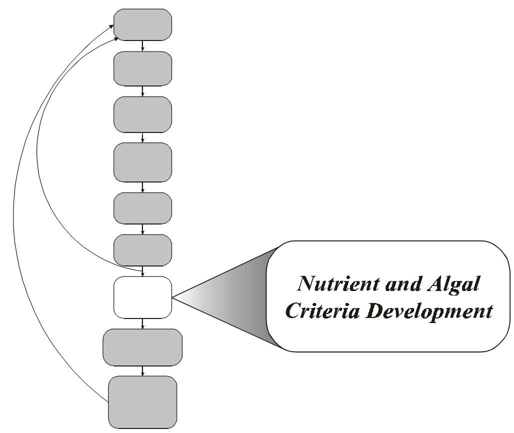
Chapter 7. Nutrient and Algal Criteria Development



7.1 INTRODUCTION

This chapter addresses the details of developing scientifically defensible criteria for nutrients and algae. Three approaches are presented that water quality managers can use to derive numeric criteria for streams in their State/Tribal ecoregions. The approaches that are presented include: (1) the use of reference streams, (2) applying predictive relationships to select nutrient concentrations that will result in appropriate levels of algal biomass, and (3) developing criteria from thresholds established in the literature. Considerations are also presented for deriving criteria based on the potential for effects to downstream receiving waters (i.e., the lake, reservoir, or estuary to which the stream drains). The chapter concludes with the process for evaluating proposed criteria including the role of the Regional Technical Assistance Group (RTAG) in reviewing criteria, guidance for interpreting and applying criteria, considerations for sampling for comparison to criteria, potential revision of criteria, and final implementation of criteria into water quality standards.

The most rational approach for deriving criteria is to determine nutrient values in the absence of non-nutrient related factors that influence growth of algal biomass (e.g., light availability, flow). Then, refinements and exceptions to the criteria can be made based on the extent to which non-nutrient related factors are present for specific streams in an ecoregion or subecoregion. Thus, for both periphyton- and plankton-dominated systems, criteria should be set with the goal of reaching an acceptable algal biomass in streams with little or no light limitation, during periods of stable, post-flood/runoff, and moderate numbers of grazing invertebrates. For periphyton-dominated streams, substrata for attachment is assumed to be adequate and stable.

Expert evaluations are important throughout the criteria development process. The data upon which criteria are based and the analyses performed to arrive at criteria must be assessed for veracity and applicability. The EPA RTAGs are responsible for these assessments. The RTAG is composed of State, Tribal, and Regional specialists that will help the Agency and States/Tribes establish nutrient criteria for adoption into State/Tribal water quality standards. The RTAG is tasked with conducting an objective and exhaustive evaluation of regional nutrient information to establish protective nutrient criteria for the ecoregional waterbodies located in their EPA Region.

7.2 METHODS FOR ESTABLISHING NUTRIENT AND ALGAL CRITERIA

The following discussions focus on three methods that can be used in developing nutrient and algal criteria ranges. The first method requires identification of reference reaches for each established stream class based on either best professional judgement (BPJ) or percentile selections of data plotted as frequency distributions. The second method advocates refinement of trophic classification systems, use of models, and/or examination of system biological attributes to assess the relationships among nutrient and algal variables. The two methods described above should be based on data for the selected index period (see Chapter 4). Finally, the third method provides several published nutrient/algal thresholds that may be used (or modified for use) as criteria. A weight of evidence approach that combines one or more of the three approaches described below will produce criteria of greater scientific validity. This section also discusses how to develop criteria for streams that feed into standing receiving waters.

USING REFERENCE REACHES TO ESTABLISH CRITERIA

One approach that may be used in developing criteria is the reference reach approach. Reference reaches are relatively undisturbed stream segments that can serve as examples of the natural biological integrity of a region. There are three ways of using reference reaches to establish criteria.

1. Characterize reference reaches for each stream class within a region using best professional judgement and use these reference conditions to develop criteria.

2. Identify the 75th percentile of the frequency distribution of reference streams for a class of streams and use this percentile to develop the criteria (see Figure 8 and the Tennessee case study, Appendix A).

3. Calculate the 5th to 25th percentile of the frequency distribution of the general population of a class of streams and use the selected percentile to develop the criteria (Figure 8).

