Nevada's Nutrient Criteria Strategy – Version 2

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YSI Dissolved Oxygen Monitoring Sonde on the Carson River below Highway 395 (Cradlebaugh Bridge), Photograph by Z. Latham, June 2004

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Nevada's Nutrient Criteria Strategy

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Nevada's Nutrient Criteria Strategy

Introduction

Significant efforts are underway throughout the country to develop more appropriate nutrient criteria. Since 1998, Nevada has been participating in our Region IX RTAG (Regional Technical Advisory Group) efforts toward improved nutrient standards. While the focus of the RTAG efforts have largely been on California waters, NDEP has participated in the process in hopes of identifying an approach for improving Nevada's existing nutrient criteria. It was also thought that Nevada could potentially follow California's nutrient criteria development plan. However some of Nevada's unique needs have made it necessary to present its own criteria strategy, building off of the Region IX RTAG efforts and those of other states. While development of *Nevada's Nutrient Criteria Strategy* has been encouraged by EPA, this plan does not represent a binding commitment of NDEP to perform certain activities.

While Nevada has nutrient standards for most of the waters listed in the regulations, there are a number of problems with these criteria. Most significantly, the beneficial criteria focus on phosphorus (and not nitrogen) for eutrophication control. Another emerging challenge is the establishment of nutrient criteria for waters being added to the regulations in the future. There is a need for a consistent, scientifically defensible approach for assigning nutrient criteria to these waters. The objective of this document is to begin defining NDEP's strategy for: 1) dealing with our existing nutrient criteria., and 2) addressing future nutrient criteria needs. This document needs to be considered a living, changing document. It is expected that as more information is gathered and more experience is gained, strategy changes may be appropriate.

Background on Nutrients and Impairment

Exceedances of total phosphorus standards are common in many of Nevada's streams. However in many cases, it is not known if the phosphorus levels are actually impacting the beneficial uses, e.g. aquatic life, recreation, etc. As discussed by TetraTech (2005), the use of nutrient concentrations alone are poor predictors of assessing eutrophication impacts. Also, Dodds et al. (2002) examined data from over 600 streams and found that nutrients concentrations accounted for less than half of the variance in the benthic algae biomass. They speculated that other factors, such as flow, light availability, channel conditions, grazing, were responsible for the remaining variability. In a detailed study of Colorado streams, Lewis, Jr. and McCutchan, Jr. (2005) found even less of a relationship between nutrient concentrations and benthic biomass, with DIN (dissolved inorganic nitrogen) accounting for only 15% of the variance. No statistically significant relationship was found between benthic biomass and other nitrogen and phosphorus species.

Given the problems of relying on nutrients concentrations to predict impairment, perhaps a more direct initial indicator of whether or not a stream is nutrient impaired is with estimates (qualitative or quantitative) of algal biomass. While some algae is a necessary component of the ecosystem, excessive algae can impact the beneficial uses in a variety of ways. According to EPA (2000):

> *"Algae are either the direct or indirect cause of most problems related to excessive nutrient enrichment, e.g. algae are directly responsible for excessive, unsightly periphyton mats or surface plankton scums, and may cause high turbidity, and algae are indirectly responsible for diurnal changes in DO and pH"*

Due to its importance as an impairment indicator, algae monitoring is an important component of any nutrient investigation. However, it is important to recognize that algal biomass levels can be highly variable with time and space and that some understanding of algal dynamics is necessary before designing the appropriate protocols. Following is a brief description of the main factors affecting benthic and planktonic algae biomass levels. Any one or more could be a factor in determining algal biomass at a given place and at a given time:

Nutrient concentrations: Nitrogen and phosphorus are the main nutrients that cause excessive algal growth (EPA, 2000) and nutrient concentrations can affect algae growth rates. However, there can be a time lag between nutrient enrichment and algal response in streams (EPA, 2000). It is interesting to note that "*…Diatoms are usually the first to establish, with more time required for FGA [filamentous green algae] to colonize due to their more complex reproduction requirements*" (EPA, 2000).

Another confounding factor is the possible existence of a diel fluctuation in the nutrient concentrations in streams with algal activity. In his recent modeling of the Carson River (a nitrogen-limited system in Nevada), Latham (2005) simulated a diel fluctuation in nitrate levels from 0.0 in the middle of the day to around 0.1 mg/l (as N) in the night. Though no data have been collected to confirm this fluctuation, it should not be unexpected given the low nitrogen in this system and the fact that the algal photosynthesis activity (and its consumption of nutrients) is peaking during the day and shutting down at night. Nolan et al. (1995) sampled Little Lost Man Creek in Northern California approximately every 2-hours for a 2-day period and found nitrate levels fluctuating from about 0.028 mg/l in the afternoon to 0.042 mg/l in the evening. Kent et al. (2005) monitored algal productivity and nitrogen levels in an effluent dominated concrete lined stream and found total nitrogen levels fluctuating from approximately 3 mg/l (as N) during the daylight hours up to approximately 8 mg/l (as N). Gregory (1979) found a greater than 80% decrease in nitrate levels from the midnight to mid-day concentrations for fifth order streams in Oregon. This information suggests that a grab sample in the middle of the day may not be indicative of levels available for algal growth, particularly in systems with low nitrogen or phosphorus and/or high algae activity.

Flow/Storage Volume: Algal biomass varies with time with peak levels generally occurring during the summer when stream flows are low and temperatures high. Biomass levels can vary from year to year, with higher flows leading to lower temperatures and possibly less algae. Another consideration is the time since the system has experienced a scouring-flow event. Biggs (2000) found that 62 percent of the variance in peak biomass was explained by the time since the last flood event (Figure 1.) Similarly for Colorado streams, Lewis, Jr. and McCutchan, Jr. (2005) found a positive relationship between periphyton biomass and time elapsed since the beginning of the growing season.

Algae growth in reservoirs can be influenced by the residence time of the water with higher residence time waters experiencing higher algal biomass (U.S. EPA, 2000). Lake/reservoir morphometry and the management of reservoirs can impact algal biomass. Based on a study of selected Nevada lakes and reservoirs, Reuter et al. (1991) concluded that those waterbodies with shallower mean depths are more likely to develop eutrophication problems than the deeper waters.

Temperature: Increased water temperature are known to increase biological activity, including algae growth (Tetra Tech, 2002). However, cladophora algae has been found to die-off at stram temperatures exceeding 23.5 °C (Dodds and Gudder, 1992). These die-off events can lead to low dissolved oxygen levels as the algae decay. On the other end of the spectrum, lower temperatures can lead to lower algal biomass. Lewis, Jr. and McCutchan, Jr. (2005) identified an inverse relationship between periphyton biomass and elevation, therefore an positive relationship between biomass and temperature.

