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TMDLs (Total Maximum Daily Loads) for Benthic Impairments

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What is a benthic impairment?

"Benthic" refers to the aquatic organisms living in or on the bottom of a body of water. Benthic organisms include crayfish, aquatic snails, clams, leeches, aquatic worms, certain insect larvae and nymphs (e.g., mayflies, dragonflies), and adult aquatic insects (e.g., riffle beetles). Changes in water quality generally result in changes in the types, numbers, or diversity of the benthic community.

In general, a water quality "impairment" exists if a body of water does not support its *designated uses*. (Italicized terms are defined in the boxes at the bottom of each page. See also *TMDLs (Total Maximum Daily Loads): Terms and Definitions*, VCE publication 442-550, http://www.pubs.ext.vt.edu/442-550/442-550.html.) Virginia's water quality standards specify that surface waters are designated for the following uses: "recreational use" (e.g., swimming, fishing, and boating) and "aquatic life use" (e.g., viable fish populations). *Water quality criteria* protect these uses. The aquatic life use is protected by a general narrative water quality criterion: "All state waters … shall be free from substances … [which] interfere directly or indirectly with designated uses … or are harmful to human, animal, plant, or aquatic life." Waters in which the benthic community is degraded violate this standard and are considered to have a "benthic impairment."

How are benthic impairments determined?

The *benthic macroinvertebrate* community present in a body of water is periodically evaluated to determine if a benthic impairment exists. Benthic macroinvertebrates (macro–organisms that are large enough to see with the naked eye; invertebrate–lacking a backbone) are "living recorders" of past and present water quality conditions. The Virginia Department of Environmental Quality (DEQ) currently uses U.S. Environmental Protection Agency (EPA) approved methods to evaluate the benthic macroinvertebrate community in freshwater streams and rivers to determine compliance with the aquatic life use criterion. DEQ biologists determine if the body of water is impaired by taking benthic mac-

benthic macroinvertebrates - organisms living in, or on, the bottom of a waterbody that are visible without a microscope ("macro-") and lack backbones ("invertebrates"). Benthic macroinvertebrates include larval or nymph forms for insects (e.g. stone flies, mayflies, etc.) crustaceans (e.g. crayfish), snails, mussels, clams, worms, and leeches.

designated use - those uses specified in water quality standards for each water body or segment. All Virginia waters are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish. Taken together, these uses are generally stated as "fishable and swimable." Through the protection of these uses, other uses such as industrial water supply, irrigation and navigation also are protected.

water quality criteria - include general narrative statements that describe good water quality and specific numeric criteria that are based on specific levels of pollutants that, if exceeded, would result in a water body not supporting a desginated use. The numerical and narrative criteria taken together describe water quality necessary to protect designated uses.

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roinvertebrate surveys in the body of water in question and comparing them to benthic macroinvertebrate surveys from a reference site. The reference site has characteristics (e.g., similar location, elevation, geology, and hydrology) similar to the body of water being evaluated, and the DEQ has determined that it supports a viable, diverse benthic macroinvertebrate community. For more information on the procedures used to assess the benthic macroinvertebrate community see the EPA's Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates and Fish.

Any stream segment with an overall rating of "moderately impaired" or "severely impaired," as determined by using the EPA approved Rapid Bioassessment Protocol, is placed on the state's 303(d) list of impaired streams. The DEQ is responsible for developing a Total Maximum Daily Load (TMDL) for waters on the 303(d) list. As of September 2002, 149 stream segments (approximately 1,055 miles) were included on the 303(d) list because of benthic impairments.

What is a TMDL?

A TMDL defines the total pollutant loading a water body can receive and still meet the applicable water quality standards. A TMDL is developed from a study that identifies the sources of a particular pollutant in a watershed, the pollutant contribution from each source, and the pollutant reduction required from those sources to attain and maintain water quality standards.

In TMDL calculations, all identified sources of the pollutant of concern are quantified, including *point sources* (e.g., pollutants coming from a pipe) and *nonpoint sources* (e.g., runoff). Natural *background levels* must also be determined and accounted for in the TMDL calculation, and the TMDL calculation has to take into account future pollutant sources. Because TMDL calculations are based on certain assumptions, they must include a *margin of safety* (a safety factor set by EPA and DEQ) to account for uncertainties in the estimation process.

What role do citizens play?