Identification of reference streams allows the investigator to arrange the streams within a class in order of nutrient condition (i.e., trophic state) from reference, to at risk, to impaired. Defining the nutrient condition of streams within a stream class allows the manager to identify protective criteria and determine priorities for management action. Criteria developed using reference reach approaches may require comparisons to similar systems in States or Tribes that share the ecoregion so that criteria can be validated, particularly when minimally-disturbed systems are rare.

Best professional judgement-based reference reaches may be identified for each class of streams within a State or Tribal ecoregion and then characterized with respect to algal biomass levels, algal community composition, and associated environmental conditions (including factors that affect algal levels such as nutrients, light, and substrate). The streams classified as reference quality by best professional judgement may be verified by comparing the data from the reference systems to general population data for each stream class. Reference systems should be minimally disturbed and should have primary parameter (i.e., TN, TP, chl *a*, and turbidity) values that reflect this condition. Factors that are affected by algae, such as DO and pH, should also be characterized. At least three minimally impaired reference systems should be identified for each stream class (see Chapter 2). Highest priority should be given to identifying reference streams for stream types considered to be at the greatest risk from impact by nutrients and algae, such as those with open canopy cover, good substrata, etc. [Conditions at the reference reach (e.g., algal biomass, nutrient concentrations) can be used in the development of criteria that are protective of high quality, beneficial uses for similar streams in the ecoregion.]

Alternatively, a reference condition for a stream class may be selected using either of two frequency distribution approaches. In both of the following approaches, an optimal reference condition value is selected from the distribution of an available set of stream data for a given stream class.

In the first frequency distribution approach, a percentile is selected (EPA generally recommends the 75th percentile) from the distribution of primary variables of known reference systems (i.e., highest quality or least impacted streams for that stream class within a region). As discussed in Chapter 3, primary variables are TP, TN, chl *a*, and turbidity or TSS. It is reasonable to select a higher percentile (i.e., 75th percentile) as the reference condition, because reference streams are already acknowledged to be in an approximately ideal state for a particular class of streams (Figure 8).

The second frequency distribution approach involves selecting a percentile of (1) all streams in the class (reference and non-reference) or (2) a random sample distribution of all streams within a particular class. Due to the random selection process, an upper percentile should be selected because the sample distribution is expected to contain some degraded systems. This option is most useful in regions where the number of legitimate "natural" reference water bodies is usually very small, such as highly developed land use areas (e.g., the agricultural lands of the Midwest and the urbanized east or west coasts). The EPA recommendation in this case is usually the 5th to 25th percentile depending upon the number of "natural" reference streams available. If almost all reference streams are impaired to some extent, then the 5th percentile is recommended.

Both the 75th percentile for reference streams and the 5th to 25th percentile from a representative sample distribution are only recommendations. The actual distribution of the observations should be the major determinant of the threshold point chosen. Figure 8 shows both options and illustrates the presumption that these two alternative methods should approach a common reference condition along a continuum of data points. In this illustration, the 75th percentile of the reference stream data distribution produces a TP reference condition of 20 µg/L. The 25th percentile of the random sample distribution produces a value of 25 µg/L. Because there is little distinction in this case, the Agency may select either 20 µg/L, 25 µg/L, or the intermediate 23 µg/L value as illustrated in Figure 8.

Each State or Tribe should similarly calculate its reference condition initially using both approaches to determine which method is most protective. The more conservative approach is recommended for subsequent reference condition calculations. A State or Tribe may choose to draw one single line vertically through the data distribution to set their criterion (the equivalent of the line drawn at the 23µg/L TP concentration shown in Figure 8). The obvious difficulty is choosing where the line is drawn. If drawn to the left of the central tendency point, most streams are in unacceptable condition and significant restoration management should occur. If the line is drawn to the right of the central tendency point, then most streams would be in acceptable condition and far less effort would be needed for