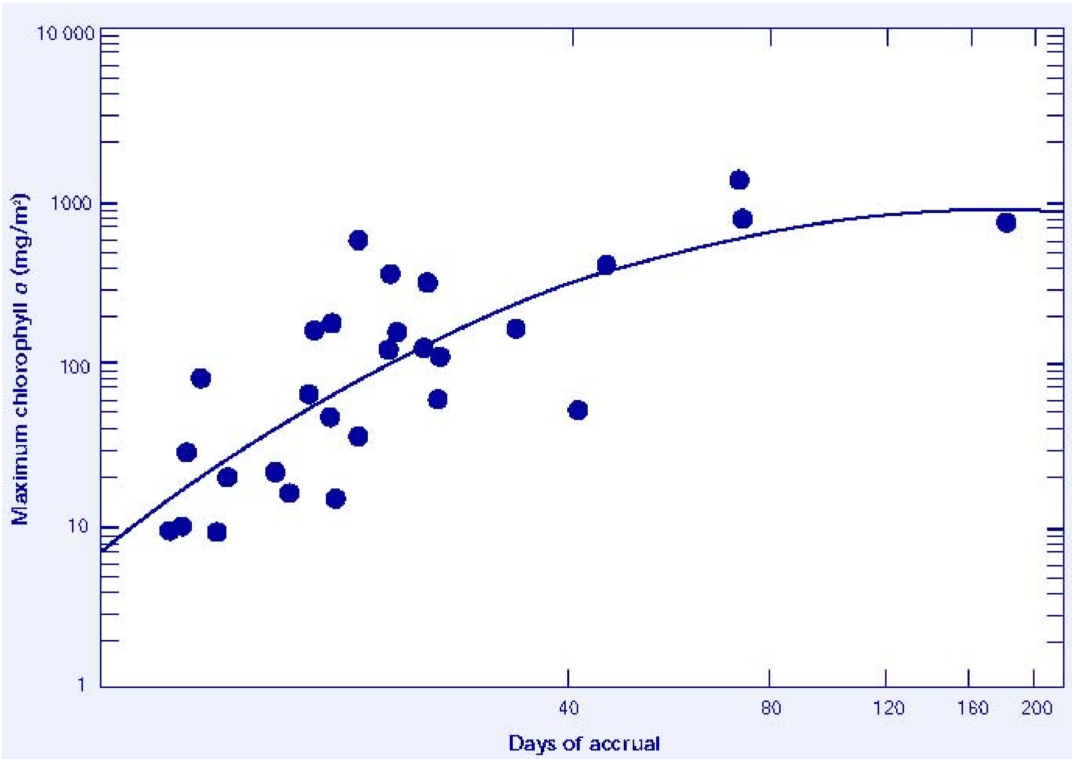

Figure 1. Maximum Chlorophyll a Concentrations in Benthic Algae as a Function of Mean Days Since Last Flood Event (from Biggs, 2000)

Shading/light: Welch and others (1992) have found that stream shading can substantially reduce algal production. High turbidity levels (>10 NTU) can also inhibit periphyton growth (Quinn et al., 1992). Another shading source to consider is the topography of the surrounding landscape. In lakes/reservoir with high turbidity, light penetration into the upper water column can be limited thereby having an affect upon planktonic algae growth.

Substrate conditions: Large, rough substrates are the best habitat for periphyton due to its need to attach to objects. Sedimentation on top of rocky substrate can decrease periphyton biomass (Welch et al., 1992).

Biological community structure: Steinman (1996) has found that dense populations of algae consuming grazers can lead to negligible algal biomass, even with high nutrient levels. Also, there is some evidence that bacteria may outcompete algae for nutrients and secrete allelopathic substances that inhibit algal growth (EPA N-Steps Website, 2007).

Cyanobacteria: Relationships between water column nutrient levels and algal biomass can be confounded by cyanobacteria, which have the ability to fix nitrogen from the atmosphere (Welch and Jacoby, 2004). As a result, low nitrogen in the water column could contribute to growth of cyanobacteria

Background on EPA Guidance

During the 1990s, reports on water quality conditions were indicating that nutrients were a leading cause of waterbody impairment throughout the country. At that time, many states did not have numeric nutrient criteria in their water quality standards. In 1998, President Clinton and Vice President Gore released their Clean Water Action Plan which called on EPA to increase nutrient criteria development efforts. Later that same year, EPA released the *National Strategy for the Development of Regional Nutrient Criteria* describing their approach in developing nutrient information and working with states and tribes in the adoption of nutrient criteria. Since the issuance of this strategy, EPA has produced some key documents in support of nutrient criteria development:

- *Nutrient Criteria Technical Guidance Manual: Rivers and Streams (2000); Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs* (2000)

  These documents "…*provide scientifically defensible technical guidance to assist States and Tribes in developing regionally-based numeric criteria and algal criteria*…"

- Four documents (covering Nevada and other areas) generally titled *Ambient Water Quality Criteria Recommendations – Information Supporting the Development of State and Tribal Nutrient Criteria*

  - Rivers and Streams in Nutrient Ecoregion II (Western Forested Mountains) (2000)
  - Lakes and Reservoirs in Nutrient Ecoregion II (Western Forested Mountains) (2000)
  - Rivers and Streams in Nutrient Ecoregion III (Xeric West) (2000)
  - Lakes and Reservoir in Nutrient Ecoregion III (Xeric West) (2000)

  These documents present EPA 304(a) nutrient criteria for Ecoregion II and III (portions of which are within Nevada). See Section **EPA 304(a) Criteria** section for more detail.

On January 9, 2001, EPA issued a memorandum recommending that states develop a nutrient criteria plan to describe their intended process for replacing narrative criteria with numeric criteria. However, EPA has always considered that Nevada already has numeric nutrient water quality standards and has not been looking to NDEP for such a document. While Nevada has nutrient standards for most of the waters listed in the regulations, the beneficial criteria focus on phosphorus (and not nitrogen) for eutrophication control.

As part of EPA's *National Strategy*, Regional Technical Assistance Groups (RTAG) (consisting of EPA staff, representatives from the states within the region, etc.) were formed throughout the U.S. to facilitate improved nutrient criteria development. Within EPA Region IX, EPA, Nevada, Arizona and California agency representatives have been participating in a series of RTAG meetings and publication reviews. Following considerable work, the RTAG recently released a final report presenting a nutrient criteria development approach for California. The RTAG findings are discussed in more detail in the **EPA Region IX RTAG Findings** section of this report

EPA 304(a) Criteria

In 2001, EPA published recommended water quality criteria for nutrients under Section 304(a) of the Clean Water Act, with the intention that they serve as a **starting point.** EPA strongly encourages states and tribe to refine these recommendations following key elements in the EPA Technical Guidance Manuals. States and tribes are encourage to address both chemical causal variables (nitrogen, phosphorus) and early indicator response variables (chlorophyll-a, turbidity) in the development of criteria or procedures for translating narrative criteria.