Citizens are involved in the TMDL development process through *stakeholder* participation. In this context, a stakeholder is any person or organization who has an economic interest in or is concerned about water quality in the watershed. Stakeholders can provide input in the TMDL process in a variety of ways: participating in public meetings by asking questions and providing feedback, providing additional information that the TMDL developer may not be aware of, and becoming involved in watershed advisory groups.

Two public meetings are generally held during the TMDL development process to inform stakeholders about the TMDL goals and the procedures for reaching them and to seek stakeholder input. The focus of the public meetings is to discuss the TMDL development process in terms the stakeholders can appreciate and understand. At the initial public meeting, typically held a few months into what is often a year-long process, the TMDL developer communicates what has been learned about the watershed and its characteristics. At this meeting the developer also explains the process and tools they intend to use to develop the TMDL.

At the final public meeting, the TMDL developer presents the draft TMDL report. Like the initial meeting, the

background levels - values of parameters that describe the chemical, physical, and biological conditions in an aquatic ecosystem prior to specific anthropogenic influences; chemical, physical, and biological levels representing conditions that would result from natural processes such as weathering and dissolution.

nonpoint source (NPS) pollution - pollution originating from diffuse sources on and above the landscape. Examples include runoff from fields, stormwater runoff from urban landscapes, roadbed erosion in forestry, and atmospheric deposition. Estimates indicate that NPS pollution accounts for more than one-half of the water pollution in the United States today. (contrast with point source pollution)

margin of safety (MOS) - a required component of the TMDL that accounts for the uncertainty in calculations of pollutant loading from point, nonpoint, and background sources.

point source pollution - pollutant loads discharged at a specific location. Point source discharges are generally regulated through the Virginia Pollution Discharge Elimination System (VPDES) permitting procedures. Point sources can also include pollutant loads contributed by tributaries to the main receiving stream or river. During TMDL development, permitted point sources are assigned a waste load allocation for the pollutant in question.

stakeholder - (in this context) any person or organization with a vested interest in TMDL development and implementation in a specific watershed.

final meeting will be publicized within the watershed, and announced in the *Virginia Register of Regulations* (http://legis.state.va.us/codecomm/register/regindex.htm). After the draft TMDL is completed, the public has 30 days to provide comments. The TMDL report and comments are then submitted to the EPA for review. After the EPA approves the report, it is presented to the Virginia State Water Control Board for adoption. Following adoption by the board, the approved TMDL becomes part of the Water Quality Management Plan for the watershed where the impaired river or stream is located, and the TMDL implementation process begins (see below).

How is a benthic impairment TMDL developed?

Identify the cause of the impairment

Because a benthic impairment is based on an assessment of benthic macroinvertebrates, rather than on some specific pollutant (e.g., the amount of bacteria in a stream), the cause of the impairment is not explicitly identified. A critical task in developing a TMDL to address a benthic impairment is identifying the cause of the impairment. This process is known as "stressor identification." Stressor identification involves examining water quality data to look for the most probable *stressor*–the pollutant or physical condition–causing the benthic degradation. Common benthic stressors include: elevated levels of sediment, organic matter, toxins, nutrients, and suspended solids; elevated temperatures; channel or runoff modifications in the watershed; and pH extremes. When the cause(s) of the benthic impairment are identified, a TMDL is developed for each specific stressor or pollutant.

Establish Pollutant Loads

A TMDL must define the target load for the identified pollutant. The target load is the amount of pollutant or physical condition that will not result in a water quality violation. If the identified pollutant is subject to a numeric water quality criterion (e.g., ammonia), the criterion is used as the target load. If no numeric water quality criterion exists for the identified pollutant (as is the case with sediment), another means for setting the target load is needed. In these instances, a reference watershed approach is often used. The reference watershed is chosen on the basis of its comparability with the impaired watershed and, most importantly, must not be impaired as determined by a DEQ biologist using benthic macroinvertebrate surveys. The load of the identified pollutant is calculated for the reference watershed and then used to set the target load for the impaired stream segment and its contributing watershed.

For example, if sediment is determined to be the critical stressor, the sediment load will be calculated for the reference watershed and the impaired watershed. If the sediment load in the impaired watershed is 8,000 tons per year, and the load in the reference watershed (adjusted to the size of the impaired watershed) is 5,000 tons per year, the load of sediment in the impaired watershed will need to be reduced by 3,000 tons per year to meet the target load.