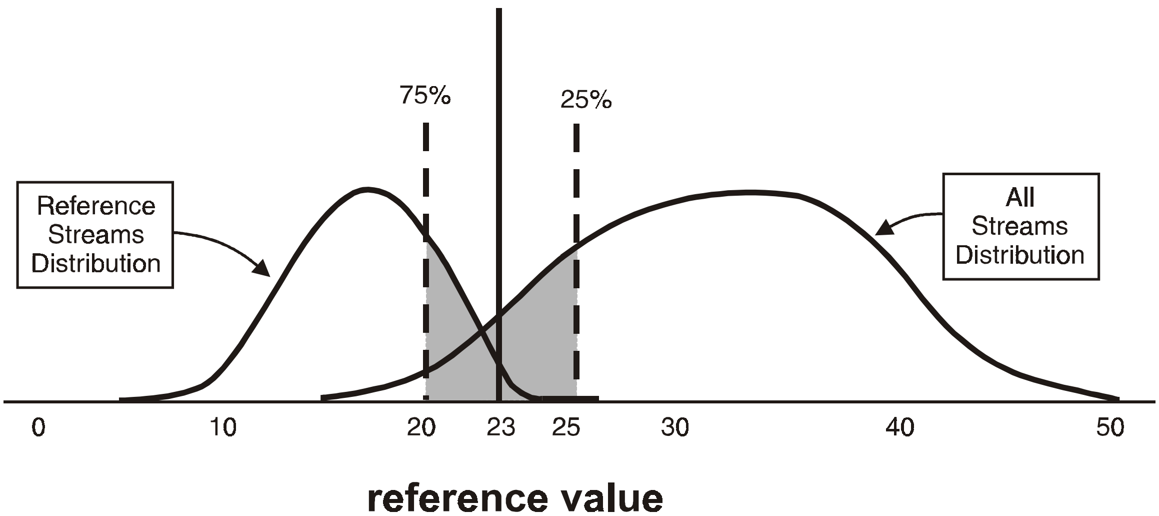


Figure 8. Selecting reference values for total phosphorus concentration (μg/L) using percentiles from reference streams and total stream populations.

restoration. The establishment of a reference condition helps to set the position of the line as objectively as possible.

It is important to understand that any line drawn through the data has certain ramifications; streams in unacceptable condition (on the right) should be dealt with through restoration. The streams to the left of the line are in acceptable condition, and should not be allowed to increase their nutrient concentrations. These streams should be protected according to the State's or Tribe's approved antidegradation policy, and through continued monitoring to assure that no future degradation occurs.

If a State or Tribe desires greater flexibility in setting their criteria, the frequency distribution can be divided into more than two segments (Figure 9). Using this approach, a criterion range is created and a greater number of stream systems fall within the criterion range. This approach divides systems into those that are of reference quality, currently in acceptable condition, or impaired. In this case, emphasis may be shifted from managing stream systems based on a central tendency (as shown above when a single line is drawn through the frequency distribution) to managing systems based on the level of impairment. This approach will also aid in prioritizing systems for protection and restoration. Stream data plotted to the right represent an increasingly degraded condition. Use of this approach requires that subsequent management efforts focus on improving stream conditions so that, over time, stream data plots shift to the left of their initial position.

State or Tribal water quality managers may also consider analyzing stream data based on designated use classifications. Using this approach, frequency distributions for specific designated uses could be examined and criteria proposed based on maintenance of high quality systems that are representative of each designated use.

In summary, frequency distributions can be used to aid in setting criteria. The number of divisions used has significant implications with respect to system management. A single criterion forces the manager to make decisions about the number of streams that will be in unacceptable condition, with considerable ramifications from that decision. If the distribution is divided into three segments, the majority of streams will be in acceptable condition (assuming that these streams are meeting their specified designated uses and do not contribute to downstream degradation of water quality), which will minimize management requirements. The method that is used may depend on the goals of the individual State or Tribe; some may wish to set criteria that encourage all State/Tribal stream systems to be preserved or restored to reference conditions. Other managers may consider additional options, such as developing criteria specific to protect the designated uses established for local streams.

USING PREDICTIVE RELATIONSHIPS TO ESTABLISH CRITERIA

The following section provides several options that can be used to evaluate nutrient and algal relationships in stream systems. These options include use of trophic state classifications, models, and biocriteria.

Trophic State Classification

One challenge associated with setting criteria is defining the relative trophic state of a stream. It is difficult to determine whether a stream is excessively eutrophic if its trophic state is not known relative

