Virginia Water Central

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FEATURE ARTICLE

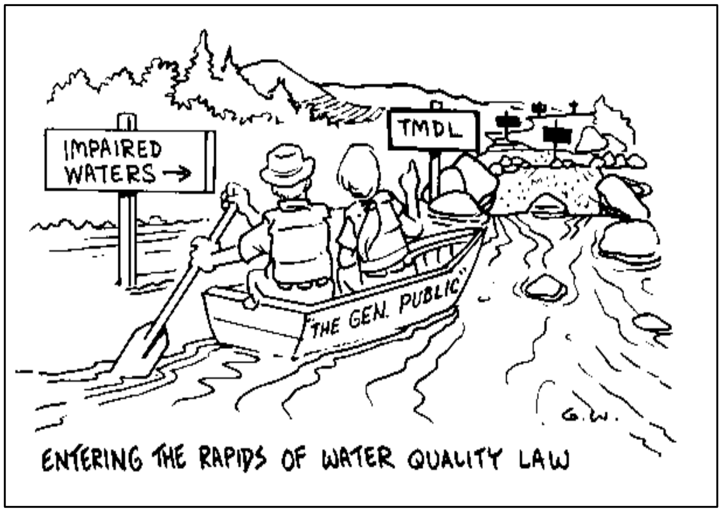
Navigating the Currents of Water Quality Law

In July 1998 the American Canoe Association and the American Littoral Society sued the U. S. Environmental Protection Agency (EPA) "for failure to perform certain nondiscretionary duties" in Virginia as required by the Clean Water Act. While the lawsuit levels a number of charges against the environmental agency, at least one of those includes its failure to establish "Total Maximum Daily Loads" (TMDLs) for watersheds in the Commonwealth of Virginia. Similar lawsuits have been filed in over 20 other states. What is the intent and purpose of these lawsuits? Why should EPA be establishing TMDLs for Virginia or any other state? What is a TMDL and why is it the subject of litigation? This article will help you navigate these and other questions of current water-quality law. A list of acronyms used is on page 2. *[Ed. note: Two new water-quality reports from the Water Center are available now. The titles and instructions on how to get the reports are in the "Notices" section, p. 14.]*

INSIDE

Clean Water Act at the Source

Travel back in time to 1972, when the Clean Water Act (CWA) was signed into law "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." One of its aims, implemented through the National Pollutant Discharge Elimination System (NPDES) permitting program, was to eliminate the pollution from **point sources**, so-called "end-of-pipe" sources where a single "point" of discharge—such as a wastewater treatment plant—can be identified. The CWA requires that point-source dischargers meet two standards, one based on the use of a body of water and the other on the technologies available to control effluents. Limits on discharges are imposed to ensure that waters can support designated uses, including aquatic life, fish and shellfish consumption, swimming, and drinking water.



Glossary of Acronyms and Reports Used Here and Elsewhere

CWA—Clean Water Act
DCR—Virginia Department of Conservation and Recreation
DEQ—Virginia Department of Environmental Quality
EPA—U. S. Environmental Protection Agency
NPDES—National Pollutant Discharge Elimination System (in Virginia, the Virginia Pollutant Discharge Elimination System, or VPDES)
NPS—Nonpoint source (of pollution)
TMDL—Total Maximum Daily Load: the amount of pollutant(s) a water body can receive daily and still meet water-quality standards and support designated uses
VAMWA—Virginia Association of Municipal Wastewater Agencies
303(d) Report—The report on impaired waters and TMDLs required by Section 303(d) of the Clean Water Act
305(b) Report—The report on water quality required by Section 305(b) of the Clean Water Act

Even with expensive state-of-the-art controls applied to point sources, however, water quality does not always meet standards. In many cases, that failure is due to **nonpoint source (NPS) pollutants**: pollutants that cannot be attributed to a single point, but rather originate from farm fields, city streets, suburban lawns, and other areas. Control of NPS pollutants was another CWA goal, but the NPDES permitting program has no authority over NPS pollutants. Until recently, control of these pollutants has been addressed primarily by a voluntary educational and financial-incentive programs.