EPA recommends 3 options for developing nutrient criteria (in order of preference)

1. Develop criteria that fully reflect localized conditions and protect specific designated uses, using EPA's Technical Guidance Method. Such criteria may be expressed either as numeric criteria or as procedures to translate a state or tribal narrative criterion into a quantified endpoint
2. Adopt EPA's 304(a) Criteria Recommendations, either as numeric criteria or as procedures to translate narrative criterion into a quantified endpoint.
3. Develop a Unique System using – empirical approaches, loading models, cause and effect based studies/relationships, other analytical tools.

Rivers and Streams

In developing their 304(a) recommendations for rivers and streams, EPA first compiled datasets from Legacy STORET, NASQAN, NAWQA from 1990 to 1998. Using these data, EPA calculated assumed "reference" conditions for various parameters within each ecoregion (Level III). EPA's Technical Guidance Manual for Developing Nutrient Criteria for Rivers and Streams describes 2 ways to establish reference values:

1. Choose the 75^{th} percentile of a population of reference streams. This is EPA's preferred way to establish reference conditions. The 75^{th} percentile was selected since it is likely associated with minimally impacted conditions, and will be protective of designated uses.
2. When reference streams are not identified, use the 25^{th} percentile of the entire population of data to represent a surrogate for an actual reference population. According to EPA, case studies have indicated that the 25^{th} percentile from an entire population roughly approximates the 75^{th} percentile of the reference population.

In the determination of the 304(a) criteria for our region, EPA did not have information on minimally impacted sites available on a national basis, so they relied on the 25^{th} percentile of the available data (within an ecoregion) for the establishing the criteria. One problem with this approach is that it automatically assumes that 75% of the streams are impaired for nutrients. **Another problem is that the STORET data do not include all of NDEP's data.** Table 1 summarizes the recommendations for the Nevada ecoregions. Figure 2 shows the location of the various Level III ecoregions in Nevada. In lieu of using the 304(a) criteria, States and tribes are encouraged to determine their own reference sites, compile additional data and evaluate at finer geographic scales.

Table 1. Recommended Criteria for Level III Ecoregion Rivers and Streams, mg/l (25th Percentile)

Parameter	Ecoregion 5 (Sierra Nevada)	Ecoregion 13 (Central Basin and Range)	Ecoregion 14 (Mojave Basin and Range)	Ecoregion 80 (Northern Basin and Range)
TKN	0.10	0.228	0.288	0.23
NO2 + NO3	0.01	0.038	0.353	0.025
TN (calculated)	0.11	0.266	0.641	0.255
TN (reported)	0.29	0.425	0.67	0.483
TP	0.015	0.0288	0.010	0.055

<u>**Lakes and Reservoirs**</u>

EPA's 304(a) recommendations for lakes and reservoirs were developed in a similar manner to the river and stream recommendations. The resulting recommendations are summarized in Table 2.

Table 2. Recommended Criteria for Level III Ecoregion Lakes and Reservoirs, mg/l (25th Percentile)

Parameter	Ecoregion 5 (Sierra Nevada)	Ecoregion 13 (Central Basin and Range)	Ecoregion 14 (Mojave Basin and Range)	Ecoregion 80 (Northern Basin and Range)
TKN	0.24	0.34	na	0.016
NO2 + NO3	na	0.01	na	0.01
TN (calculated)	na	0.35	na	0.17
TN (reported)	0.25	0.51	na	na
TP	0.015	0.030	na	0.086
Secchi (m)	na	2.3	na	2.8
Chlorophyll-a (ug/l)	na	1.9 – 3.5	na	3.1 – 4.4

