

EPA's Nutrient Criteria Recommendations
and Their Application in Nutrient Ecoregion XI

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West Virginia Rivers Coalition Permit Analysis Program

The West Virginia Rivers Coalition (WVRC) seeks to protect and restore West Virginia's exceptional rivers and streams. WVRC's Permit Analysis Program promotes public participation in permitting processes that affect water quality by conducting research, publishing reports, sponsoring workshops, serving as a resource for permit-related questions, and supporting watershed organizations in their efforts to watchdog local permits.

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1 Introduction

This report assesses the U.S. Environmental Protection Agency's (EPA's) ambient water quality criteria recommendations for nutrients, with particular attention to Nutrient Ecoregion XI, where West Virginia (WV) is located. While these comments are focused locally, many are applicable more broadly to other regions as well.

EPA's national nutrient strategy stems from the Clean Water Action Plan released by President Clinton and Vice President Gore in 1998. The nutrient strategy, implemented within the framework of the Clean Water Act, leaves the responsibility for setting and enforcing water quality standards to State and Tribal governments. But throughout the process of developing and adopting new criteria, EPA has played—and will continue to play—an important role.

The process began with the declaration of a strategy in 1998 (EPA, 1998), continued with the development of statistical methods for calculating nutrient criteria (EPA, 2000c and d), and proceeded with the publication of nutrient criteria recommendations for the various ecological regions, or "Nutrient Ecoregions," in the country (EPA, 2000a and b). States and Tribes are now expected to use the guidance provided in these documents to develop and adopt criteria by the end of 2003. If states have not adopted scientifically defensible criteria by this deadline, EPA can step in and promulgate them.

Following a background section that summarizes nutrients and harms, this document assesses EPA's recommended process by which states can develop scientifically sound and publicly acceptable nutrient criteria. The report then analyzes the criteria proposed by EPA for Nutrient Ecoregion XI by comparing them with local data, current water quality standards in WV, and nutrient reduction goals for downstream water bodies affected by WV rivers. Recommendations for EPA, States, and Tribes are included throughout this report.

2 Background: Nutrients and harms

Nutrients include any elements needed for growth, especially of plants, but in terms of water quality, the word “nutrients” refers chiefly to nitrogen (N) and phosphorus (P). Both of these elements have several chemical forms, and are used by humans in a variety of ways. Both also have the potential to increase the productivity of plants, either on land or in aquatic ecosystems.

N takes several inorganic forms in water, including NH_4^+ , NH_3 , NO_3^- and NO_2^- , as well as the dissolved gases N_2 and N_2O . Of these, the ionic forms and unionized NH_3 are of concern as nutrients, because the dissolved gases are either unavailable or only slowly available to plants, or are readily lost to the atmosphere. Dissolved organic compounds may also contain N. In well aerated waterways, N compounds not taken up in living biomass are likely to become oxidized and N will exist in the water as NO_3^- . P in the environment is usually in the form of phosphate, but that phosphate group may be dissolved as an individual ion (“ortho” phosphate) or bound within organic molecules in an ester linkage, or it may be adsorbed to suspended particles or to particles being transported as part of a river or stream’s bed load.

Because of the many uses of N and P, several human caused sources have the potential to add them to surface waters.

- N and P are applied to agricultural land as fertilizer and can leach into surface water.
- Livestock and poultry waste contain nutrients that can be washed into waterways.
- Fertilized soil can be eroded into waterways, carrying nutrients, especially P.
- Several types of industrial facilities discharge N and P.
- Both septic and municipal sanitary wastewater contain relatively high concentrations of N and P.
- Atmospheric deposition of pollutants from fossil fuel combustion (both in vehicles and in industry) probably adds NO_3^- to surface waters in Nutrient Ecoregion XI.
- In some areas of Nutrient Ecoregion XI, NH_3 is being used to neutralize acid mine drainage.

The chief harm due to nutrients is cultural eutrophication. An increase in nutrient concentrations of surface waters, especially in lakes and reservoirs, causes an increase in the amount of material algae produce (net primary production, or NPP) in the water column. Consequently, increased nutrients augment the slow rain of organic particles out of surface layers and into deeper layers of the water body. These particles may be dead cells after an algal bloom depletes the nutrient supply, or the dead bodies or feces of consumers, including zooplankton and fish. The increase in the flux of organic matter to deep water increases the amount of substrate for decomposition in deep water. Decomposition consumes oxygen in the deeper stratum, and this change in the habitat can rapidly exclude fish and other species that depend on well-oxygenated water. This effect may take place at the site of the N and P additions, or anywhere downstream.

Research on the relationship between NPP and N and P concentrations is extensive. A few generalizations seem strong. P is necessary for increasing NPP. N is also necessary, but in the presence of high P concentrations, certain organisms (bluegreen algae) with the ability to use nitrogen gas, which is dissolved in the water from the atmosphere, proliferate, and can gradually

supply enough N that green algae may bloom. Nevertheless, in waters where natural conditions or human intervention has created a P supply, NPP may be strongly correlated with N concentrations.

