very impressive and have somehow taken on a reputation of invincibility. Some view it as unscientific to challenge a model but as we saw in the hurricane forecasting, just because a model has been used and refined for decades does not make it accurate. With the considerations and concerns that have been pointed out in this modeling effort it is difficult to believe that Nampa spending $2,753,623 to reduce each pound of TP at Parma is in any way justifiable. This allocation of financial resources is difficult to justify based on modeling results. As stated on page 117 “all models are mathematical approximations of a true system, with some uncertainty being an inherent component of model results”.

I am aware that there is a proposal for Nampa to discharge into the Phyllis Canal rather than Indian Creek. This scenario certainly provides environmental benefits through reuse of a valuable resource. Regardless of where the final discharge is located I feel the USEPA should yield an administrative decision that Nampa is in full compliance with the completion of Phase I.

Thanks you for your consideration. If you have any questions please don’t hesitate to contact me.

Larry Olmsted