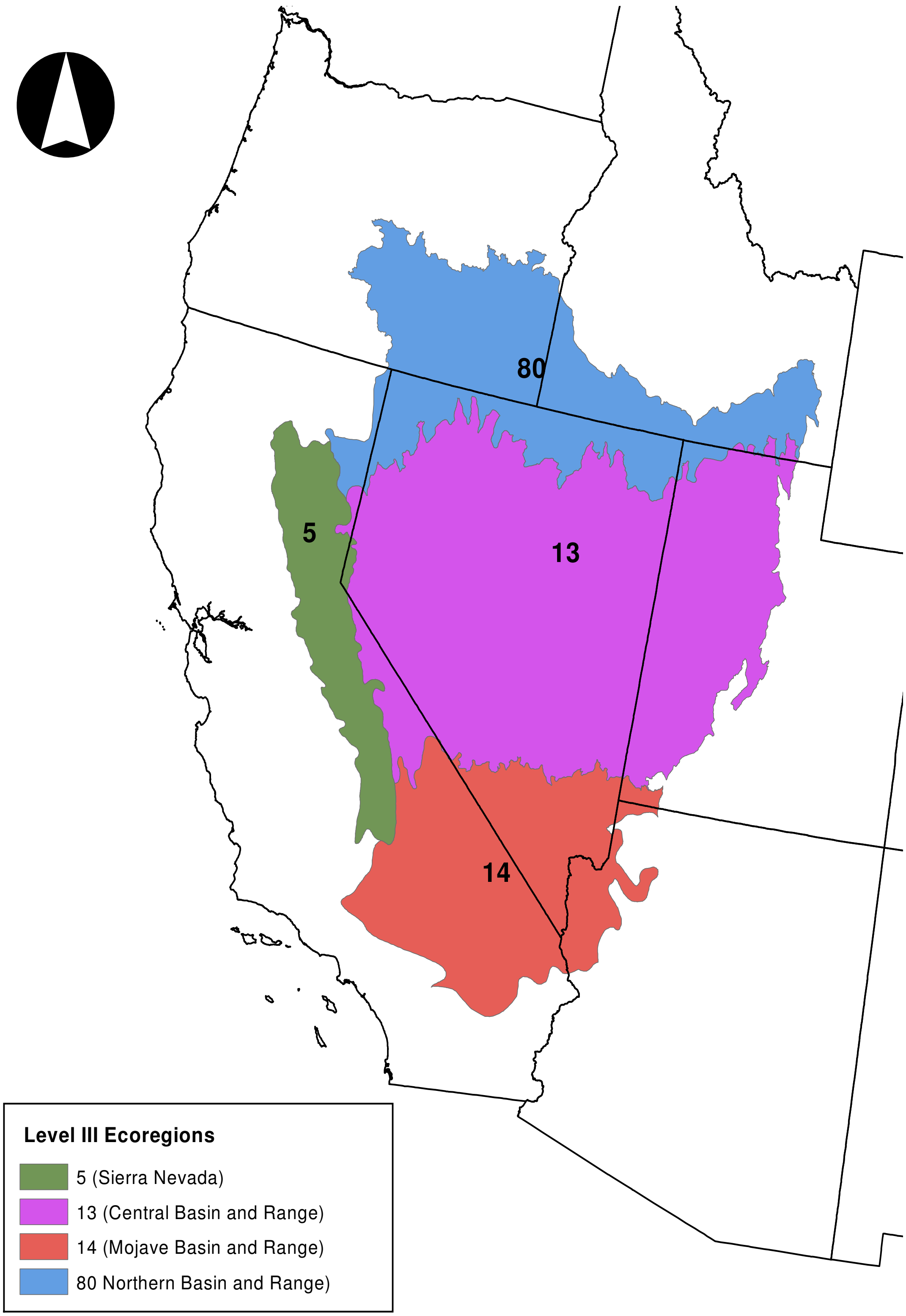

Figure 2. Level III Ecoregions in Nevada

EPA Region IX RTAG Findings

Since 1998, Nevada has been participating in Region IX RTAG meetings with representatives from EPA, California, Arizona, consulting firms, research organizations, etc. While the focus of the RTAG efforts have largely been on California waters, NDEP has participated in the process in hopes of identifying an approach for improving Nevada's existing nutrient criteria. It was also thought that Nevada could potentially follow California's nutrient criteria development plan.

With the assistance of TetraTech, the Region IX RTAG has made progress toward improved nutrient standards. A comparison of the EPA 304(a) criteria with the findings of a pilot study indicated the use of the 304(a) criteria would result in numerous waters being misclassified as impaired. Overall, the RTAG concluded that nutrient concentrations (both nitrogen and phosphorus species) alone are poor predictors of the likelihood of impairment. Other factors such as substrate conditions, light, flow, turbidity, days of accrual, etc. also affect algal dynamics and potential dissolved oxygen problems. TetraTech and the RTAG have concluded that other secondary indicators (such as benthic algae density, dissolved oxygen) provide more direct evidence of nutrient impairment status. Therefore, the RTAG decided to pursue an alternative approach to EPA's 304(a) criteria. However it is believed that additional data are needed throughout California to better understand the linkages between nutrients and these secondary indicators.

The proposed California approach calls for the generation of site-specific nutrient numeric endpoints as part of TMDL development activities throughout the state. Overtime, a robust database will accumulate with improved nutrient and secondary indicator data that the Regional Water Boards could use "*to move beyond these site-specific applications"* and set water quality standards. To assist the Regional Board in the development of nutrient numeric endpoints, TetraTech and the RTAG developed a unique approach that includes:

- A beneficial use risk classification framework
- Risk-based secondary indicators
- Modeling tools to link secondary indicators to nutrient concentrations

According to TetraTech and the RTAG (2005), "*for many of the biological indicators associated with nutrients there is not clear scientific consensus on a target threshold that results in impairment*." Three Beneficial Use Risk Categories (BURC) have been proposed to begin addressing this problem:

> BURC I – waterbodies are not expected to exhibit nutrient impairment (presumptively unimpaired)
> BURC II – waterbodies may require additional information and analysis to determine status (potentially impaired)
> BURC III – waterbodies have a high likelihood of exhibiting nutrient impairment (presumptively impaired)

In support of this classification system, the RTAG agreed upon some secondary indicator values defining the boundaries between each of these BURCs (See Table 3). For translating the secondary indicators into numeric nutrient criteria, TetraTech provided some simplified modeling tools. However, the RTAG recognizes that more detailed modeling tools may be needed for some TMDLs. The RTAG emphasizes that these tools are only a single line of evidence and need to be used as part of an overall approach with multiple lines of evidence considered.

Table 3. Nutrient Numeric Endpoints for Secondary Indicators – EPA Region IX RTAG

<table>
<tr><th rowspan="2">Response Variable</th><th rowspan="2">Risk Category</th><th colspan="7">Beneficial Use</th></tr>
<tr><th>COLD</th><th>WARM</th><th>REC-1</th><th>REC-2</th><th>MUN</th><th>SPWN</th><th>MIGR</th></tr>
<tr><td rowspan="3">Benthic Algal Biomass (chl-a, mg/m2) – Maximum</td><td>I</td><td><100</td><td><150</td><td rowspan="3">C</td><td rowspan="3">C</td><td><100</td><td><100</td><td rowspan="3">B</td></tr>
<tr><td>II</td><td>100 - 150</td><td>150 - 200</td><td>100 - 150</td><td>100 - 150</td></tr>
<tr><td>III</td><td>>150</td><td>>200</td><td>>150</td><td>>150</td></tr>
<tr><td rowspan="3">Planktonic Algal Biomass in Lakes and Reservoirs (chl-a, ug/l) – summer mean</td><td>I</td><td><5</td><td><10</td><td><10</td><td><10</td><td><5</td><td rowspan="3">A</td><td rowspan="3">B</td></tr>
<tr><td>II</td><td>5 – 10</td><td>10 - 25</td><td>10 - 20</td><td>10 -25</td><td>5 - 10</td></tr>
<tr><td>III</td><td>10</td><td>25</td><td>20</td><td>25</td><td>10</td></tr>
<tr><td rowspan="3">Clarity (Secchi depth, m) – summer mean</td><td>I</td><td rowspan="3">A</td><td rowspan="3">A</td><td>>2</td><td>>2</td><td rowspan="3">A</td><td rowspan="3">A</td><td rowspan="3">B</td></tr>
<tr><td>II</td><td>1 - 2</td><td>1 – 2</td></tr>
<tr><td>III</td><td><1</td><td><1</td></tr>
<tr><td rowspan="3">Dissolved Oxygen (mg/l) – Streams, mean of 7 daily minimums</td><td>I</td><td>>9.5</td><td>>6.0</td><td rowspan="3">A</td><td rowspan="3">A</td><td rowspan="3">A</td><td>>8.0</td><td rowspan="3">C</td></tr>
<tr><td>II</td><td>5.0 – 9.5</td><td>4.0 – 6.0</td><td>5.0 – 8.0</td></tr>
<tr><td>III</td><td><5.0</td><td><4.0</td><td><5.0</td></tr>
<tr><td rowspan="3">pH maximum – photosynthesis driven</td><td>I</td><td><9.0</td><td><9.0</td><td rowspan="3">A</td><td rowspan="3">A</td><td rowspan="3">A</td><td rowspan="3">C</td><td rowspan="3">C</td></tr>
<tr><td>II</td><td>9.0 – 9.5</td><td>9.0 – 9.5</td></tr>
<tr><td>III</td><td>9.5</td><td>9.5</td></tr>
<tr><td rowspan="3">Dissolved Organic Compounds</td><td>I</td><td rowspan="3">A</td><td rowspan="3">A</td><td rowspan="3">A</td><td rowspan="3">A</td><td><2</td><td rowspan="3">A</td><td rowspan="3">A</td></tr>
<tr><td>II</td><td>2 – 5</td></tr>
<tr><td>III</td><td>>5</td></tr>
</table>