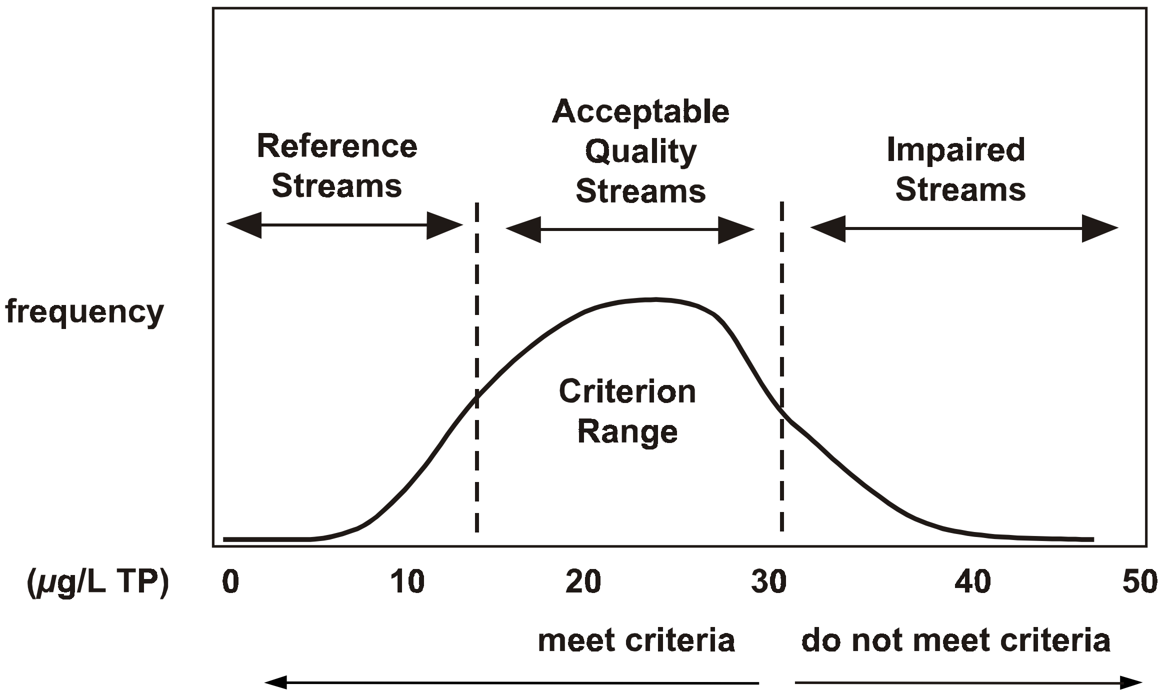


Figure 9. Frequency distribution divided into three segments that represent (from left to right) high-quality reference streams, acceptable quality streams, and impaired streams.

to other streams. There is no generally accepted system for classifying the trophic states of streams (Dodds et al. 1998). The only proposed system divides data plotted as cumulative frequency diagrams into oligotrophic (lower third), mesotrophic (middle third), and eutrophic (upper third) categories (see Chapter 2) (Dodds et al. 1998). This approach is similar to the reference reach method described in the previous section. More data are necessary to determine the applicability of such a classification scheme to streams from different ecoregions.

Models

A few models establish correlations between TN/TP and benthic algal biomass in streams (e.g., Lohman et al. 1992; Dodds et al. 1997; Bourassa and Cattaneo 1998; Chételat et al. 1999; Biggs 2000). Such models estimate algal biomass as a function of water column nutrients (as has often been done for lakes and reservoirs).

A regression model linking TP to river phytoplankton has been published (Van Nieuwenhuyse and Jones 1996). This model can be used to set TP criteria. The TP levels can in turn be used to calculate corresponding TN concentrations using the Redfield ratio (Harris 1986). This model captures additional variance when watershed area is considered (as discussed in Chapter 6).

Finally, it is necessary to relate instream TN and TP concentrations to nonpoint and point sources of nutrients. Models allowing prediction of nutrient loading in streams are needed. A method for determining instream TN and TP concentrations based on loading from point sources has been developed for use in the Clark Fork River (Dodds et al. 1997). Simple correlation techniques using data available from various regions may yield a nutrient and chlorophyll relationship that can be used to predict what management strategies are necessary to bring nutrients from point sources, and consequently algal biomass, to target levels.

Biocriteria

Biocriteria involve the use of biological parameters to establish nutrient impairment in streams. There are two ways to use biocriteria to establish water quality criteria. The first approach involves the protection and restoration of ecosystem services, which is almost exclusively related to biological features and functions in aquatic ecosystems. Although it is recognized that chemical and physical factors play a critical role in the algal-nutrient relationship, it is felt that the effect of nutrients on algae and other components of aquatic ecosystems is critical. This is why ecoregional and waterbody-specific nutrient criteria are recommended and chl *a* and Secchi depth/turbidity, arguably biocriteria, are required. The second approach is based on the concept that attributes of biological assemblages vary less in space and time than most physical and chemical characteristics. Thus, fewer mistakes in assessment may occur if biocriteria are employed in addition to physical and chemical criteria.