Other harms are less well documented than O₂ depletion. In terrestrial habitats, it is clear that changes in nutrient supply, even when they do not lead to any dramatic effects in the ecosystem, may contribute to shifts in species. For example, an increase in N supply in certain European ecosystems, attributed to the N added to rainwater by fossil fuel combustion and volatilization of NH₃ from fertilizers, has caused an increase in certain grasses at the expense of heather plants, many of which are adapted to extremely low nutrient supply regimes (van Breeman and van Dijk, 1988). Such species shifts are also possible in aquatic ecosystems.

- *EPA, with guidance from RTAGs, should summarize literature concerning nutrient-induced species shifts in aquatic ecosystems in future technical guidance documents.*

3 The process for generating state nutrient criteria

EPA's guidance documents outline a process for generating state nutrient criteria (EPA, 1998; 2000a, b, c, d). The five factors that states are generally expected to incorporate into their criteria-setting process include:

1. Regional Technical Assistance Groups,
2. Historical information,
3. Statistical analysis of present reference condition,
4. Models, and
5. Downstream effects.

While State and Tribes are not required to apply all five factors to all nutrient criteria, they are expected to use a weight of evidence technique to blend several factors into scientifically justifiable criteria.

This section assesses each of these five factors—as well as several additional factors in the criteria-setting process—and makes recommendations that will help ensure that the criteria-setting process will be based in science and publicly acceptable.

3.1 Regional Technical Assistance Groups

Regional Technical Assistance Groups (RTAGs) play a crucial role in the criteria-setting process. These groups are comprised of “qualified regional specialists able to objectively evaluate all of the available evidence and select the value(s) appropriate to nutrient control in the water bodies of concern” (EPA, 2000a, p.2). In addition, RTAGs will be relied upon to recommend classification techniques for determining criteria at disaggregated levels, evaluate downstream effects, and assure EPA during their review of State and Tribal standards that proposed criteria are sufficient to protect uses.

Although RTAGs do not enjoy any real authority, EPA's intention to rely on their advice during their review of State and Tribal standards suggests that States and Tribes will benefit from working together with RTAGs and seeking their advice and approval throughout their criteria-setting process. Still, states that historically hesitate to accept outside recommendations in their water quality standards may not take full advantage of RTAGs, thereby leading to the possibility of EPA disapproval of new nutrient criteria. This scenario should be avoided by encouraging early and frequent collaboration between States and Tribes and their RTAGs.

The composition of RTAGs is important. EPA envisions that RTAGs will be comprised of specialists from disciplines such as limnology, biology, and natural resources management. While this diversity is important, it is also important that RTAGs be comprised of people with a diversity of backgrounds (e.g., university, government, public-interest science, and industry backgrounds) and of people from throughout the region. Further, to improve the likelihood that RTAG decisions are respected by the various constituencies affected by new criteria, the process for appointing RTAG members must be clarified.

- *EPA should strongly encourage States and Tribes to participate actively with their RTAGs. Participation can be encouraged by ensuring that each State and Tribe is represented in their RTAG. It can also be encouraged by requiring States and Tribes to submit milestone reports to EPA for approval, with the understanding that EPA will rely on RTAGs for assistance in their approval of these milestone reports.*
- *RTAGs should include qualified specialists with a diversity of backgrounds (e.g., university, government, public-interest science, and industry backgrounds).*
- *EPA should clarify the process of nominating and appointing people to RTAGs, and should ensure that public input is encouraged in this process.*

3.2 Historical information

The EPA recommendations note two sources of historical data that should be used for the purpose of determining what the “reference condition” might have been for a population of water bodies in an area:

- Recent trends in nutrient concentrations or indicator variables (see Section 3.7.1, also EPA, 2000a, b), and
 - Paleolimnological studies (EPA, 2000d).
- *Other historical data should also be used, including:*
 - *Data concerning changes in the sources of nutrients in the watershed (such as periods of population growth, arrival of large industries, or changes in agricultural practices);*
 - *Observations from early settlers or visitors; and*
 - *Known manipulations to waterways, such as channelization or the introduction of flood control structures.*
 - *When historical water quality data are used to justify nutrient criteria, data known to predate significant human influence in the watershed—through population growth, air deposition of nutrients, or other factors—should be given greater weight.*

3.3 Statistical analysis of present reference condition

EPA recommends and carries out a statistical approach to identify total nutrient criteria in lakes and reservoirs (EPA, 2000b, d) and in rivers and streams (EPA, 2000a, c). Two possible statistical methods are suggested for developing criteria. If a diverse population of “reference” water bodies can be identified, which are relatively unimpacted by human processes, the concentrations at the 75th percentile of that population are recommended as standards. That is, the standard should be greater than three out of four of the measurements, and less than one out of four.

If such a reference population cannot be identified, then concentrations equal to those found in the 25th percentile of the entire population of reference and non-reference water bodies are suggested as appropriate surrogate values. EPA maintains that several case studies show that these concentrations are accurate surrogates for concentrations based on reference data, and they apply this method in their guidance documents.

These statistical techniques are appropriate for setting new nutrient criteria that are based on the goal of reducing and eliminating nutrient loads above natural background levels. Even though EPA reports that case studies show that the use of the 75th percentile of all water bodies is an accurate surrogate for the use of the 25th percentile of reference water bodies, new criteria will be best justified and accepted if they are based on reference data.