How Clean Are U. S. Waters?

When it was passed into law, the CWA declared that the discharge of pollutants into navigable waters was to be *eliminated* by 1985. The plaintiffs in the citizen suits argue that this goal has not been met. They cite as evidence the country's record of water-quality assessment and remediation. Many of the nation's waters remain unmonitored, and of those that have been assessed a significant number fail to meet water-quality standards.[1] Assessment rates are 19 percent for rivers and streams; 40 percent for lakes, ponds, and reservoirs; and 72 percent for estuaries. Of the waters that have been assessed, 35-39 percent do not meet water-quality standards or fully support uses.

Such data provide the impetus for the lawsuits brought by citizen groups. Litigants charge that states ought to use the CWA to develop and implement plans for control of NPS (or any other) pollutants that prevent a water body from meeting water-quality standards, once point-source controls are in place. Specifically, the suits charge that Section 303(d) of the CWA should be implemented. This section requires that pollutants causing water-quality problems be identified and plans drawn up to reduce the load of those pollutants.

Enter TMDLs—the amount of a pollutant that a water body can receive daily and still meet water-quality standards and support designated uses. Environmental groups and others believe that the establishment and implementation of TMDLs will improve water quality, specifically by advancing efforts to reduce NPS pollution, and more generally by changing the focus of water-quality efforts. A 1997 memorandum to EPA regional water division directors made the latter point: "We. . .are making the transition from a clean water program based primarily on technology-based controls to water-quality-based controls implemented on a watershed basis."[2]

Lawsuits in Many States

Virginia is not alone in being the subject of a suit over TMDLs; the box below shows where TMDL litigation stands in a number of

[1]Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program, EPA 100-R-98-006, July 1998.

[2]Memorandum on New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs), by former EPA Assistant Administrator Robert Perciasepe, August 1997.

states. In the early 1990s, suits in western states resulted in EPA promulgating TMDL regulations, explained Ron Gregory of the DEQ's Office of Water-quality Assessment and Planning. "TMDLs had been part of the CWA since 1972," said Gregory, "but until EPA's regulations went into effect states were not required to comply." Oliver A. Houck, professor of law at Tulane University, asserts that Section 303(d) of the CWA was ignored until citizen suits made it impossible to do so.[1] Houck has written, "It is hard to think of any program more precipitously driven by citizen suits…than TMDLs. Short of some outside impetus…Section 303(d) was going to be ignored for no more complex reasons than (1) compliance was hard and (2) ignoring seemed possible."

Section 303(d), the TMDL section, requires states to provide EPA periodically with a list of "water-quality limited" or "impaired" waters that fail to meet water-quality standards, designated uses, and other requirements. These waters can be lakes, ponds, ocean coastal waters, wetlands, rivers, streams, estuaries, or bays. The list of impaired waters is known as the 303(d) report. The Commonwealth of Virginia has produced a 303(d) report every two years since the regulations went into effect in the early 1990s, said Gregory. The 1998 report, which Gregory terms "much expanded," was to be submitted to EPA October 15, 1998.[2]

The lawsuit involving Virginia's water quality charges that Virginia's 303(d) report of 1996 should not have been approved by EPA. The plaintiffs claim that Virginia failed to monitor all waters for compliance with standards, and that the report did not include all waters that are impaired, all pollutants causing impairment, or any TMDLs.[3]

EPA, rather than Virginia itself, is being sued because, the plaintiffs argue, the CWA provides that EPA is to do for any state what that state fails to do for itself. That is, if EPA sees Virginia fall short in meeting the requirements of the CWA, then EPA is supposed to step in and do it. In 11 states where similar lawsuits have been settled, EPA is under court order to establish TMDLs if the states do not. This could happen in Virginia as well, maintains James Stuhltrager at the Widener University Environmental and Natural Resources Law Clinic, whose James R. May is legal counsel for the citizen groups. "One outcome of the Virginia suit could be that EPA would be placed under a court order to provide a schedule for TMDL development," Stuhltrager commented. This possibility worries Patricia Miller, Virginia Department of Conservation and Recreation's (DCR) program coordinator of TMDL development. "The schedule we have proposed is already a tough one," she explained. "It's going to be hard to be sure the science is done well, and if we had to step up the pace there's very much a danger that we'd be making decisions based on shoddy science."