Multimetric indices are a special form of biocriteria in which many metrics are used to summarize and communicate in one number the state of a complex ecological system. Multimetric indices for macroinvertebrates and fish are used successfully as biocriteria in many States. A multimetric index of trophic status could be developed to complement N, P, and chl *a* criteria (see Section 6.2, Developing Multimetric Indices to Complement Nutrient Criteria).

The same approaches used to establish nutrient and algal criteria could be employed to establish criteria for other biological attributes, such as a Diatom Index of Trophic State (DITS). Frequency distributions of reference conditions or a random sample of streams would provide a target for management and restoration efforts. Alternatively, dose-response relations (predictive models) between biocriteria and nutrients could be used to set nutrient and biocriteria, based on a desired level of biotic integrity or other valued ecosystem component.

A fourth approach is also possible when characterizing the responses of many biological attributes to nutrients. Some of these factors change linearly with increasing nutrient concentrations, for a number of reasons, and some factors change non-linearly. Non-linear changes in metrics indicate thresholds along environmental gradients where small changes in environmental conditions cause relatively great changes in a biological attribute. These thresholds are valuable for setting nutrient criteria, but changes in these metrics are not necessarily the best indicators of biotic integrity. They can for example, remain relatively constant as human disturbance increases until a stress threshold is reached. Alternatively, during restoration, they may not respond to remediation until a lower threshold is reached. Thus, metrics or indices that change linearly (typically higher-level community attributes such as diversity or a multimetric index) provide better variables for establishing biocriteria because they respond to environmental change along the entire gradient of human disturbance. However, parameters changing non-linearly along environmental gradients are valuable for determining where along the environmental gradient the physical and chemical criteria should be set and, correspondingly, where to establish other biocriteria.

USING PUBLISHED NUTRIENT THRESHOLDS OR RECOMMENDED ALGAL LIMITS

In addition to using the 'reference reach' concept or applying predictive relationships to establish criteria for trophic state variables, other methods to consider include using thresholds and criteria already recommended in the literature. These approaches might be used as limits if identifying reference reaches proves difficult or as temporary measures until reference reaches can be adequately described. The following text describes potential criteria for several nutrient-related variables. Because most of the following threshold concentrations were derived primarily for northern to mid-temperate cobble-bottom streams, caution should be exercised when applying them to streams found in other geographic areas such as southern temperate and subtropical regions. The nutrient/algal relationships described below may not be valid for sandy streams of the southeast and southwest and should be tested on intermittent and effluent-dominated systems. Literature values may be used as criteria if a strong rationale is presented that demonstrates the suitability of the threshold value to the stream of interest (i.e., the system of interest should share characteristics with the systems used to derive the threshold, published values).

Nutrients

Criteria for nutrients in streams have been set or suggested by various agencies and investigators (Table 4). However, in contrast to lake management schemes, there is much less agreement on whether to use total nutrient concentrations, soluble nutrient concentrations, or nutrient concentrations that might produce a given biomass level or an undesirable effect in gravel-bed streams. Although much of the total nutrient concentrations in the water column of streams is not immediately available (due to a high fraction of detritus, as discussed previously), total concentrations probably have more general applicability than soluble fractions. While soluble fractions are more available, they also may be held at low levels during high-biomass periods due to uptake (Dodds et al. 1997). Nevertheless, some investigators have had considerable success relating soluble nutrients to algal biomass if annual mean or seasonal values are used for nutrient concentrations. Using the Bow River as an example, mean TDP during summer was more useful than TP (Table 4).

Table 4. Nutrient (µg/L) and algal biomass criteria limits recommended to prevent nuisance conditions and water quality degradation in streams based either on nutrient-chlorophyll *a* relationships or preventing risks to stream impairment as indicated.

TN	TP	DIN	SRP	Chlorophyll *a*	Impairment Risk	Source
PERIPHYTON Maximum in mg/m²						
				100-200	nuisance growth	Welch et al. 1988, 1989
275-650	38-90			100-200	nuisance growth	Dodds et al. 1997
1500	75			200	eutrophy	Dodds et al. 1998
300	20			150	nuisance growth	Clark Fork River Tri-State Council, MT
	20				*Cladophora* nuisance growth	Chetelat et al. 1999
	10-20				*Cladophora* nuisance growth	Stevenson unpubl. data
		430	60		eutrophy	UK Environ. Agency 1988
		100[1]	10[1]	200	nuisance growth	Biggs 2000
		25	3	100	reduced invertebrate diversity	Nordin 1985
			15	100	nuisance growth	Quinn 1991
		1000	10[2]	~100	eutrophy	Sosiak pers. comm.
PLANKTON Mean in µg/L						
TN	**TP**	**DIN**	**SRP**	**Chlorophyll *a***	**Impairment Risk**	**Source**
300[3]	42			8	eutrophy	Van Nieuwenhuyse and Jones 1996
	70			15	chlorophyll action level	OAR 2000
250[3]	35			8	eutrophy	OECD 1992 (for lakes)