- *When sufficient data exist, EPA should strongly recommend that States and Tribes develop new criteria based on statistical analyses of reference data alone, in preference to statistical analyses of combined reference and non-reference data.*

One risk of the approach used in EPA’s guidance documents is that, by definition, 75% of the water bodies included in the data analysis may be out of compliance with recommended nutrient criteria. An additional statistical approach might help distinguish water bodies suitable for urgent action. For example, all water bodies with nutrient concentrations greater than the 90th percentile might be designated in need of immediate enforcement of nutrient standards.

- *EPA should encourage States and Tribes to place a high priority on TMDL development for 303(d)-listed water bodies that are severely impacted by nutrients.*

Generally, the statistical approach that EPA recommends for use by States and Tribes is most useful in cases where large datasets for water quality parameters are available. Data for the Level III Ecoregions represented in WV, however, are less abundant than data commonly available in several other geographical areas. In addition, total N data are particularly scarce in several Level III Ecoregions in Nutrient Ecoregion XI. For the four Level III Ecoregions in WV, Table 1 shows the number of water bodies in EPA’s dataset that are available for determining nutrient criteria for total N and total P.

- *EPA should encourage and help States, Tribes and Non-Governmental Organizations to monitor chemical causal variables and early indicator variables in regions with small datasets.*

Table 1: Numbers of water bodies available for criteria determination

Level III Ecoregion	Lakes and reservoirs		Rivers and streams	
	Total N	Total P	Total N	Total P
66	2	27	5	84
67	9	40	174	533
69	1	31	98	291
70	0	64	29	326

Note: Level III Ecoregions 66, 67, 69, and 70 are found in WV. Numbers for total N are for reported, rather than calculated, values.

3.4 Modeling

A strength of EPA’s nutrient recommendations for Nutrient Ecoregion XI is their uniformity and stringency: they will probably provide good protection for both lakes and reservoirs and for rivers and streams. Entities that release nutrients, however, may have legitimate arguments that certain bodies of water may be less sensitive to human-caused increases in nutrient loads. Many

characteristics of a water body can affect its sensitivity to nutrients in a variety of ways. Models are therefore useful for examining as many processes as possible, and evaluating their relationships with nutrient loads.

Models are not the only way to justify modifying nutrient criteria. Changing how waters are “aggregated” is a complementary process to models, and is discussed in Section 3.6.

- *RTAGs should help States and Tribes identify, understand, calibrate and validate computer models that have the ability to keep track of all important processes that affect sensitivity to nutrients.*
- *RTAGs should provide guidance through summaries of ecological literature relating characteristics of water bodies to their sensitivity to nutrient loads.*
- *Exceptions to States’ and Tribes’ nutrient criteria should only be allowed when States and Tribes have considered all the physical characteristics and ecological processes that might influence sensitivity to nutrients in lakes, reservoirs, rivers or streams, including those in the two lists below:*

Characteristics of waters in Nutrient Ecoregion XI that may **decrease** sensitivity to nutrient loading:

- Water residence time: long, linear reservoirs make up a large percentage of Nutrient Ecoregion XI’s lakes. Such reservoirs have appreciable downstream flow, which can flush nutrients out before they accumulate in the hypolimnion, the sediments or the biota.
- Weak stratification: the movement of water down a long, linear lake can keep a lake mixed, and prevent sinking of nutrients in organic matter into the hypolimnion.
- Steep terrain: high gradient streams keep waters aerated, diminishing the potential for anoxic zones.
- Nutrient-poor soils: in many, but not all, cases, nutrient-poor soils will retain nutrients efficiently, and prevent them from entering nearby streams.
- Siltiness: turbidity may be dominated by silt in steep, erodible landscapes. Algal growth must reach a higher threshold before causing any harms via turbidity.
- Siltation may threaten the deep-water habitat in lakes more than hypoxia.

Characteristics of waters in Nutrient Ecoregion XI that may **increase** sensitivity to nutrient loading:

- Complex trophic webs: the biota in the waters of Nutrient Ecoregion XI are extremely diverse. The sensitivities of many of the organisms to subtle changes in nutrient and productivity regimes is unknown.
- Fish stocking: addition of fish to waters causes unpredictable changes in trophic structure, and may represent large nutrient additions to oligotrophic waters.
- High atmospheric deposition: the Eastern Uplands receive some of the highest rates of atmospheric pollutant deposition in the country (Adams, 1999).

3.5 Downstream effects

Nutrients added to Nutrient Ecoregion XI surface waters have the potential to cause cultural eutrophication in a number of lakes and rivers that are highly valued for both recreation and drinking water supply. Stringent criteria, such as those suggested in EPA's recommendations, are needed to protect them.

EPA is correct, however, in relying on RTAGs for their judgment over whether nutrient criteria will adequately protect downstream waters. The greatest downstream impact of WV nutrients are in the Chesapeake Bay and in the "Dead Zone" of the Gulf of Mexico.

- *EPA and RTAGs play a crucial role in requiring State and Tribal nutrient criteria to not only protect local water quality, but also to account for downstream effects.*
- *EPA should clarify the process it will use to incorporate nutrient reduction goals that address eutrophication in the Chesapeake Bay and in the Gulf of Mexico, into State and Tribal nutrient criteria.*

3.6 Scope of recommendations

Deciding whether to have different criteria for different classes of water bodies, or for fine geographical divisions, is important. One criterion applied to a broad class of water bodies or over a wide area may inadequately protect some water bodies, or may cause needless regulation for others. On the other hand, the more accurately that new criteria can correctly mirror natural nutrient concentrations, the less likely it will be that site-specific criteria are needed.

