

DEVELOPMENT OF NUMERIC INTERPRETATIONS OF KENTUCKY'S NARRATIVE WATER QUALITY STANDARDS FOR NUTRIENTS

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Kentucky Agricultural Science Monitoring Committee

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Department for Environmental Protection



To Protect and Enhance Kentucky's Environment

Acknowledgements

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- **Direct effects – excess algal and plant growth**
 - low and/or widely fluctuating D.O. and pH - physiological stress to aquatic organisms
 - taste and odor problems in drinking water
- **Indirect effects on aquatic life – biological integrity**
 - reduced biodiversity
 - loss of sensitive species
 - increased dominance of tolerant and/or nuisance species



401 KAR 10:31. Surface water standards

Section 1. Nutrient Limits. In lakes and reservoirs and their tributaries, and other surface waters where **eutrophication problems** may exist, nitrogen, phosphorus, carbon, and contributing trace element **discharges shall be limited...**



401 KAR 10:31. Surface water standards (continued)

Section 2. Minimum Criteria Applicable to All Surface Waters.

- (1)...Surface waters shall not be aesthetically or otherwise degraded by substances that
- (c) Produce objectionable color, odor, taste, or turbidity;**
 - (d) Injure, are chronically or acutely toxic to or produce adverse physiological or behavioral responses in humans, animals, fish, and other aquatic life;**
 - (e) Produce undesirable aquatic life or result in the dominance of nuisance species;**

Water Quality Standards

- **narrative standards:**
 - “eutrophication problems”
 - “objectionable color, turbidity”
 - “undesirable aquatic life”
 - “dominance of nuisance species”
 - “injure ...or produce adverse physiological or behavioral responses in ...fish, and other aquatic life”

Assessment and Listing

- indicators of excess nutrients
 - D.O. and pH
 - bioassessment index scores and nutrient-related indicator metrics (e.g. % Nutrient Tolerant Individuals)
 - field observations of benthic algae and plant growths (e.g., % cover category)
 - field observations or measurements of high suspended algae (e.g., chlorophyll-*a* concentration)
 - nutrient concentrations higher than regional expectations



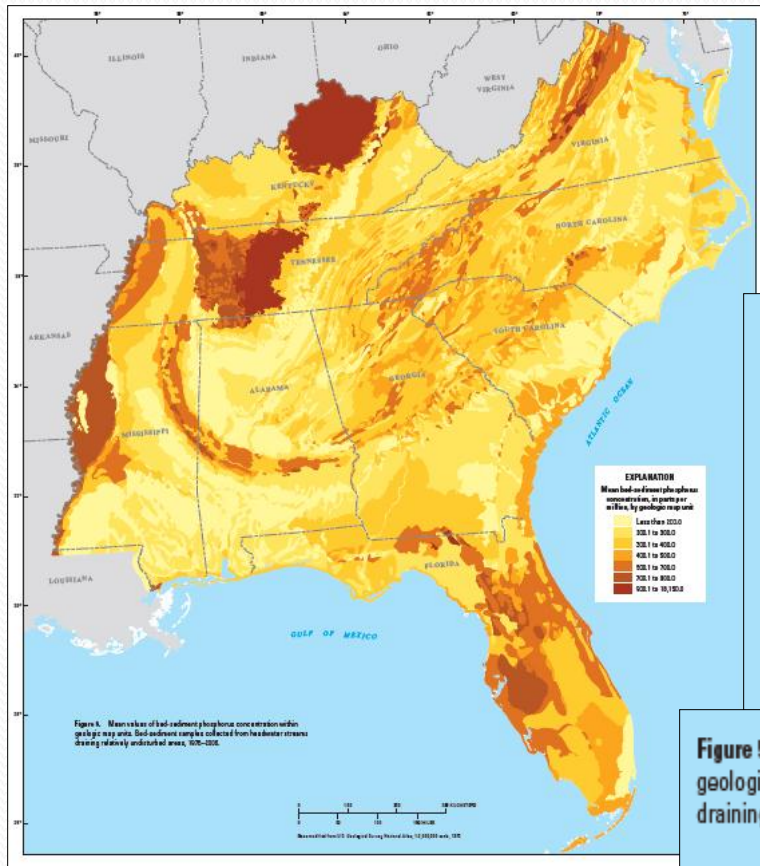
Challenges and considerations



Challenges and considerations

Mapping Watershed Potential to Contribute Phosphorus from Geologic Materials to Receiving Streams, Southeastern United States