[1]30-day biomass accrual time
[2]Total Dissolved P
[3]Based on Redfield ratio of 7.2N:1P (Smith et al. 1997)

Notwithstanding the sparse set of cases, there is an indication of some consistency for total and soluble P criteria (Table 4). In two separate data sets, the tendency for *Cladophora* to begin dominating the periphyton was observed at TP concentrations of 10-20 µg/L (Chetelat et al. 1999; Stevenson pers. comm.). This general range was also selected by the Clark Fork Tri-State Council to limit maximum biomass to levels below 150 mg chl a/m^2. Setting a criterion equivalent to ‘no filamentous green algae’, even if chl *a* levels exceed 150 mg/m^2, would protect aesthetic use and still may not limit fisheries production.

Using a criterion for periphytic or planktonic biomass to initially judge if nutrient concentrations are excessive, may have a practical management and enforcement appeal. Advantages are several: (1) there is general agreement among some investigators and agencies on a biomass level that minimizes risk to recreational and aquatic life uses (see Table 4), (2) problems of algal control that result in poor dose-response relationships of nutrients versus biomass (due to shading by riparian canopies or suspended sediment and grazing) are averted, and (3) TMDLs and resultant controls would be required only for situations in which biomass criteria were exceeded. However, criteria for nutrients (specifically TN and TP) will ultimately be required for all stream classes within an ecoregion.

Algal Biomass

Criteria for levels of periphyton algal biomass that present a nuisance condition in streams and impact aesthetic use have been recommended by several investigators. There is surprising consistency in these values, with a maximum of about 150 mg/m^2 chl *a* being a generally agreed upon criterion (Table 4). As objective support for that criterion, percent coverage by filamentous forms was less than 20 percent, but increased with increased biomass and noticeably affected aesthetic quality (Welch et al. 1988). At this level, there were no apparent effects on DO, pH, or benthic invertebrates, which, as described earlier, occur at higher biomass levels.

Furthermore, a literature review of 19 cases indicated biomass levels greater than 150 mg/m^2 tended to occur with enrichment and when filamentous forms were more prevalent (Horner et al. 1983). As noted earlier, Lohman et al. (1992) observed that biomass rapidly recovered following flood-scour events in 12 Ozark streams when biomass exceeded the 150 mg/m^2 level at moderately to highly enriched sites. Pre-disturbance biomass did not recover as rapidly when initial levels did not exceed approximately 75 mg/m^2 at unenriched sites.

A provisional guideline of a maximum 100 mg/m^2 chl *a* and 40 percent coverage of filamentous forms was proposed for New Zealand streams to “protect contact recreation”. There was insufficient evidence for protection of other uses that require specific DO and pH thresholds, which in turn vary due to atmospheric exchange (area:volume ratio) and buffering capacity (Quinn 1991).

While the 150 mg/m^2 level cannot be supported as an absolute threshold above which adverse effects on water quality and benthic habitat readily occur, it nonetheless is a level below which an aesthetic quality use will probably not be appreciably degraded by filamentous mats or any other of the adverse effects attributed to dense mats of filamentous algae (e.g., objectionable taste and odors in water supplies and fish flesh, impediment of water movement, clogging of water intakes, restriction of intra-gravel water flow and DO replenishment, DO/pH flux in the water column, or degradation of benthic habitat) (Welch 1992). Avoidance of these problems in many stream systems may be achieved with a maximum 150 mg/m^2 chl *a* criterion. As an example, control strategies were developed for the Clark Fork River, Montana, using a 100-150 mg/m^2 maximum as a criterion (see Appendix A case studies) (Watson and Gestring 1996; Dodds et al. 1997).

CONSIDERATIONS FOR DOWNSTREAM RECEIVING WATERS

More stringent nutrient criteria may be required for streams that feed into lentic or standing waters. For example, it is proposed that 35 µg/L TP concentration and a mean concentration of 8 µg/L chl *a* constitute the dividing line between eutrophic and mesotrophic lakes (OECD 1982). In contrast, data from Dodds et al. (1997) suggest that seasonal mean chlorophyll *a* values within stream systems of 100 mg/m^2 are likely at concentrations of 221 µg/L TP. Thus, unacceptable levels of chlorophyll may occur in lakes at much lower nutrient concentrations compared to streams (Dodds and Welch 2000).