More tightly focused criteria will save money spent by NPDES permit holders, who may otherwise decide to perform studies to determine site-specific criteria on their receiving water bodies. It will also free up state agencies from ruling on site-specific criteria requests. Finally, criteria based on appropriate ecological distinctions and geographic divisions will allow public interest organizations to participate up front in the criteria setting process, without having to engage in potentially large numbers of site-specific criteria requests.

If a single criterion is not adequate for a class of water bodies in a region, then disaggregation is a reasonable method for modifying nutrient criteria that is complementary to modeling (Section 3.4). Either effective modeling or proper disaggregation require availability of personnel (through state or other cooperative agencies) who are familiar both with the dynamics of productivity in water bodies in general, and also with the particular populations of water bodies in the region.

3.6.1 Scope: water body type

EPA's recommendations divide the various water bodies into groups quite coarsely. Categories include only 1) rivers and streams, 2) lakes and reservoirs, 3) wetlands, and 4) coastal ecosystems. In light of these coarse divisions, states may need guidance on how to modify criteria based on other divisions. For instance, lakes where water has a short residence time may be deemed less sensitive than those with a long residence time. Streams and rivers which are shaded by trees for most of their length, and which receive large percentages of their carbon input in the form of dead leaves may be deemed less sensitive than those that receive carbon

primarily through algal photosynthesis. Current limnological literature, which often documents and explores empirical relationships in populations of water bodies, should support such distinctions.

- *EPA and RTAGs should provide guidance on acceptable ecological distinctions for the criteria-setting process. This guidance should be in the form of general guidance as well as specific advice on distinctions proposed by States and Tribes.*
- *Technical guidance documents should be expanded to include general scientific consensus concerning differences in nutrient sensitivities for large vs. small lakes, for lakes with short vs. long residence times, for rivers with high vs. low gradients, and for streams with production dominated by allochthonous vs. autochthonous inputs.*

3.6.2 Scope: geographical region

Geographical divisions are also quite coarse. Scientific literature on aquatic ecosystems may also contain a consensus on patterns of sensitivity to nutrient impacts based on kinds of variations that occur within Level III Ecoregions, for example, the variable bedrock materials in the Ridge and Valley and Central Appalachian regions (Level III Ecoregions 67 and 69).

- *EPA and RTAGs should provide guidance on acceptable geological and geographical divisions for the criteria-setting process. This guidance should be in the form of general guidance as well as specific advice on divisions proposed by States and Tribes.*
- *Technical guidance documents should be expanded to include general scientific consensus concerning differences in nutrient sensitivities for lakes in limestone, fine-grained sedimentary, coarse-grained sedimentary or igneous bedrock regions, if there is variability in bedrock type within a single Nutrient Ecoregion.*

3.7 Other important factors

In addition to the five factors outlined by EPA as contributing toward the criteria-setting process, several additional factors are likely to be important. This section identifies and assesses several of these factors.

3.7.1 Using additional data

EPA guidance for Nutrient Ecoregion XI is based on data contained in Legacy STORET or housed at Auburn University, New York State Department of Environmental Conservation, or at EPA Regions 3 and 4. However, additional data are available from many other universities and from non-governmental resource management and environmental protection groups. Such data may be crucial resources for calculating accurate criteria at appropriate levels of disaggregation.

- *The widest range of reliable local data should be used to develop criteria, including not just government data, but also data from universities and non-governmental resource management and environmental protection groups.*

There is an important example of such additional data that may affect nutrient criteria in some areas of Nutrient Ecoregion XI. Several researchers have found high NO_3^- concentrations in the

Allegheny Plateau region of WV and Pennsylvania. From these data, the authors have generally concluded 1) this region is unusual in the eastern U.S. for its high NO_3^- concentrations, even in watersheds without human activity; 2) high NO_3^- concentrations are not universal throughout the region, but are probably controlled by interacting factors; and 3) the high concentrations are probably caused by humans, not through activities in the watersheds of these streams, but by atmospheric deposition of pollutants.

The high NO_3^- concentrations were first noted by Edwards and Helvey (1991). From 1971 to 1987, NO_3^- concentrations in a stream in the Fernow Experimental Forest (Tucker County, WV) increased from 0.66 to approximately 3.5 g $\text{NO}_3^- \text{ m}^{-3}$ (or 0.15 to 0.79 mg nitrate-N/L). Average concentrations have not been less than 0.31 mg nitrate-N/L, EPA's criterion for Nutrient Ecoregion XI for rivers and streams, since 1973. Since that study, other scientists have shown that these higher levels are not unique to that particular stream. DeWalle and Pionke (1994) compiled annual NO_3^- fluxes from forested watersheds in or close to the Chesapeake watershed. A "hot spot" of watersheds with relatively high NO_3^- exports appeared in northern WV, western MD and southwestern PA. The highest export rate was approximately 8 kg nitrate-N/year, from the same stream in the Fernow Experimental Forest.