Terziotti, Silvia, Hoos, AB, and Garcia, AM. 2010. USGS Investigations Map 3102, 1 sheet.



EXPLANATION

Mean bed-sediment phosphorus concentration, in parts per million, by geologic map unit

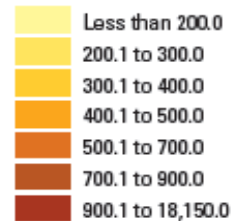


Figure 5. Mean values of bed-sediment phosphorus concentration within geologic map units. Bed-sediment samples collected from headwater streams draining relatively undisturbed areas, 1976–2006.

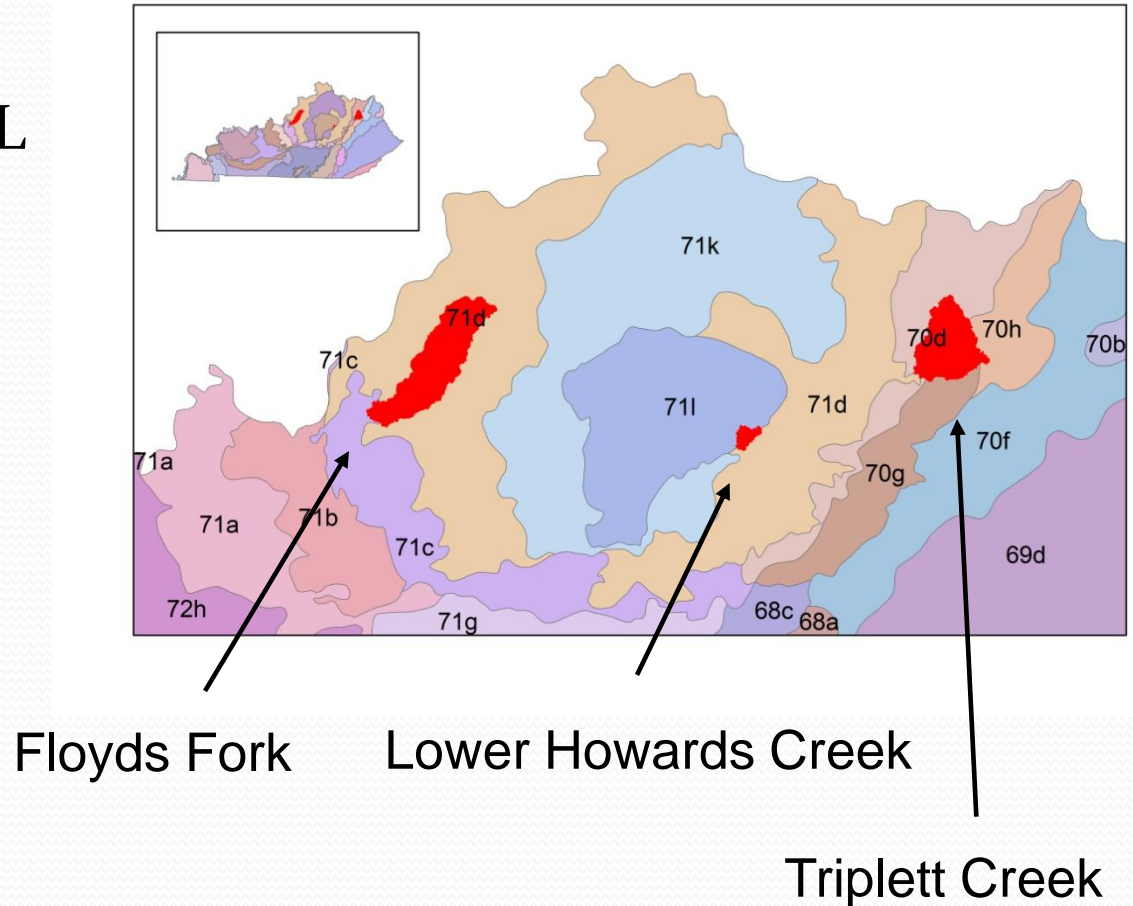
Watershed-specific Interpretations of Narrative Standards