A = no direct linkage
B = more research needed to quantify linkage
C = addressed by aquatic life criteria
COLD = coldwater fishery; WARM = warmwater fishery; REC-1 = non-contact recreation; REC-2 = contact recreation; MUN = municipal supply; SPWN = fish spawning; MIGR = fish migration

As part of an initial effort to test this approach, eight pilot waterbodies through California are being evaluated following the RTAG procedures and associated modeling tools. These waterbodies either have a TMDL that is completed or underway. RTAG recommendations for continued refinement of the California approach include:

- ❑ Supply collected data from the pilot waterbodies into California State Water Boards databases
- ❑ If the Regional Water Boards approve the approach, they should consider development of draft waterbody impairment assessments based on the proposed BURC
- ❑ Develop monitoring guidance for all secondary indicator parameters (algae, dissolved oxygen, etc.) and procedures for conducting BURC impairment assessments

As future work within this framework occurs, refinements can be made with the classification system, secondary indicators and linkage analysis models. It is still uncertain how this information will be translated into numeric water quality standards.

Upon review of Tetra Tech's most recent document for the RTAG (*Technical Approach to Develop Nutrient Numeric Endpoints for California*, 2006), NDEP believes that a different approach may be appropriate for Nevada. Like California, Nevada also needs more data to better understand linkages between nutrients and secondary indicators, such as algal biomass. However, Nevada is not likely to pursue the collection of these data through its TMDL program. While there are numerous waterbodies on Nevada's Draft 2006 303(d)/305(b) Integrated Report for exceedances of total phosphorus standards, there is great uncertainty as to which waters actually have eutrophication problems and for which TMDLs may be appropriate. Nevada is opposed to developing TMDLs for listed waters unless impairment can be confirmed through additional lines of evidence, such as algal biomass or dissolved oxygen.

Nevada's Nutrient Criteria Approach

As previously discussed, Nevada has established nutrient criteria for many of its waters. While these criteria have shortcomings, NDEP is still required to use these criteria as our basis for the 303(d) Listing analyses. This document attempts to address strategies for dealing with issues associated with the existing standards, along with strategies for working toward improved nutrient standards for all waters.

Existing Nutrient Criteria

An understanding of Nevada's existing nutrient criteria is a necessary first step before developing an overall strategy. Nevada's water regulations contain two types of nutrient criteria: beneficial use criteria and RMHQs (Requirements to Maintain Existing Higher Quality).

- The beneficial use criteria have generally been derived from EPA guidance as needed to protect the most restrictive use.
  - Phosphorus – Most of the waters have TP standards ranging from 0.05 to 0.10 mg/l for the protection of aquatic life.
  - Nitrogen – Most of the waters have Nitrate standards of 10 mg/l (as Nitrogen) for the protection of drinking water uses. Nevada regulations contain no beneficial use nitrogen limits for the control of eutrophication. The Truckee River has a nitrate standard of 2 mg/l (as N) due to toxicity concerns related to Lahontan Cutthroat Trout. No waters have Total Nitrogen beneficial use standards.
  - Dissolved Oxygen – most waters have DO standards of 5.0 or 6.0 mg/l.
- RMHQs are part of Nevada's antidegradation policy. Under the current approach, discharge permit limitations are set based upon RMHQs if they exist for the particular water. If they do not exist, beneficial use standards are used for setting effluent limits. RMHQs are generally calculated as the 95th percentile of the historic sample data. RMHQs are set for reaches where the 95th percentiles are better quality than the Beneficial Use standard.
  - Phosphorus – Most Phosphorus RMHQs have been set for TP. The Truckee River has both TP and OP RMHQ values.
  - Nitrogen – Most of the nitrogen RMHQs have been set for TN. A few waters have nitrate RMHQs.

While several waterbody reaches have TN RMHQs and are meeting these RMHQs, one should not assume that all of these waters are free from eutrophication problems.

Monitoring Efforts to Date

Ambient Water Quality Monitoring

Over the years, BWQP has maintained a water quality database for over 700 sites (streams, lakes, reservoirs) throughout Nevada with much of the data starting as early as the mid-1960s. However the amount of data per site is highly variable, with ~½ of the sites in the database having only 5 or fewer sampling events and ~10% of the sites with more than 100 sampling events (as of September 2008). A majority of these data are for routine parameters (such as pH, nutrients, TSS, turbidity, TDS, color, etc.) and dissolved/total metals in the water column.

Historically, the monitoring network has been relatively static with little variation from year to year. Occasionally, stations were added or dropped as needed to address special needs. Recently, BWQP implemented a rotational design for its ambient water quality monitoring program. Under this new approach, more detailed monitoring and associated standards reviews activities are applied to a given region of the state on a rotational basis, moving into a new region about every 2-3 years depending upon resources.

Biomonitoring and Assessment

BWQP and EPA have been performing bioassessment monitoring at reference, targeted, and probabilistic sites throughout the state since 2000. Originally, bioassessment data were collected using targeted riffle protocols developed by California (Harrington, et al., 2000). More recently, BWQP has been collecting bioassessment samples/data using reach/transect protocols (Western EMAP, National Rivers and Streams Assessment). Much of this work has been supported by Clean Water Act Section 106 Monitoring Initiative funds. In a push to develop statistically-valid assessment, EPA is providing financial incentives (through Monitoring Initiative funds) to those states that implement state-scale statistically-valid sampling/surveys as part of their monitoring program. To meet EPA's minimum requirements and qualify for additional Monitoring Initiative funds, Nevada needs to monitor at least 10 sites per year over a 5 year period on a rotating basin approach or another appropriate method. BWQP believes that bioassessment data are key to developing more appropriate effects-based water quality standards and has agreed to include a state-scale probabilistic survey into its overall program to increase our biodatabase. BWQP expects to meet these minimum requirements (10 probabilistic sites per year) and also monitor several additional targeted and reference sites each year.

Proposed Approach

Nevada's proposed approach draws from several methods presented by other states and EPA. The foundation of the strategy is the well-recognized conclusion that nitrogen/phosphorus levels alone are poor indicators to nutrient problems. A goal of Nevada's strategy is to begin using nutrient, DO and biological data together to determine beneficial use impairment. It is difficult to impossible to reduce our complex water systems to a simple set of numeric nutrient values. There will be considerable uncertainty with any criteria that are utilized, therefore considerable flexibility is needed in dealing with nutrient issues. Unfortunately, water quality standards have tended to focus on black-and-white demarcations between unimpaired and impaired conditions, with little room for flexibility.