Although the region contains many streams with high NO_3^- concentrations, there are also many streams with low concentrations. Several studies have explored relationships between NO_3^- concentrations in streams and other ecological factors in the watersheds. Williard et al. (1997) demonstrated that high concentrations of NO_3^- occurred in streams draining watersheds where soils had high nitrification rates. Peterjohn et al. (1990) pointed out that, in the same watershed where Edwards and Helvey documented increasing NO_3^- concentrations, water draining out of the soil on the western side had much higher NO_3^- concentrations than that draining from the soil of the eastern side. This observation generated hypotheses that the composition of the tree species, the depth of the soil, or the aspect of the land (the compass direction toward which land slopes) may control NO_3^- loss. Williard et al. (1999) compared concentrations from several watersheds and tested whether geological substrate influenced NO_3^- concentrations. The work provided some evidence that NO_3^- loss is greater from watersheds with more base-rich bedrock (such as limestone or lime-rich shales): there was a positive correlation between NO_3^- concentrations and pH, and streams which stemmed entirely from the base-poor Pottsville sandstone layer had low NO_3^- concentrations. To date, there is no model that predicts stream NO_3^- concentrations precisely.

These measurements have been taken in uninhabited, undeveloped watersheds, but there is a consensus among scientists that these increasing NO_3^- concentrations may be an anthropogenic effect. Aber et al. (1989) and Ågren and Bosatta (1988) elucidated how small but steady inputs of N in rain could gradually enrich soil to the point where atmospheric deposition supplies more N than trees would use for growth. The set of symptoms associated with this process is known among ecologists as "nitrogen saturation." In fact, the N input via both rain and snow and via dry deposition is quite large in the Central Appalachians (Adams, 1999), which is the first high ground downwind of the heavily industrialized Ohio River Valley. Although 79% of the air consists of an inert form of N (N_2 gas), N can be converted to forms that settle out of the atmosphere in rain or with dust by industrial and automotive combustion processes. Peterjohn et

al. (1996) enumerated symptoms exhibited by the watershed studied by Edwards and Helvey, and demonstrated how well they matched predictions made by Aber et al. (1989).

These studies demonstrate that even water bodies with no human activity in their watersheds may not truly be in a pristine or “reference” condition. They also demonstrate that certain nutrient enrichment problems cannot be addressed through water pollution control discharge permits alone.

- *States and Tribes, with assistance from RTAGs, should incorporate the science concerning N saturation into the development of N criteria.*
- *States and Tribes should maintain and expand communication with natural resource managers, environmental scientists, and non-governmental environmental groups to maximize the amount of data available for their criteria-setting decisions.*
- *An understanding of regional atmospheric N influxes is essential for correctly interpreting historical and reference instream water quality data. Atmospheric N data must therefore be incorporated into the criteria-setting process to ensure that criteria truly represent reference conditions that are unaffected by human activities.*

3.7.2 New discoveries

Nutrient regulations must be adaptive. New research may lead to additional concerns, particularly in the area of species shifts due to low levels of nutrient enrichment. States and Tribes must be prepared to modify standards as new information becomes available.

- *EPA should require consideration of new nutrient-related information during States’ and Tribes’ triennial review processes.*

3.7.3 Averaging periods

EPA does not recommend that nutrient criteria be met at all times, but rather suggests that seasonal or annual averaging periods (e.g., based on weekly measurements) be considered appropriate. There are risks associated with such averaging periods, however, because stratified lakes have the potential to retain nutrients, even in pulses of short duration, and then initiate algal blooms.

- *Averaging periods, if used, must be justified by models that account for all relevant processes (see Section 3.4) and predict no harmful downstream results.*
- *EPA should provide science-based, written guidance on acceptable policies regarding averaging periods for nutrient criteria.*

3.7.4 Assuring prompt and meaningful state adoption of new criteria

States may be reluctant to adopt strong water quality standards for nutrients, and may be tempted to allow EPA to promulgate regulations rather than adopt unpopular measures themselves. Objections from the broad range of point and nonpoint source dischargers that will be impacted

by new criteria is likely to be strong. EPA can take several steps to encourage States and Tribes to adopt meaningful nutrient criteria promptly.

- *EPA should require all States and Tribes to synchronize the beginning of enforcement of nutrient criteria.*
- *EPA and RTAGs must be very consistent in evaluating different States' and Tribes' nutrient criteria.*
- *EPA should provide incentives for early development of criteria.*
- *EPA should encourage research and investment in efficient ways to reduce point and nonpoint source discharges of nutrients to surface water.*

4 The criteria and their implications

EPA applies the statistical technique described above (Section 3.3) and obtains numbers assumed to be representative of natural, unpolluted waters. These results for Nutrient Ecoregion XI are summarized in Tables 2 and 3. In the following sections, recommended criteria developed for the entire *Nutrient Ecoregion XI* for *all year* are compared with local WV conditions, existing WV water quality standards and nutrient reduction goals for downstream water bodies.