Information used to translate narrative standards to numeric targets:

- **empirical data** (“stressor-response”)
 - how do valued indicators respond along a gradient of nutrients?
- **conditions at “reference sites”**
 - Ecoregional Reference Reaches - Network of ~200 stations statewide, most with few grab samples
 - Regional biologically healthy sites - 162 sites statewide with Good or Excellent quality macroinvertebrate community
- **literature thresholds, classification systems, guidelines, historical data**

Current applications

- Floyds Fork TMDL
- Triplett Creek Watershed Plan
- Lower Howards Creek Watershed Plan



Total Maximum Daily Load (TMDL)

- a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant.
- how are targets used?
 - in models used to calculate allowable loads
 - indicator/trigger in post-implementation monitoring

Floyds Fork Nutrient TMDL

Watershed characteristics – stream sizes



Ashers Run
2.8 mi²



Chenoweth Run
17 mi²



Floyds Fork @ Seatonville
172 mi²

- depth
- canopy width
- flow regime
- substrate
- biota
- stream function

Floyds Fork Nutrient TMDL

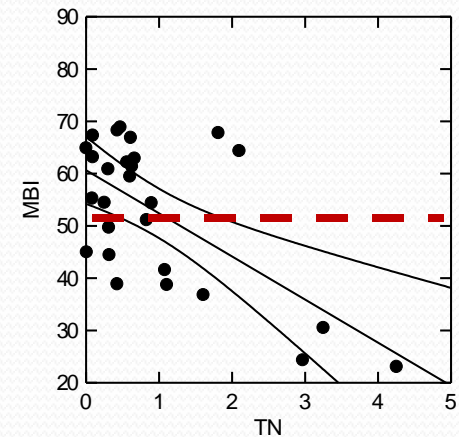
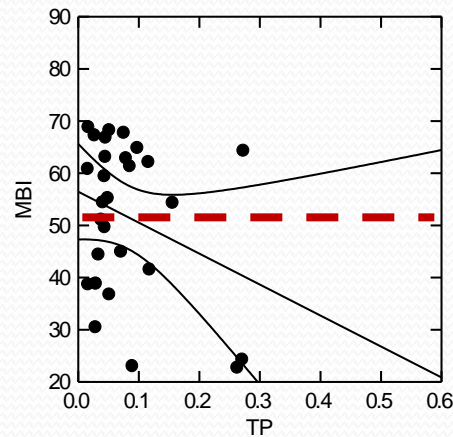
Stratification by stream size

Size Category	Catchment Area	Description
Headwater	<5 sq mi ²	Low or no summer-fall flow; distinct size category for biological indices; bioassessments in March-May
Wadeable	5-100 mi ²	Year-round flow; biological assessments May-September
Transitional/ Boatable	>100 mi ²	Long, slow, sunny pools during growing season; boating recreation important; biological assessments May-October

Floyds Fork Nutrient TMDL

Headwater size class

- **empirical data** – not strong indication of well-defined thresholds, particularly for TP, but evidence for reduced biological integrity in the range 0.8 – 1.5 mg/L TN



Relationship of Macroinvertebrate Bioassessment Index (MBI) scores with TN and TP, headwater Bluegrass streams; 90% confidence intervals on linear smoother.