EPA recognizes the need to move beyond just water chemistry for nutrient standards. In a May 26, 2007 memorandum, Benjamin Grumbles, EPA Assistant Administrator, encourages the adoption of standards for both causal (both nitrogen and phosphorus) and response (chlorophyll-a and transparency) variables.

Whatever Nevada chooses to do, it needs to:

- ❑ Be scientifically defensible and protect the designated uses
- ❑ Consider the potential effects of the proposed criteria on downstream water quality and uses

Short-Term Strategy

Until more progress is made in developing appropriate nutrient criteria, the following short-term strategies are recommended, separated into 2 divisions: 1) addressing waters with existing nutrient criteria; and 2) addressing new waters to be added to the regulations. A slightly different approach is suggested for these 2 water classifications. There are a number of waters in the state that are not specifically mentioned in the regulations, yet warrant improved protection. Part of the NDEP Long Range Plan is to include more of these waterbodies in the water quality regulations.

1. Nitrogen/phosphorus Criteria

a. **Existing Waters:** ***Continue to use existing phosphorus criteria in the regulations as appropriate.***
   - Since phosphorus criteria are in the regulations, NDEP is required to use these values in determining use status for the 303(d) Impaired Waters List (Category 5 of the Integrated Report). Currently, the ability to revise these values is thought to be limited. However, the existing phosphorus criteria will be used as indicators of "potential" use support or impairment. Multiple lines of evidence such as algae biomass, DO data, etc. along with water chemistry could be used to assess the actual support status (as resources allow). EPA has agreed that NDEP could use a weight of evidence approach to determine whether or not listing or delisting is appropriate, regardless of exceedances of TP standards.
   - For waters on the 303(d) List for phosphorus, followup activities should take place (as resources allow) to determine whether or not nutrient-related problems exist (excess algae, depressed DO) and what may be appropriate next steps (such as delisting, TMDLs, etc.) – See *Nevada's Nutrient Assessment Protocols for Wadeable Streams* (NDEP, 2009) and *Nevada's Nutrient Assessment Protocols for Lakes and Reservoirs* (NDEP, 2008) for discussions on approaches for determining use support status.

b. **New Waters:** ***Numeric nutrient criteria should <u>not</u> be added to the regulations, unless available data/information suggest otherwise. Instead, preliminary P, N and chlorophyll-a indicators should be established for assessment purposes only.***
   - **Streams:** When N and/or P indicators are exceeded as presented in *Nevada's Nutrient Screening Indicators for Wadeable Streams* (NDEP, 2009), followup assessment activities should take place (as resources allow). See *Nevada's Nutrient Assessment Protocols for Wadeable Streams* (NDEP, 2009) for discussions on approaches for determining use support status. It is anticipated that the current P and N indicators will be refined and tested as more data are collected as part of the Long-Term Strategy.
   - **Lakes/reservoirs:** It may be appropriate to develop waterbody specific criteria for a given lake/reservoir depending upon NDEP's resources. This would require some detailed monitoring and analyses along with a review of available literature to assist in the evaluation. In lieu of setting specific criteria in the NAC, an alternative would be to establish N, P and chl-a indicators that could be used to identify the need for additional investigations. *Nevada's Nutrient Assessment Protocols for Lakes and Reservoirs* (NDEP, 2008) lays out the use of chlorophyll-a indicators. Like the stream indicators, the lake/reservoir indicators could be tested and refined over time.

2. Narrative Standard

a. Existing and New Waters: ***Add a narrative standard to the NAC to address algal growth.***

- Currently, the NAC does not include any narrative standard explicitly for algal growth. It is recommended that such a narrative standard be added to the regulations. Protocols for applying the narrative standard are described in *Nevada's Nutrient Assessment Protocols for Wadeable Streams* (NDEP, 2009) and *Nevada's Nutrient Assessment Protocols for Lakes and Reservoirs* (NDEP, 2008).

3. Dissolved Oxygen Standard

a. Existing Waters: ***Continue to use existing dissolved oxygen standards in the regulations;*** New Waters: ***Add dissolved oxygen standards in the regulations.***

- It is well recognized that DO is an important indicator of eutrophication problems and that appropriate DO monitoring (early morning readings to capture daily low values) needs to a part of the protocols for evaluating nutrient impairment status. However, it needs to be recognized that in streams, DO criteria may not be protective from other modes of nutrient impairment for aquatic life (physical habitat impacts) and recreation (aesthetics). Experience with Nevada rivers suggests that algae levels need to be rather "excessive" before DO levels below 5 mg/l are observed. Prior to reaching these "excessive" levels, the algae are likely impairing recreation uses and aquatic life through modes other than dissolved oxygen.

4. Antidegradation Protection

a. Existing and New Waters: ***Improve antidegradation protection***

- Currently, Nevada implements antidegradation requirements through the setting of RMHQs (Requirements to Maintain Existing Higher Quality) limits in the NAC. While RMHQs are not used in determining 303(d) impairment, they are used in setting effluent limits for discharge permits. For the new waters, nutrient protection could be provided with the addition of RMHQs (total nitrogen, dissolved inorganic nitrogen, total phosphorus, orthophosphates) depending upon the availability of sufficient data. However, it is unlikely that sufficient data will exist for many of these waters.
- Nevada is embarking on the development of an improved antidegradation policy. Under the current RMHQ approach, only those few waters with RMHQs are offered antidegradation protection. The new policy will hopefully provide antidegradation protection of all waters with higher quality water as appropriate.

Long-Term Strategy

As stated earlier, many states and others have concluded that nutrient levels are not a good indicator of eutrophication impairment. Attempts in other states to develop relationships between N and P levels and stream impairment status have met with minimal success. The literature suggests that there has been better success at establishing relationships between nutrients and algal biomass for reservoirs/lakes, however there is still considerable uncertainty in these relationships and they may not be appropriate for a specific waterbody (Welch and Jacoby, 2004).

With that in mind, it seems that future nutrient criteria may need to incorporate considerable flexibility recognizing all the other factors that play a role in eutrophication (shading, flow, substrate, etc.) along with consideration given to responses (algae, macroinvertebrates, DO, etc.). Unfortunately, this can be challenging as water quality standards have historically focused on black-and-white N and P demarcations between "use support" and "use impairment". A more robust approach is needed than the traditional use of N and P criteria. Therefore, the overarching goal for the long-term strategy is to develop/refine a multiple line of evidence approach, incorporating factors such as nutrients, algal conditions, macroinvertebrate conditions, etc. into the nutrient impairment analysis.