Table 2: EPA’s recommended nutrient criteria for lakes and reservoirs

Aggregation level in		Total N (mg/L)	Total P (µg/L)	Secchi depth (m)	Chlorophyll a (µg/L)
Space	Time				
<i>Nutrient Ecoregion XI</i>	<i>All year</i> ^a	0.226	8	2.86	2.79
	Spring ^b	1.16	2	2.68	2.09
	Summer	0.12	2.5	3.20	3.50
	Fall	0.34	2.5	3.05	3.74
	Winter	0.54	5	1.92	1.82
Level III Ecoregion 66	All year ^c	0.115	5	4.37	2.5
	Spring ^d		5	3.99	2.0
	Summer	0.12	5	3.98	3.0
	Fall		5	4.75	3.0
	Winter		6.5	6.34	1.0
Level III Ecoregion 67	All year	0.43	17.5	2.10	5
	Spring		9.25	2.10	5.0
	Summer	0.59	7.25	2.68	6.25
	Fall		6.63	2.10	5.0
	Winter		13.8	1.48	2.0
Level III Ecoregion 69	All year	0.178	5	3.36	1.24
	Spring		5	2.75	0.25
	Summer	0.38	5	3.66	2.23
	Fall		2.5	3.05	3.04
	Winter		7.5	3.96	0.25
Level III Ecoregion 70	All year	0.207	9.75	2.80	3.81
	Spring		9.5	2.36	1.83
	Summer		7.63	2.92	5.80
	Fall		10	2.67	5.80
	Winter		10	3.96	0.55

All criteria from EPA, 2000b.

^aRecommendations for Nutrient Ecoregion XI for the entire year are taken from Table 2 (p. 16). Numbers from the column “25th Percentiles based on all seasons data for the Decade” are used, as recommended.

^bSeasonal recommendations for Nutrient Ecoregion XI are taken from the “P25” column (“P75” for Secchi depth), as recommended, of the appropriate tables of Appendix A.

^cRecommendations for Level III Ecoregions are taken from Tables 3d, 3e, 3g and 3h, using numbers from the column “25th Percentiles based on all seasons data for the Decade.”

^dSeasonal recommendations for Level III Ecoregions are taken from the “P25” column (“P75” for Secchi depth), as recommended, of the appropriate tables in Appendix B.

Table 3: EPA’s recommended nutrient criteria for rivers and streams

Aggregation level in		Total N (mg/L)	Total P (µg/L)	Turbidity (NTU)	Chlorophyll a (µg/L)
Space	Time				
Nutrient	All year^a	0.31	10	2.3	1.6
Ecoregion XI	Spring ^b	0.26	8.25	2.1	1.68
	Summer	0.35	10	1.8	1.60
	Fall	0.26	10	2.5	1.63
	Winter	0.41	10	2.7	0.63
Level III Ecoregion 66	All year ^c	0.16	7.1	1	2
	Spring ^d	0.2	5	1.00	2.39
	Summer	0.26	7.25	1.00	1.50
	Fall	0.3	7	1.43	2.00
	Winter	0.39	8	0.63	
Level III Ecoregion 67	All year	0.40	10.0	2.4	1.1
	Spring	0.25	10	1.8	2.50
	Summer	0.39	10	1.6	1.13
	Fall	0.16	10	3.0	1.00
	Winter	0.18	10	5.0	1.00
Level III Ecoregion 69	All year	0.29	7.6	2.2	
	Spring	0.25	7	2.8	0.25
	Summer	0.31	9	3.1	0.46
	Fall	0.69	5.5	4.9	0.25
	Winter	1.1	8.25	5.0	0.25
Level III Ecoregion 70	All year	0.26	10.0	4.6	3.3
	Spring	0.27	10	3.9	2.02
	Summer	0.5	10	2.4	4.65
	Fall	0.65	10	5.25	4.49
	Winter	0.93	15	7.63	1.23

All criteria from EPA, 2000a.

^aRecommendations for Nutrient Ecoregion XI for the entire year are taken from Table 2 (p. 15) in Rivers and Streams in Nutrient Ecoregion XI document. Numbers from the column “25th Percentiles based on all seasons data for the Decade” are used, as recommended.

^bSeasonal recommendations for Nutrient Ecoregion XI are taken from the “P25” column, as recommended, as recommended, of the appropriate tables of Appendix A.

^cRecommendations for Level III Ecoregions are taken from Tables 3d, 3e, 3g and 3h, using numbers from the column “25th Percentiles based on all seasons data for the Decade.”

^dSeasonal recommendations for Level III Ecoregions are taken from the “P25” column, as recommended, of the appropriate tables in Appendix B.

4.1 Comparison with local reference data

Local reference data provided by the WV Department of Environmental Protection (WVDEP) (Dave Montali, West Virginia DEP, Personal communication) provides a comparison with EPA’s recommended criteria for rivers and streams for Nutrient Ecoregion XI. This dataset includes 112 samples collected between 1996 and 1999 on reference streams throughout the state. About one-half of the samples were analyzed for total P. Although total N was not directly reported, nitrite-N plus nitrate-N, as well as either ammonia-N or TKN were reported for most samples. Table 4 shows the minimum, median, and maximum values, as well as the number of samples, for total P and several N species in this reference dataset.

Table 4: WV reference stream data for N and P (mg/L)

Pollutant	Minimum	Median	Maximum	No. samples
Total P	<0.02	<0.02	0.20	63
Nitrite-N plus nitrate-N	<0.05	0.206	1.03	65
Ammonia-N	<0.50	<0.50	<1	43
TKN	<0.50	<0.50	0.905	17

Source: Dave Montali, WVDEP, Personal communication.