TMDL Litigation by State

States where suits have led to consent decrees against EPA: Alaska, Arizona, California, Delaware, Georgia, New Mexico, Oregon, Pennsylvania, Washington.

States with pending cases: Alabama, Colorado, Kansas, Louisiana, Maryland, Mississippi, Montana, New Jersey, New York, North Carolina, Oklahoma, Oregon, Virginia, Wyoming (and D.C.)

States that have received notices of intent to sue: Alabama, California, Florida, South Dakota.

Note: Some suits focus on specific watersheds, with more than one suit in a particular state.

Source: U. S. EPA web site: www.epa.gov/owow/tmdl/lawsuitl.html, as of October 1998 (list last updated April 10, 1998).

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[1]Houck, Oliver A. 1998. TMDLs III: A New Framework for the Clean Water Act's Ambient Standards Program. *Environmental Law Reporter* 28:10415-43.

[2]Virginia 303(D) Total Maximum Daily Load Priority List and Report (Draft), revised June 1998, prepared by the Department of Environmental Quality and the Department of Conservation and Recreation, Richmond, Virginia.

[3]Notice of Intent to File a Citizen Suit Under the Clean Water Act and the Endangered Species Act, Widener University Environmental and Natural Resources Law Clinic, Wilmington, Delaware.

Lawsuit Concerns Other Groups

Although it was not sued by the citizen groups, the Virginia Association of Municipal Wastewater Agencies (VAMWA) has intervened in the TMDL lawsuit. "We've become a party to the lawsuit to assist EPA in the defense," explained VAMWA legal counsel Dave Evans. Evans said that VAMWA believes that Virginia's water-quality program is substantial and meets the requirements of the CWA.

One defense raised is that the submission of the 1998 303(d) report will make the 1996 303(d) list of impaired waters, on which the citizen suit is based, out-of-date. But according to James Stuhltrager, the new report won't have much effect on the lawsuit. The charges about the 1996 report will stand, and "[o]nce EPA approves the 1998 report the complaint can be amended to include any deficiencies we see in the '98 report," he commented.

The VAMWA's Evans considers TMDLs important, but he contends that Virginia has been getting water-quality standards in place, issuing VPDES permits, and organizing its enforcement program. He maintains that the thousands of VPDES permits in the state are the "functional equivalents" of TMDLs. "To say that Virginia has done nothing with regards to water quality is a gross mischaracterization of what the state's program is all about, and that's the principal reason for our intervention in the suit," he stated.

The suit is currently pending in U. S. District Court in Alexandria. The merits of the case, both legal and factual, will be decided when it goes forward to summary judgment in early to mid-November.

TMDLs Further Defined

How are TMDLs supposed to work to improve water quality? A specific, current example in Virginia is Muddy Creek in Rockingham County. The creek has a fecal-coliform bacteria count such that is considered unsafe for swimming, and a nitrate level that disallows the creek's use as a drinking-water source. Virginia is therefore required to set TMDLs for fecal coliforms and nitrates. The state must determine the total daily amount of bacteria and nitrate this water can receive without impairing designated uses. The source or sources of the bacteria and nitrates must be determined and a plan must be developed for reducing the load from those sources.

That may seem fairly straightforward on paper, but Stuart Wilson, assistant division director for NPS programs at DCR, argues that it is not. For each *site* and each *pollutant*, the state must estimate the proportion of the total load coming from each of various *sources*—such as, potentially, agriculture, urban runoff, and septic systems—and how much each source must reduce its contribution to meet the TMDL. "It's not an easy process to quantify contributions from various sources," Wilson commented.

