Executive Summary

WERF

Nutrients guidance for developing site-specific water quality criteria

Modeling Guidance for Developing Site-Specific Nutrient Goals (LINK1T11)

The Central Issue

WERF has developed this guidance because a numeric nutrient criteria are developed by various states, the United States Environmental Protection Agency (U.S. EPA) has defined three categories of approaches: 1) Reference Condition Approach, 2) Stressor-response Analysis, and 3) Process-based (Mechanistic) Modeling. The U.S. EPA has provided guidance for developing nutrient criteria using the reference condition and stressor-response approaches; however, *similar guidance is not currently available for the modeling approach.* The lack of guidance is likely an impediment for the more rigorous modeling approach being taken.

Context and Background

Developing scientifically sound nutrient goals, such as Total Maximum Daily Loads (TMDLs) and site-specific numeric nutrient criteria, is one of the highest-profile challenges facing states and the regulated community. Goals must recognize that receiving water responses to nutrient loading depend on site-specific characteristics such as morphology, hydrology, turbidity, temperature, etc., all which vary in space and time. A number of applicable water quality models exist today – ranging from simple to more complex – that can be used in flowing waters, lakes and reservoirs, and estuaries to derive quantitative relationships between nutrient loads and site-specific water quality and ecological response indicators. This project identified and assessed the relevant models and provides a selection process and guidance for how to apply these models at the local level.

Findings and Conclusions

The research report presents guidance and tools for the use of models to set waterbody-specific nutrient goals, including Numeric Nutrient Criteria and allowable nutrient loadings.

The Nutrient Modeling Toolbox (NMT) contains fact sheets on 30 models capable of quantifying the relationship between nutrient loads and their impacts in terms of water quality or ecological response indicators. All models are in the public domain, and they include process-based, empirical, and hybrid (consisting of both process-based and empirical components) models. A Model Selection Decision Tool (MSDT) guides users in selecting potential models for their specific site, condition, response indicator(s), and available data and resources. The MSDT is software that prompts NMT users for details about their site and matches that with model characteristics to identify applicable models. The MSDT considers three general categories of factors when narrowing down the list of process-based and hybrid models from the NMT:

- Site-specific characteristics;
- Ecological response indicator(s); and
- Application type (e.g., nutrient management objectives).

The MSDT helps the user select the models that are candidates for application to the site being modeled.

Six case studies are included in the NMT to demonstrate the application. The case studies focus on the decisions/judgments that need to be made regarding the use of the model.

Management and Policy Implications

Process-based load-response modeling approaches are more thorough than simpler methods. Generally, modeling approaches also require more resources such as data, time, funding, expertise, etc. By using a stepwise process and model selection tools, the user can choose to assess at any point. This research can facilitate the use of models for deriving scientifically sound nutrient goals and numeric nutrient criteria.

Ultimately, the goal for these modeling applications is regulatory decision making. The NMT is intended to complement existing regulatory guidance on non-modeling approaches for deriving NNC, such as reference condition and stressor-response approaches (U.S. EPA, 2010a). The NMT can also be used in establishing allowable loads in a TMDL, in assessing waterbody impairments, and in Use Attainability Analysis (UAA) applications.

Interaction with regulators at every step of the MSDT is recommended. By involving regulators at project initiation, prior to model development and prior to model application it's possible to ascertain existing protocols for regulatory review of models, problems and QAPP requirements, and to reconcile differences between model results and regulatory frameworks. It can be useful for water quality managers, environmental managers, utilities, permit writers, regulators, state agencies, modelers, and others to:

- Provide considerations/guidance for the load-response modeling approach for developing nutrient goals.
- Quantitatively link nutrient loads to site-specific water quality and ecological response indicators.

It is hoped that this WERF research will be used as a starting point for specific guidance for process-based modeling. This model-based approach can be used alone or in combination with the other methods and may be particularly useful when the permit writers and permittees are faced with understanding the relative contributions from multiple sources.

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Case Study	Waterbody Type	Waterbody Size	Nutrients	Response Variables	Model Complexity	Regulatory Application	Model
Screening-Level Modeling of Stream Benthic Algal Responses, Virginia	Stream	Short (<1 km) representative segments	N, P	Benthic algal biomass & type	Screening Level	Screening management options	AQUATOX
Wenatchee River Basin Phosphorus TMDL, Washington	Stream/river	84 km segment	P	Dissolved oxygen, pH	Moderate	TMDL	QUAL2Kw
Yellowstone River Numeric Nutrient Criteria, Montana	Large river	233 km segment for calibration; 586 km segment for corroboration	N, P	Dissolved oxygen, total diss. gas, pH, turbidity, benthic algae biomass	High	NNC	QUAL2K, AT2K
Massachusetts Estuary Nitrogen TMDL	Estuary	7,000 acres	N	Dissolved oxygen, chlorophyll *a*, benthic communities, eelgrass	High	NNC, TMDL	Hybrid (RMA2/ RMA4, Empirical stressor-response)
Upper Mississippi River – Lake Pepin Turbidity and Phosphorus TMDL	Lake/reservoir, stream/river	Three pools covering 90 miles of river/lake	P, N	Turbidity (river), chlorophyll *a* and algal type (lake), SAV	High	TMDL	UMR-LP
Numeric Nutrient Endpoints for the Klamath River Watershed, California	Lake/reservoir, stream/river	423 km river segment, 810 ha in reservoir area	N, P	Dissolved oxygen, clarity, chlorophyll *a*, cyanobacteria, benthic algae	Screening Level	NNE, TMDL	QUAL2K, BATHTUB

Related WERF Research

Project Title	Research Focus
Linking Receiving Water Impacts to Sources and to Water Quality Management Decisions (WERF3C10)	Captures the state of the knowledge on nutrients and lays out a framework for addressing nitrogen control. The framework includes establishing water quality impacts, linking these impacts to nutrients, quantifying major nitrogen sources, evaluating the costs and benefits of available nitrogen controls, estimating receiving water responses to controls, and assessing water quality for potential improvements.
Technical Approaches for Setting Site-Specific Nutrient Criteria (99WSM3)	A study from 10 years ago – most of which is still applicable – that provides methods to derive nutrient criteria for surface waters based on local factors, such as water quality requirements or designated uses.

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