VERMONT

Implementation Procedure for Development of Site-Specific Aquatic Life Water Quality Criteria for Copper Using the Biotic Ligand Model

The Biotic Ligand Model (BLM) for copper is recommended by the U.S. Environmental Protection Agency and is Vermont's preferred method for determining freshwater aquatic life criteria for copper as described in the 2007 Revision Aquatic Life Ambient Freshwater Quality Criteria for Copper (EPA-822-R-07-001). This model determines site-specific criteria that account for changes in bioavailability, and thus toxicity, of copper to aquatic life due to differences in water chemistry. The BLM uses ten water quality parameters to calculate acute and chronic instantaneous water quality criteria (IWQCs) that represent copper toxicity at a given location and time. The parameters used to calculate an IWQC must be collected concurrently at the same location.

The BLM predicts toxicity of metals by estimating the bioavailability of the metal to bind to the biological receptor, or biotic ligand, such as the gill surface. In contrast to hardness-based criteria, which only account for competitive binding at biotic ligand sites by calcium and magnesium cations, the BLM also accounts for binding at biotic ligand sites by other cations, as well as metal speciation and complexation with DOC and other inorganic ligands.

While the BLM can be run with one set of input parameters (one "dataset") to calculate an instantaneous criterion, an instantaneous criterion is a "snapshot in time" that reflects the water chemistry values for each of the ten parameters at one specific instant and location. Deriving an instantaneous criterion based on a single ambient sample would not account for variations in the BLM input parameters, some of which may vary substantially on a temporal and/or spatial scale. Using the BLM with one dataset is akin to using the hardness-based equation with only one value for hardness.

When using the BLM for assessment, reasonable potential determinations, and TMDL development, the Vermont Department of Environmental Conservation (VTDEC) requires a minimum of twelve samples for the input parameters that represent different temporal and/or spatial scales, as described in the following sections. Vermont will use the BLM on a targeted basis when site-specific data are available, as described in the Vermont Water Quality Standards. The hardness-based criterion remains in the Vermont Water Quality Standards and applies to all waters except for those where site-specific criteria are derived using the BLM.

BLM Input Parameters

Since the BLM predicts metal toxicity for a particular site based on the ambient water quality, multiple site-specific water quality parameters must be concurrently monitored to provide the necessary input data. These parameters include temperature, pH, dissolved organic carbon, major geochemical cations (calcium, magnesium, sodium, and potassium), alkalinity, and other major

geochemical anions (chloride, sulfate). Generally, for the BLM, the most sensitive input values are DOC and pH.

Number of Sampling Events and Spatial Variability When Using the BLM

To ensure that criteria values derived will protect aquatic biota during critical conditions (i.e., when copper is most bioavailable), Vermont requires the concurrent collection of water chemistry data for the input values under a range of temporal and spatial conditions to account for the variability of those parameters in each waterbody or waterbody segment. Conditions of pH, total hardness, and DOC may vary within a waterbody throughout the year, thereby affecting the bioavailability of copper over time. To identify when critical conditions may occur in a waterbody, Vermont requires that sampling data representative of summer, fall, winter, and spring conditions be collected for the input parameters. A minimum of twelve samples will be collected upstream of the discharge and representing seasonal conditions. Sampling methods will follow guidance provided in the WSMD Field Methods Manual and Ambient Biomonitoring Network Bioassessments of Flowing Waters in Vermont Quality Assurance Plan 2018 for rivers (lotic waters).

Spatial variability in the BLM input parameters caused by physical factors such as watershed size or the presence or absence of a point source discharge(s) to a waterbody should also be considered when determining how many sampling events are necessary when using the BLM to develop site-specific copper criteria.

The Vermont DEC Watershed Management Division monitors the water quality of lakes, ponds, rivers, streams, and wetlands across Vermont. The total number of river/stream and lake monitoring stations exceed 1,650 and 650 respectively. The Vermont Integrated Watershed Information System (IWIS) is an online data portal for water quality information. Water quality parameters include nutrients, metals, chloride, cations, anions, total hardness, alkalinity, pH, dissolved oxygen, temperature and dissolved organic carbon (DOC). This monitoring data will help provide and identify the chemistry data needed to satisfy input values for implementation of the BLM to develop site-specific copper criteria.

Calculating a Single Numeric Site-Specific Criterion from Multiple BLM-derived Instantaneous Criteria

The BLM calculates a copper criterion value for each set of input parameters (e.g., each dataset). For example, if there are twelve datasets or sampling events for a particular site, then the BLM will calculate twelve unique instantaneous copper criteria values. A minimum of twelve samples must be collected representing seasonal conditions. There are several options for developing a single numeric site-specific criterion from the BLM output. The site-specific criterion should protect the waterbody (i.e., its designated use for aquatic biota), under a variety of circumstances (e.g., seasonal conditions, high and low flows) and should not be exceeded more than the time allowed by Vermont Water Quality Standards (e.g., once every three years, on average).

Site-specific conditions may influence the selection of the statistical metric for calculating a numeric criterion for copper. If the water quality parameters and BLM-derived copper criteria are relatively constant over a range of seasonal and flow conditions, the 10^{th} percentile of model

outputs will be used, which will be protective under conditions when copper is most available and toxic to aquatic biota. For receiving waters with rare, threatened, and endangered species, the 5th percentile of model outputs will be used.

References

EPA (US Environmental Protection Agency). 2007a. Aquatic Life Ambient Freshwater Quality Criteria – Copper: 2007 Revision. Washington, DC: EPA, Office of Water. EPA-822-R07-001. https://nepis.epa.gov/Exe/ZyPDF.cgi/P1000PXC.PDF?Dockey=P1000PXC.pdf

EPA (US Environmental Protection Agency). 2007b. Training materials on Copper BLM: Data Requirements. Washington DC: EPA, Office of Water. www.epa.gov/sites/production/files/2015-11/documents/copper-data-requirementstraining.pdf

EPA (US Environmental Protection Agency). 2016. Draft Technical Support Document: Recommended Estimates for Missing Water Quality Parameters for Application in EPA's Biotic Ligand Model. Washington DC: EPA, Office of Water. EPA-820-R-15-106. www.epa.gov/sites/production/files/2016-02/documents/draft-tsd-recommended-blmparameters.pdf

EPA Publication # 820Q16001 Water Quality Standards Academy Biotic Ligand Model and Copper Criteria – March 2016