Ms. Miller of the DCR agreed that developing TMDLs will be a complicated and time-consuming process. "Muddy Creek is a good example," she explained. "Nitrogen chemistry is very complex; it exists in many forms that depend on oxygen, the pH of the water, and other factors. Developing a TMDL for fecal coliform bacteria will be a completely separate task; we have to look at biological instead of chemical processes."

Confusion about TMDLs sometimes results from the different ways the term is used. In one usage, a TMDL is a numerical limit; in another, a TMDL is a comprehensive plan for improving water quality in a watershed. The Federal Advisory Committee on the TMDL Program, for example, refers to TMDLs in both ways. As a *limit*, a TMDL is "a quantitative assessment of water-quality problems, contributing sources, and pollution reductions needed to attain water quality standards." As a *plan*, a TMDL "allocates pollution control or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a waterbody."

Virginia's TMDL Program

At the same time EPA is being sued for its alleged failure of proper oversight of Virginia's TMDL program, Virginia is actively developing that program. Since 1991, Virginia's DEQ and DCR have prepared 303(d) reports, and in 1997 the General Assembly passed a bill (SB 1122, which went into effect July 1, 1997) that amends the *Code of Virginia* to include the requirements of the CWA's Section 303(d). Sponsored by Joseph Gartlan, the bill calls for the expansion of monitoring in Virginia's waters to represent all river and stream miles and for an increase in frequency of sample collection. Gartlan commented, "In my opinion, it's the best thing we've ever done for Virginia's waters."

According to Chesapeake Bay Foundation's Roy Hoagland, the legislation expands existing statutory obligations. "SB 1122 broadens the list of what must appear in the 303(d) report," said Hoagland. He notes, for example, that Virginia law now requires condemned shellfish beds to be listed as impaired waters, but the EPA does not.

How Impaired Are Virginia's Waters?

The 1998 303(d) draft report (covering the 1992-1997 monitoring period) lists 240 waters that do not meet standards based on chemical and biological monitoring, and another 262 waters for which the Virginia Department of Health has restricted harvesting and consumption of fish or shellfish. For each of the impaired waters, the report describes the pollutant causing impairment along with its source, if known. Of 49,000 stream miles in Virginia, approximately 17,000 are monitored. Of these, the report lists 2,200 miles as impaired, with 1,500 miles due to NPS pollution and 600 miles due to unknown causes. An additional 157 square miles of tidal waters are listed as impaired. The report also specifies a schedule for TMDL development: 13 of the impaired waters by 2000, the others by 2010.

Better Get Used to This Acronym

The TMDL program is here to stay. Meeting its goals will require participation from federal, state, local, and tribal governments; regulatory agencies; industries; farmers; and homeowners. Public participation will be required for setting every TMDL.

Tulane University's Oliver Houck expects more lawsuits with regards to Section 303(d), following the first wave in the early 1990s that sought to get recognition for the TMDL program. Houck wrote, "Yet another round of citizen suits can be expected over the contents and, then, the implementation of TMDLs." Keep your acronym glossary handy.

–By Carolyn Kroehler,
Special Correspondent to Water Central

SCIENCE BEHIND THE NEWS

A 'Fish-eye' View of Water Quality

Understanding water quality can be as challenging as catching a school of fish one by one. The terms are many and sometimes difficult to grasp, and a search for information can—like disturbed fish—head off in many different directions.

This article takes one main direction: towards understanding what water quality means to Virginia's freshwater fish.[1] While focusing on fish, we'll encounter a number of terms and concepts that also apply to what water quality means for insects, clams, algae, and a host of other water-inhabiting or water-using organisms—including us.

Virginia's Water-quality Assessment Program

When headlines earlier this year reported "Creeks Unsuitable for Drinking, Swimming" (*Washington Post*, May 31, 1998) and "2,200 Miles of Virginia Rivers Polluted..." (*Richmond Times-Dispatch*, April 30, 1998), they were referring to what the Virginia Department of Environmental Quality (DEQ) calls "impaired" waters. According to the DEQ's 1996 *Water Quality Assessment Report* (1993-1995 period)[2], "impaired" means that the water bodies do not fully "support [one or more designated] uses for those waters..."