To assist in the implementation of the Short Term Strategy, the following documents have been developed:

- *Nutrient Assessment Protocols for Wadeable Streams in Nevada* (2009)
- *Nutrient Asssessment Protocols for Lakes and Reservoirs in Nevada* (2008)
- *Nevada's Nutrient Screening Indicators for Wadeable Streams* (2009)

These documents present some initial protocols to use in assessing nutrient impairment status. The intent of the Long Term Strategy is to build off of these efforts and develop a robust weight of evidence approach.

Three basic steps have been identified for the long-term strategy:

1. Continue existing sampling program for nutrients, algae characterization, physical conditions, macroinvertebrates, etc. and look for opportunities to augment efforts
2. Test protocols, indicators, and other weight of evidence factors, and refine as appropriate
3. After adequate testing, consider incorporating weight of evidence approach in the regulations

1. Continue existing sampling program for nutrients, algae characterization, physical conditions, macroinvertebrates, etc. and look for opportunities to augment efforts

Additional data are needed to support the development and refinement of a multiple line of evidence approach. At this time, there is little algae (benthic and planktonic) data for Nevada waters (streams, lakes, reservoirs). Only recently has our biomonitoring efforts included benthic algae sampling for chlorophyll-a in streams. Additionally, limited chlorophyll-a data exists for only a handful of lakes/reservoirs. A key part of Nevada's strategy is to continue our current monitoring program and seek means to collect more data on algae, nutrients, etc. as resources allow; and to promote opportunities with others such as EPA, DRI, USGS, BLM, USFS, etc. to assist in the development of algae, nutrient, physical condition information, etc. A long term goal is to collect data for a range of waterbody types, with varying use support/impairment conditions (from reference sites to 303(d) listed waters), within various geographic areas throughout Nevada. It may be appropriate to target some of the same sites that have been monitored in the past as part of the biomonitoring efforts. Ultimately, a significant level of biological data will be needed in order to develop appropriate effects-based nutrient criteria for aquatic life protection.

River and Streams

Future monitoring of rivers and streams is recommended to include the following as appropriate:

- N and P species (**NOTE: current State Lab detection limits for nitrates (0.1 mg/). Lower detection limits are recommended for detailed investigations**)
- dissolved organic carbon
- periphyton chlorophyll-a and AFDM (ash-free dry mass)
- periphyton species composition
- algal percent cover of substrate, N/P/C stoichiometry of algae
- diel DO monitoring
- diel temperature monitoring
- diel pH monitoring
- physical conditions (shading, substrate, flow, channel characteristics (slope, width, depth, etc.))
- macroinvertebrates
- streamflow

In many of Nevada's streams, nutrients can be more of a concern during the summer when algae growth is typically at its highest. With that in mind, it may be more valuable to perform more nutrient monitoring during the algae growth season than during other times of the year. Also, algal conditions for a given waterbody can have great temporal and spatial variability. For a given water, it will be desirable to monitor at a number of locations several times during the growing season (or longer), possibly for multiple years.

Under the bioassessment program, significant levels of nutrient, macroinvertebrate and physical condition information has been collected for a variety of streams throughout Nevada. It is anticipated that these data will be useful in identifying aquatic life effects-based nutrient criteria based upon relationships between N/P and macroinvertebrate metrics (similar to Figure 3). BWQP's current strategy includes the continuation of bioassessment monitoring following EMAP-type protocols for selected sites.

The literature provides a variety of benthic algal biomass (chlorophyll-a) thresholds (most ranging from 100 to 200 ug/l chl-a) recommended for the protection of aquatic life and recreation uses (see *Nevada's Nutrient Assessment Protocols for Wadeable Streams* (2009)) that may be useful in assessment our streams. However, little information can be found describing the sampling design needed to collect the appropriate algal samples for comparison to these thresholds. Two general approaches exist for collecting benthic algae samples: 1) targeted approach in which a specific type of substrate is sampled; and 2) multihabitat/reachwide approach[1] in which samples are collected at transect locations covering a variety of substrate conditons. The approach presented in *Nutrient Assessment Protocols for Wadeable Streams in Nevada* (NDEP, 2009) describes a targeted approach where sampling is limited to a 100 meter reach regardless of stream width.

[1] The multihabitat/reachwide approach is the technique most common with bioassessment monitoring and is used by Nevada's bioassessment crews. Under the EMAP protocols, algae biomass samples are collected at 11 transects equally spaced out over a stream reach (set at 40 x stream width), with the 11 samples composited for chlorophyll-a analysis.

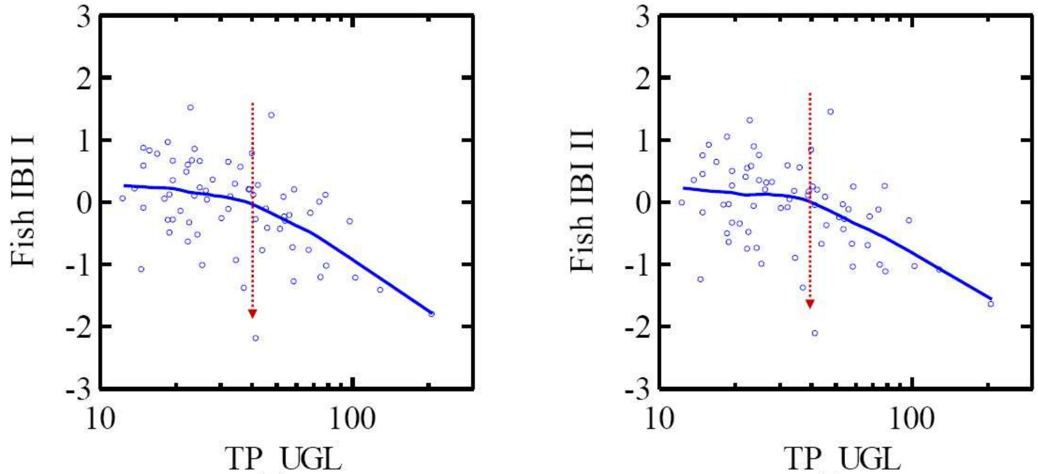

Figure 3. Use of Fish IBI to Develop Effects-Based TP Criteria (taken from Stevenson presentation posted on N-Steps Website - http://n-steps.tetratech-ffx.com/)

While the Nevada bioassessment data will be invaluable in developing aquatic life effects-based nutrient criteria, these data may not be as useful in characterizing benthic algal biomass in subject streams. Only recently has BWQP's stream bioassessment monitoring included algae sampling for biomass (chlorophyll-a) algae sampling, however the EMAP methods are being used and the data may not be directly comparable to the literature thresholds (100 to 200 ug/l). Also, the bioassessment sampling occurs only once during the growing season and may not capture the peak algal biomass.