This dataset demonstrates that the state’s detection levels are insufficient to clearly determine whether or not ambient concentrations in reference streams meet or exceed EPA’s recommended criteria for Nutrient Ecoregion XI. For example, with a median value of “<0.02 mg/L,” it is unclear if most of these reference streams exceed EPA’s proposed P criterion of 0.01 mg/L.

- *States and Tribes should ensure that detection levels used to measure ambient N and P concentrations are low enough to provide data that can be used to develop and demonstrate compliance with new nutrient criteria.*

Data for 15 of WV’s 108 public lakes are available in WV’s 1998 305(b) report (WVDEP, 1998). These data (Table 5) indicate that lakes in this state are highly eutrophied compared with EPA’s nutrient criteria recommendations. The 305(b) report also designates 11 of these 15 lakes as eutrophic.

The WV 1998 305(b) report states that of the 2462 lake acres surveyed, the ability of 75% of the acres to support their designated use was threatened, and 19.2% of the acres were unable to support their designates uses, underlining the need for new nutrient criteria. Stringent criteria, such as those in the EPA recommendations, will potentially serve as tools for improving the ability of lakes to support their designated uses.

Table 5: Summary of data from 15 WV lakes, summer 1996

Variable	Minimum	Median	Maximum
Total P (µg/L)	10	24	50
Total N (mg/L)	0.24	0.55	0.91
Chlorophyll a (µg/L)	0.99	32.2	164
Secchi Depth (m)	0.33	1.22	2.67

Source: WVDEP, 1998.

4.2 Comparison with existing water quality standards

WV’s water quality standards include several criteria related to nutrients: ammonia, nitrate, nitrite, dissolved oxygen, and turbidity. No criteria exist for phosphorous. Current criteria are summarized in Table 6. In some cases, the nutrient recommendations are more stringent than current regulations, in other cases less.

Table 6: WV’s current nutrient-related water quality standards

Parameter	Designated uses	Value
Ammonia	Warm water fish-acute, warm water fish-chronic, cold water fish-acute, cold water fish-chronic	Determined using EPA, 1999.
Unionized ammonia	Public water supply	50 µg/L
Nitrate	Public water supply	10 mg/L nitrate-N
Nitrite	Warm water fish	1.0 mg/L nitrite-N
	Cold water fish	0.060 mg/L nitrite-N
Dissolved oxygen	Warm water fish, public water supply, water contact recreation	Not less than 5 mg/L at any time
	Cold water fish	Not less than 7 mg/L in spawning areas and not less than 6 mg/L at any time
Turbidity	No point or non-point source to WV's waters shall contribute a net load of suspended matter such that the turbidity exceeds 10 NTUs over background turbidity when the background is 50 NTU or less, or have more than a 10% increase in turbidity (plus 10 NTU minimum) when the background turbidity is more than 50 NTUs. This limitation shall apply to all earth disturbance activities and shall be determined by measuring stream quality directly above and below the area where drainage from such activity enters the affected stream. Any earth disturbing activity continuously or intermittently carried on by the same or associated persons on the same stream or tributary segment shall be allowed a single net loading increase. This rule shall not apply to those activities at which Best Management Practices in accordance with the State's adopted 208 Water Quality Management Plan are being utilized, maintained and completed on a site-specific basis as determined by the appropriate 208 cooperative or an approved Federal or State Surface Mining Permit is in effect. This exemption shall not apply to Trout Waters.	

Notes: Unionized ammonia is calculated as $(1.2 * (\text{Total ammonia-N})) / (1 + 10^{(\text{pKa}-\text{pH})})$, where $\text{pKa} = 0.0902 + 2730 / (273.2 + T)$ and T is temperature in degrees C. There are exceptions to the DO standard on the Kanawha and Ohio Rivers. Acute standards are based on one-hour average concentrations not to be exceeded more than once every three years on average. Chronic standards are based on four-day average concentrations not to be exceeded more than once every three years on average.

The NH_3 and NH_4^+ standard: Ammonia (NH_3) is toxic to many fish species, particularly at the very beginning of their life cycle. Ammonia exists in water in equilibrium with NH_4^+ , and the distribution between NH_3 and NH_4^+ is controlled by pH and temperature. EPA’s 1999 Update of Water Quality Criteria for Ammonia has a Criterion Continuous Concentration (CCC) listed for the sum of NH_3 and NH_4^+ (EPA, 1999). These are compiled for waters of different temperatures and pH, and are calculated based on the amount of NH_3 that would be present under the given conditions. Table 7 indicates pH and temperature conditions at which the NH_3 criterion would be more stringent than EPA’s recommended N criterion, if all the N were present as NH_3 and NH_4^+ . Waters with such high pH and temperature are rare in WV; therefore, enforcement of the new total N criterion should result in meeting the existing ammonia criterion.

Table 7: NH₃ + NH₄⁺ (mg-N/L) criteria tabulated by temperature and pH

		Temperature (°C)					
		20	22	24	26	28	30
pH	8.0	1.71	1.50	1.32	1.16	1.02	0.897
	8.1	1.47	1.29	1.14	1.00	0.879	0.773
	8.2	1.26	1.11	0.973	0.855	0.752	0.661
	8.3	1.07	0.941	0.827	0.727	0.639	0.562
	8.4	0.906	0.796	0.700	0.615	0.541	0.475
	8.5	0.765	0.672	0.591	0.520	0.457	0.401
	8.6	0.646	0.568	0.499	0.439	0.386	0.339
	8.7	0.547	0.480	0.422	0.371	0.326	0.287
	8.8	0.464	0.408	0.359	0.315	0.277	0.244
	8.9	0.397	0.349	0.306	0.269	0.237	0.208
9.0	0.342	0.300	0.264	0.232	0.204	0.179	
				Total N recommendation for rivers and streams exceeds NH ₄ ⁺ criterion		Total N recommendation for lakes and reservoirs exceeds NH ₄ ⁺ criteria	

Source: EPA, 1999.