7.3 EVALUATION OF PROPOSED CRITERIA

During criteria derivation, the RTAG will provide expert assessment of any proposed criteria or criteria ranges and their applicability to all streams within the class of interest. Criteria will need to be verified in many cases by comparing criteria values for a stream class within an ecoregion across State and Tribal boundaries. In addition, prior to recommending any proposed criterion, the RTAG must consider the potential for the proposed criterion to cause degradation of downstream receiving waters. In developing criteria, States/Tribes must consider the designated uses and standards of downstream waters and ensure that their water quality standards provide for the attainment and maintenance of water quality standards in downstream waters. Criteria recommended by the RTAG can be adopted by the State or Tribe as approved by EPA if there is documented evidence that no adverse effects will result downstream. However, if downstream waters are not adequately protected at the concentration level associated with the proposed criteria, then the criteria should be adjusted accordingly. Load estimating models, such as those recommended by EPA (USEPA 1999), can assist in this determination (see Section 4.2, Nutrient Load Attenuation). Water quality managers responsible for downstream receiving waters should also be consulted.

GUIDANCE FOR INTERPRETING AND APPLYING CRITERIA

After evaluating criteria proposed for each stream class, determining streams condition in comparison with nutrient criteria can be made by following the steps:

1. Calculate duration and frequency of criteria violations as well as associated consequences. This can be done using modeling techniques or correlational analysis of existing data.

2. Develop and test hypothesis to determine agreement with criteria. Analyze for alpha and beta (Type I and II) errors (see Appendix C).

3. Reaffirm appropriateness of criteria for protecting designated uses and meeting water quality standards.

The goal is to identify protective criteria and standards. Criteria should be based on ecologically significant changes as well as statistically significant differences in compiled data. Although criteria are developed exclusively on scientifically defensible methods, assignation of designated uses requires consideration of social, political, and economic factors. Thus, it is imperative that some thought be given during the criteria development process of how realistically the criteria can be implemented into standards that are accepted by the local public.

SAMPLING FOR COMPARISON TO CRITERIA

Once criteria have been selected for each indicator variable, a procedural rule to assess stream concurrence with criteria should be established. The four primary criteria variables include two causal variables (TN and TP) and two response variables (chl *a* and Secchi depth or a similar indicator of turbidity). Failure to meet either of the causal criteria should be sufficient to require remediation and typically the biological response, as measured by chl *a* and turbidity, will follow the nutrient trend. Should the causal criteria be met, but some combination of response criteria are not met, then a decisionmaking protocol should be in place to resolve the issue of whether the stream in question meets the proposed nutrient criteria.

Sampling to evaluate agreement with the standards implemented from nutrient and algal criteria will have to be carefully defined to ensure that State or Tribal sampling is compatible with the procedures used to establish the criteria. If State or Tribal observations are averaged over the year, balanced sampling is essential and the average should not exceed the criterion. In addition, no more than ten percent of the observations contributing to that average value should exceed the criterion.

A load estimating model (e.g., BASINS [see Appendix C]) may be applied to a watershed to back-calculate the criteria concentration for an individual stream from its load allocation. This approach to criteria determination may also be applied on a seasonal basis and should help States/Tribes relate their stream reach criteria with their lake or estuarine criteria. It may also be particularly important for criteria developed for streams and rivers that cross State/Tribal boundaries.

Algal Sampling for Comparison to Criteria

Once criteria for algal biomass have been established, certain sampling considerations must be addressed to obtain meaningful samples. This section discusses some of the more relevant considerations, using several questions as the basis for determining stream condition with respect to nutrients and algae.

1. How can algal criteria be applied to samples that come from only certain depths of the stream? Aesthetic criteria should be applied to the wadeable portion of large rivers, as has been done in British Columbia (Nordin 1985; see Table 4). The level necessary to protect aquatic life is likely to be system-specific and is best evaluated by determining how algal biomass affects DO, pH, and aquatic communities.