Lakes and Reservoirs

Future monitoring for lakes and reservoirs is recommended to include the following as appropriate:

- N and P species
- pH
- dissolved organic carbon
- phytoplankton chlorophyll-a and species composition
- secchi depth
- dissolved oxygen profiles
- temperature profiles
- physical conditions (volume, depth, surface area, inflow/outflow)

Like in streams, algal levels in lakes/reservoirs can be variable. Monitoring may need to occur at several locations on a lake/reservoir, several times during the growing season (or longer), and possibly over multiple years. It can also be useful to collect water chemistry samples for the lakes inflows and outflows, and to measure the streamflows in order to evaluate loadings to the lake. *Nevada's Nutrient Assessment Protocols for Lakes and Reservoirs* (NDEP, 2008) provides some recommendations on the number of sampling locations needed for a given waterbody.

2. Test protocols, indicators, and other weight of evidence factors, and refine as appropriate

To assist in the implementation of the Short Term Strategy, initial assessment protocols have been developed which rely on several factors: water column chemistry, algae levels (qualitative and quantitative), and DO levels. These protocols include both sampling guidance for these factors and thresholds for acceptable levels for these factors. As more data are collected, these protocols and thresholds should be reviewed and revised as appropriate.

It is intended that the multiple line of evidence approach include effects-based thresholds to the extent possible. In setting effects-based criteria, a defineable relationship between a stressor and a response needs to be identified, such as the Fish IBI vs. TP relationship presented in Figure 3, or the recreation user vs. attached algae levels in Figure 4.

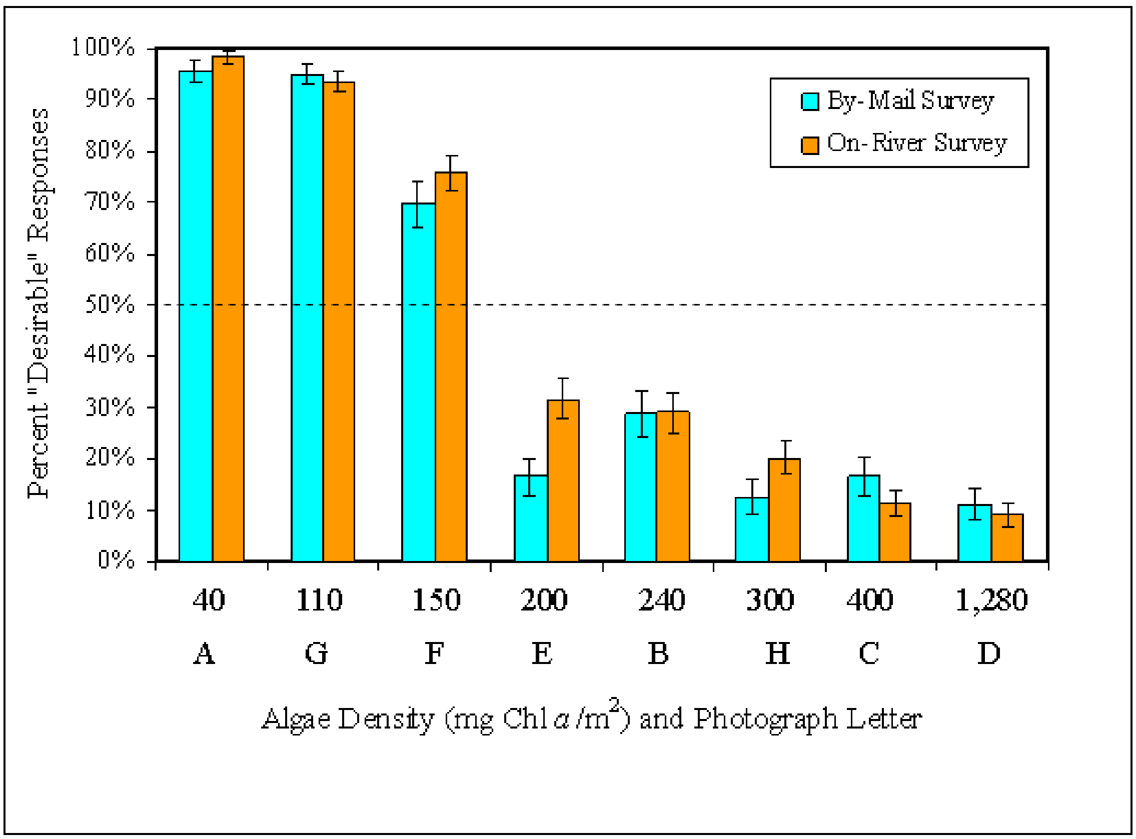

Figure 4. User Perceptions of Desirable Recreation Conditions vs. Algal Biomass (Suplee, 2008)

3. **After considerable testing, consider incorporating weight of evidence approach in the regulations as criteria**

   After thoroughly using/testing the sampling/analysis protocols, and the associated indicators, it may be possible to begin incorporating these indicators into the regulations as a weight of evidence appropach. However, it is expected that such a step may be years in the future. Any efforts to incorporate new nutrient criteria into the NAC would follow the necessary administrative steps for setting new regulations, involving public input and State Environmental Commission hearings.

Future Work

It is expected that this Nutrient Strategy document will be revised with time as NDEP increases its understanding of nutrients throughout the state. Some of the questions that need to be addressed include:

- ❑ What are the appropriate sampling and analytical protocols for benthic and phytoplankton algae taking into account:
    - temporal and spatial variability
    - varying substrate conditions (sand vs. cobble)
    - lake/reservoir shape, depth

- ❑ What levels of algal biomass constitutes impairment given that streams/lakes/reservoirs have a gradient of Aquatic Life Uses (from excellent to poor) that need to be recognized?

- ❑ At what point does algal biomass begin to negatively impact dissolved oxygen levels? While it is recognized that algae/DO relationship are highly variable due to affects by other factors such as flow conditions, channel characteristics, is it possible to identify algae/DO thresholds for different stream types?

- ❑ What is the extent and impact of blue-green algae in Nevada waters? How should the occurrence of blue-green algae be accounted for in setting nitrogen water quality standards?

- ❑ What affect do diel fluctuations in nutrients have upon daytime nutrient sampling results? Does this phenomenon need to be accounted for when setting nutrient criteria?

- ❑ How do physical conditions (including flow/water levels) affect nutrient/algal relationships? How should these conditions be accounted for in the setting of nutrient criteria?
    - While streams with better physical conditions (good shading, etc.) can handle more nutrients than lesser streams, the better streams probably should not have higher (less restrictive) N and P standards than the poorer streams.
    - Nevada regulations state only that standards do not apply during “extreme” events, however “extreme” has not been defined. The 7Q10 low flow statistic has been used upon occasion as a threshold for determining when flows are “extremely” low. While a useful approach, 7Q10 statistics can only be calculated for streams with gaging stations which exist for only a small subset of the state’s waters. What is an appropriate threshold for lakes and reservoirs?

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