Floyds Fork Nutrient TMDL

Headwater size class

- **reference site approach**
 - no appropriate reference sites within watershed or region with sufficiently frequent sampling
 - *Healthy site* - distribution of grab samples at all biologically healthy sites (71d ecoregion only, MBI ratings Good or Excellent)
 - 75th percentile used as conservative estimate of upper range in healthy sites

	TP mg/L	TN mg/L
N	8	8
maximum	0.157	0.909
75 th percentile	0.085	0.638

Floyds Fork Nutrient TMDL

Headwater size class

- **literature**

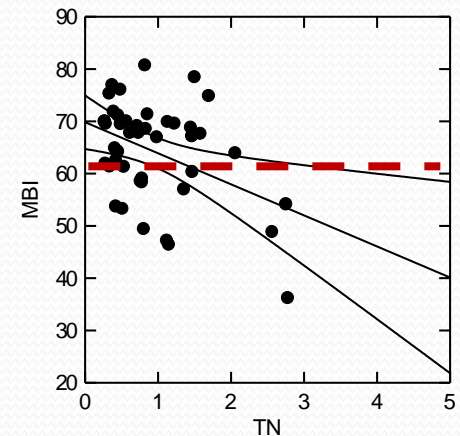
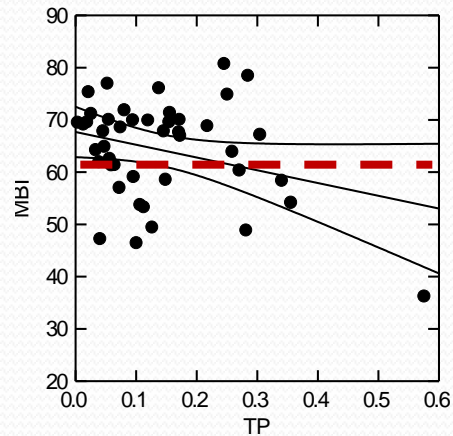
- widely cited recommendation of 0.100 mg/L TP to prevent nuisance algae is slightly above reference site candidate target
- trophic classification (Dodds et al 1998): mesotrophic - eutrophic boundary 0.075 mg/L TP and oligotrophic-mesotrophic boundary 0.7 mg/L TN are near reference site candidate targets

	TP mg/L	TN mg/L
Oligotrophic	0.025	0.700
Mesotrophic	0.075	1.5

Floyds Fork Nutrient TMDL

Wadeable size class

- **empirical data** – as with headwaters, considerable variability limits the ability to define a clear threshold, but biological integrity does appear to decline in the range 0.1 - 0.3 mg/L TP and 1 - 2 mg/L TN.



Relationship of Macroinvertebrate Bioassessment Index (MBI) scores with TN and TP, wadeable Bluegrass streams 90% confidence intervals on linear smoother.

Floyds Fork Nutrient TMDL

Wadeable size class

- **reference site approach**
 - no appropriate reference sites in watershed or region with sufficiently frequent sampling
 - *Healthy site* - using distribution of all biologically healthy sites (71d ecoregion only, MBI ratings Good or Excellent)
 - 75th percentile used as conservative of upper range in healthy sites

	TP mg/L	TN mg/L
N	13	13
maximum	0.219	1.591
75 th percentile	0.147	1.140

Floyds Fork Nutrient TMDL

Wadeable size class

- **literature**
 - published guidelines for nuisance algae prevention and trophic status generally are lower than reference site candidate targets, with the exception of the mesotrophic-eutrophic boundary for TN (1.5 mg/L).