2. How large an area must exceed an algal criterion (e.g., 150 mg chl *a*/m^2) to be considered unacceptable? The area must be large enough to interfere with aesthetics and recreation or to cause undesirable water quality changes. Obviously, regional and site-specific testing of criteria will be necessary. The related sampling question is: how large an area should be characterized when assessing whether a reach exceeds a quantitative criterion? To ensure that a reasonably representative portion of a reach is sampled, replicate samples should be distributed over a reach at least 100 m long. Before selecting a point for sampling, a walk upstream and downstream a few hundred meters should be conducted to ensure that the preferred sampling point is not atypical of the reach being characterized.

Low altitude aerial photos taken on a sunny day in mid-to-late growing season can be used to determine the longitudinal extent of conditions similar to those at the sampling site. Floating the stream by boat can serve a similar purpose.

3. For how long must algal biomass exceed criteria to be considered unacceptable?
Attached algal biomass does not change as rapidly as water column parameters. Hence, one sample a month(from June to September) may be adequate to assess algal biomass, though weekly or bi-weekly sampling is ideal. If only two samplings can be afforded, the likely period containing the highest biomass levels should be bracketed. However, such a sampling scheme may be regarded as unacceptable if both sample values exceed aesthetic criteria. If algal biomass is high enough to cause excessive DO and pH fluctuations that violate water quality standards or that release toxins at unacceptable levels, then the time frames for those water quality violations should be used to judge the acceptability of algal biomass levels. As an example, some States or Tribes might regard the exceedance of algal biomass criteria once in 10 years (i.e., only during the 10-year low-flow) as acceptable, but more frequent exceedances may be deemed unacceptable.

4. How many replicate samples at a site are needed to obtain acceptable precision of data in order to detect differences between sites and changes over time? This depends on the variability in algal biomass in the particular system. The Kendall test with Sen slope estimate (Hirsch et al. 1982) allows the determination of the number of replicate samples needed to detect a certain percent change in annual means of a variable or a certain percent trend over a period such as 10 years (see Clark Fork River case study, Appendix A).

CRITERIA MODIFICATIONS

There may be specific cases identified by States or Tribes that require modification of established criteria, either due to unique stream system characteristics or specific designated uses approved for a stream or stream reach. Two examples of acceptable criteria modifications are presented below.

Site Specific Criteria
If a State/Tribe has additional information and data which indicate a different value or set of values is more appropriate for specific stream systems than ecoregionally-derived criteria, a scientifically defensible argument should be prepared that a “site specific” criteria modification is required. Once approved by EPA, this value can be incorporated into State or Tribal water quality standards. If no action is taken by the State or Tribe involved, EPA may propose to promulgate criteria based on the regional values and best available supporting science at the time.

Designated Use Approaches
Once a regional criterion has been established, it is subject to periodic review and calibration. Any State or Tribe in the region may elect to use the criterion as the basis for developing its own criteria to protect designated uses for specific stream classes. This is entirely appropriate as long as the criteria are as protective as the basic EPA criterion for that region. This ecoregional criterion represents EPA’s “304(a)” recommendation for protection of an aquatic life use.

The Clean Water Act as amended (Pub. L. 92-500 (1972), 33 U.S.C. 1251, *et seq*.) requires all States to establish designated uses for their waters (Section 303[c]). Designated uses are set by the State. EPA’s interpretation of the Clean Water Act requires that wherever attainable, standards should provide for the protection and propagation of fish, shellfish, and wildlife and provide for recreation in and on the water (Section 101[a]). Other uses identified in the Act include industrial, agricultural, and public water supply. However, no waters may be designated for use as repositories for pollutants (see 40 CFR 131.10[a]). Each water body must have legally applicable criteria or measures of appropriate water quality that protect and maintain the designated use of that water. It is therefore proper for States and Tribes to set nutrient criteria appropriate to each of their designated uses in so far as they are as protective as the regional nutrient criteria established for those classes of waters.

IMPLEMENTATION OF NUTRIENT CRITERIA INTO WATER QUALITY STANDARDS

Criteria, once developed and adopted into water quality standards by a State or Tribe, are submitted to EPA for review and approval (see 40 CFR 131). EPA reviews the criteria (40 CFR 131.5) for consistency with the requirements of the Clean Water Act and 40 CFR 131.6, which requires that water quality criteria be sufficient to protect the designated use (40 CFR 131.6[c] and 40 CFR 131.11). The procedures for State/Tribal review and revision of water quality standards, EPA review and approval of water quality standards, and EPA promulgation of water quality standards (upon disapproval of State/Tribal water quality standards) are found at 40 CFR 131.20 -22 (see Figure 1, Chapter 1). The Water Quality Standards Handbook (EPA 1994) provides guidance for the implementation of these regulations.