Nitrate: The total N criterion recommended for both lakes and reservoirs (0.226 mg-N/L) and for rivers and stream (0.31 mg-N/L) is much more stringent than the existing nitrate criterion for Public Water Supply (10 mg-N/L). Therefore, if waters meet the recommended criterion for total N, they will also meet the Public Water Supply criterion for NO₃⁻, even if all of the N present is in the form of NO₃⁻.

Nitrite: The total N criterion is more stringent than the NO₂⁻ criterion for warm water fisheries, but less stringent than that for cold water fisheries. If waters meet the recommended nutrient criterion for total N, they will meet the warm water fish criterion for NO₂⁻ even if all the N is present as NO₂⁻. However, maintaining concentrations of NO₂⁻ low enough to meet the criterion for cold water fish will take continued enforcement of the NO₂⁻ standard.

Total N and P: WV currently has no criteria for total N and total P. Adopting the recommended criteria for these variables will provide stringent and effective protection against cultural eutrophication.

Dissolved oxygen: Total nutrient criteria will limit NPP in the waters of Nutrient Ecoregion XI, and are expected to help maintain oxic conditions in lakes and reservoirs and in rivers and streams.

Turbidity: Criteria for turbidity recommended by EPA (2.3 NTU) are much more stringent than those currently in force in WV, where increases in turbidity are limited to 10 NTU for any single entity on a particular waterway. Because turbidity in many Nutrient Ecoregion XI streams is dominated by silt, rather than algae, enforcing these strict turbidity standards may be an inefficient way to protect waters from cultural eutrophication.

- *RTAGs should clarify an appropriate protocol for setting turbidity criteria that are independent of silt present in the water. Possible approaches might be to measure*

turbidity in settled samples, or to emphasize chlorophyll a criteria rather than turbidity standards.

Chlorophyll a: WV currently has no chlorophyll a criteria. Adoption of the criteria recommended by EPA would introduce an effective, stringent means to protect waters from eutrophication.

4.3 Downstream effects

As mentioned in Section 3.5, the responsibility for determining whether the criteria chosen by States and Tribes adequately protect downstream waters falls to RTAGs. As a preliminary evaluation, however, this section compares the nutrient criteria with targets set for reducing cultural eutrophication in the Chesapeake Bay and in the Gulf of Mexico. WV rivers contribute nutrients to the Chesapeake Bay via the Potomac River and to the Gulf of Mexico via the Monongahela and Ohio Rivers.

4.3.1 Chesapeake

The Chesapeake Bay is impaired by an overabundance of N and P. The Chesapeake Bay Program, which is a coalition of States, Washington, D.C., EPA, and the Chesapeake Bay Commission, has made two commitments regarding nutrient concentrations. First, in 2000 they reaffirmed a 1987 commitment to reduce nutrient loading to the Chesapeake by 40%. Second, they set a goal to improve water quality so that the Bay would no longer be listed as impaired in 2010.

The Potomac River, with its headwaters in WV, adds the second largest amount of water, N and P to the Bay. The fraction of N and P that it contributes is greater than the fraction of water, so that it is more concentrated in nutrients than the “average” tributary to the Bay. From 1985 to 1998, the Potomac had average concentrations of 1.8 mg N/L and 60 µg P/L. If the EPA nutrient recommendations are enforced for the Potomac, and concentrations are brought down to 0.31 mg-N/L and 8 µg-P/L, the 83% and 87% reductions in N and P, respectively, would satisfy the Chesapeake Bay Program’s nutrient reduction goals.

4.3.2 Mississippi/Gulf

The Mississippi River/Gulf of Mexico Watershed Nutrient Reduction Task Force (DZ Task Force) has adopted a Final Action Plan calling for the reduction in N loads to the Gulf via the Mississippi of 30%. In 1998, the U.S. Geological Survey reports average total N concentrations in the Monongahela River between the WV border and its confluence with the Allegheny at Pittsburgh to be 1.1 mg N/L. Reduction to the level of 0.226 mg N/L of the EPA recommendations would constitute a roughly 80% reduction in the load of N from north-central WV, and would thus constitute a fair share of its part in reducing the problems of eutrophication in the Dead Zone.

5 Conclusions

New nutrient criteria are very important because they begin to address local and regional problems caused by nutrient enrichment. New criteria, once established, will affect several Clean Water Act mandated processes, such as the establishment of waste load allocations and water pollution control discharge permits, listing of polluted water bodies under Section 303(d), and development of total maximum daily loads.

This document provides recommendations for EPA, States, and Tribes as the development of nutrient criteria proceeds. Using the best science and statistical techniques, and involving the public at all phases of criteria development, will result in defensible criteria that stand the greatest chance of local acceptability and that will produce actual results as they are applied in the context of the Clean Water Act.

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