Floyds Fork Nutrient TMDL

Transitional/Boatable Size Class

- **empirical data**
 - limited information available because of historically limited biological sampling at larger size streams
- **reference site approach**
 - watershed reference: Floyds Fork, RM 0 - 11.6
 - strong evidence of use support and 10+ years of water monitoring data

Floyds Fork Nutrient TMDL

Monthly/ bimonthly samples – Growing season geometric means

Floyds Fork @ KY1526

Year	TP mg/L	TN mg/L
1999	0.159	1.359
2000	0.150	1.154
2001	0.133	1.194
2002	0.111	1.426
2003	0.185	1.434
2004	0.173	1.729
2005	0.158	2.191
2006	0.173	1.676
2007	0.198	1.848
2008	0.126	1.720
2009	0.174	1.768
min	0.111	1.154
max	0.198	2.191



Floyds Fork Nutrient TMDL

TN and TP targets for model assessment points

Size category	TP target 1	TP target 2	TN target 1	TN target 2
Headwater (<5 sq mi ²)	0.09	0.12	0.70	1.0
Wadeable (5-100 mi ²)*	0.15	0.25	1.1	1.6
Transitional/Boatable (>100 mi ²)**	0.20	0.66	2.2	2.4

* includes tributaries in that size range and Floyds Fork mainstem above (Upper) Chenoweth Run

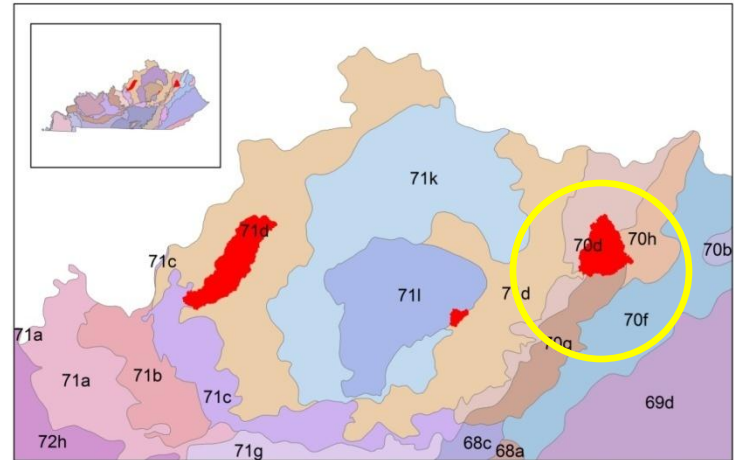
** includes mainstem of Floyds Fork downstream of (Upper) Chenoweth Run

Target 1: not to exceed as an annual (headwater) or growing season geometric mean more than once in a three year period

Target 2: never to exceed as an annual (headwater) or growing season geometric mean

Triplett Creek Watershed, Rowan County

- Western Allegheny Plateau (70d, 70h, 70g)



Triplett Creek Watershed, Rowan County

Nutrient Benchmarks

Total P 0.02 mg/L

Total N 0.65 mg/L

- Ongoing consultation to refine targets as needed

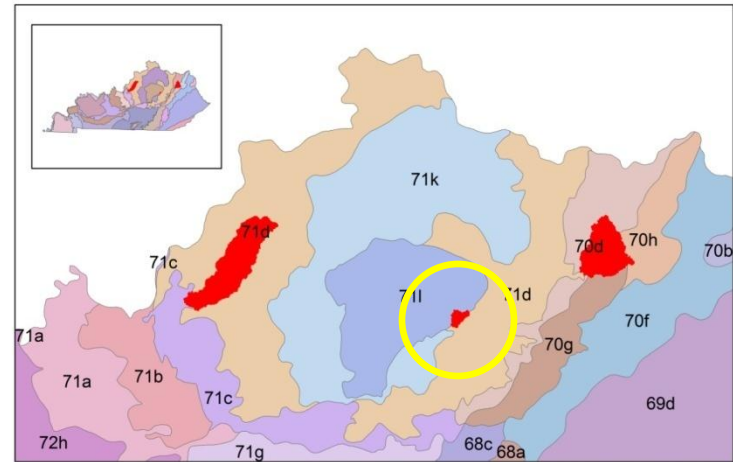
Lower Howards Creek Watershed Plan

- Inner Bluegrass, high P
Lexington Limestone
- Lower section has
Exceptional quality fish
community

Nutrient Benchmarks

Total P 0.25 mg/L

Total N 2.5 mg/L



Thank you

Thoughts, comments,
questions, more
information:

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