TMDL Tools

A key component of developing a benthic TMDL is describing the relationships between the stressor/pollutant loading in the watershed and in-stream water quality conditions. Simulation models help relate watershed "inputs" like land use, topography, soil type, pollutant sources, etc. to "outputs" like in-stream pollutant concentrations and target loads. Once the target load is determined, the load is allocated to the different identified pollutant sources. Computer simulations are performed to develop pollutant load allocation scenarios showing alternative ways that the pollutant sources can be reduced to meet the TMDL target load. The final load allocation scenario must meet the TMDL target, and should be economically feasible, practical, and acceptable to stakeholders. Reducing the pollutant load in the impaired watershed to the target TMDL load is expected to restore water quality.

What happens after a TMDL is developed?

According to Virginia law, an Implementation Plan must be developed for each approved TMDL. Implementing a TMDL involves using specific pollution control and land-use management measures to restore water quality. The Implementation Plan must specify the steps needed to achieve the load allocations set forth in the TMDL. Implementation Plans are developed as a cooperative effort among stakeholders and local and state government agencies.

stressor - any substance or condition that adversely impacts the aquatic ecosystem, e.g., elevated levels of nutrients or sediment.

A typical TMDL Implementation Plan includes:

- a review of the TMDL and the final load allocation scenario,
- a description of local stakeholder participation in developing the Implementation Plan,
- a detailed description of the necessary pollution control measures required to restore the water quality in the impaired body of water,
- a cost/benefit analysis of the pollution control measures specified in the Implementation Plan,
- a schedule of implementation milestones, and
- a plan for continued water quality monitoring to document water quality improvements over time.

Executing the Implementation Plan may take ten years or more, and recovery of the benthic community may take even longer. Once monitoring data indicate that the body of water has sufficiently recovered to fully support the aquatic life designated use (that it is no longer "impaired"), the DEQ can request that the EPA "de-list" the water body (i.e., remove it from the 303(d) list). In fact, during any stage of the TMDL process, the body of water can be de-listed if legally and scientifically valid reasons are provided. Such reasons may include new data, results using acceptable new monitoring protocols, new standards, or simply errors in listing. Removal from the 303(d) list means that the water body has either met its TMDL requirements or no longer requires development of a TMDL.

Where can I find additional information?

The DEQ is the state agency leading the TMDL process. Questions about specific TMDLs can be directed to your regional DEQ office. The DEQ receives support from other state agencies. The Virginia Department of Conservation and Recreation (DCR) provides guidance on voluntary nonpoint source pollution controls and offers financial incentives to implement *best management practices*. The Virginia Department of Mines, Minerals, and Energy (DMME) assists with TMDLs relating to mineral extractions. DMME's Customer Services manages grant activities for restoration activities related to mining.

World Wide Web Resources

U.S. EPA: Total Maximum Daily Load Program Description

http://www.epa.gov/OWOW/tmdl/

U.S. EPA: Nonpoint Source Pollution Control Program Description

http://www.epa.gov/OWOW/NPS/

Virginia Department of Environmental Quality TMDL Homepage

http://www.deq.state.va.us/tmdl/

Virginia Department of Conservation and Recreation

http://www.dcr.state.va.us/sw/

USDA Water Quality Information Center

http://www.nal.usda.gov/wqic/

USDA Cooperative States Research, Education, and Extension

http://www.usawaterquality.org/

Conservation Technology Information Center, Purdue University

http://www.ctic.purdue.edu/kyw/tmdl/tmdlhome.html

Companion Virginia Cooperative Extension Publications

A Glossary of Water-Related Terms. VCE publication 442-758, *http://www.pubs.ext.vt.edu/442-758/*

TMDLs (Total Maximum Daily Loads) - Terms and Definitions. VCE publication 442-550, *http://www.pubs.ext.vt.edu/442-550/*

For a complete listing of Virginia Cooperative Extension fact sheets and bulletins, please go to *http://www.ext.vt.edu/resources*

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best management practices (BMPs) - reasonable and cost-effective means to reduce the likelihood of pollutants entering a water body. BMPs include riparian buffer strips, filter strips, nutrient management plans, conservation tillage, etc.

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Virginia Department of Environmental Quality. 2002. *2002 303(d) Report on Impaired Waters*. Richmond, Va.: Virginia Department of Environmental Quality. (http://www.deq.state.va.us/water/305b.html)