Virginia recognizes five designated uses that state waters support: **swimming**, **fish consumption**, **shellfishing** (some waters), **drinking water supply** (some waters) and **aquatic life**. For the first four uses, the question of "support" focuses on protection of human health. But the aquatic-life use involves the less easily defined notion of a *water body's* "health."

If a fish kill occurs in a water body (the 1996 DEQ listed 47 fish kills and one crab kill), that water body is clearly unhealthy (temporarily, at least). But, of course, monitoring by fish kill would be rather drastic, and late. Instead, water-quality monitors regularly measure various physical, chemical, and biological factors that relate to the health of an aquatic system. Most measurements are compared to **standards**, set by regulation, that are assumed to support aquatic life.

The Virginia program for aquatic life involves three main sets of measurements:

1) Measurements of water for dissolved oxygen, pH, and maximum temperature, so-called "**conventional measurements**" because these factors have long been used to characterize water quality;

2) Measurements of water, sediments, and fish tissue for these **toxic substances**:
Metals—arsenic, cadmium, chlorine, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc;
Organic compounds (such as pesticides and petroleum derivatives)—aldrin, chlordane, chlorpyrifos, cyanide, DDT, demeton, dieldrin, endosulfan, endrin, guthion,

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[1] The focus on fresh waters is due to time, space, and available information, *not* because Virginia's other waters are any less important.

[2] This is also called the "305b Report," after one of the relevant sections of the federal Clean Water Act. All state water-quality statistics in this article come from the 1996 305b report. The report assesses rivers and streams, lakes, estuaries, coastal waters, groundwater, and wetlands.

heptachlor, hexachlorocyclohexane, kepone, malathion, methoxychlor, mirex, parathion, PCB's, pentachlorophenol, toxaphene, and tributyltin (TBT);
Other—ammonia and hydrogen sulfide;

3) Measurements of the community of **benthic macroinvertebrates** (in streams, rivers, and estuaries only). These are animals that live on the bottom of the water body ("benthic"), which are visible without a microscope "macro-"), and that have no backbones ("invertebrates").

In some cases, Virginia applies different standards to different classes of waters. Virginia's water-quality program recognizes six classes of waters: I. ocean; II. estuaries; III. non-tidal waters; IV. mountain zone waters; V. put-and-take trout waters; and VI. natural trout waters.

With this short introduction to Virginia's water-quality assessment program, we turn now to our designated aquatic-life experts: freshwater fish.

Virginia Fish and Fish Habitats

Two hundred and ten fish species are known to inhabit Virginia's freshwater areas, according to *Freshwater Fishes of Virginia*, by Robert Jenkins and Noel Burkhead (1994).[1] These species display a variety of physical features (size, fin shape, etc.) and ecological needs (such as habitat requirements).

Virginia's freshwater habitats include headwater streams, medium- to large-sized rivers, Dismal Swamp, two natural lakes, impoundments (lakes formed by dams), farm ponds, large springs, and caves. The characteristics of any given habitat are due in large part to Virginia's climate; to the physical and geographical features of an area, known as the physiographic setting[2]; and to human activities and land uses. The characteristics of Virginia's major river basins also influence where fish species live.[3]

The fish living in these various habitats and locations have a range of needs related to survival, growth, and reproduction. Let's see how Virginia's aquatic-life water-quality measurements relate to these needs.

Fish Needs and Virginia Waters

Dissolved Oxygen

What's really the matter with a "fish out of water"? Mostly, the fish can't breathe. Like most organisms, fish need to take in oxygen to live. But fish do not normally get their oxygen from air; instead, they use their gills to transfer dissolved oxygen from the water to their blood.[4]

Fish use dissolved oxygen in **respiration**. Respiration is one of the main chemical processes by which organisms use energy stored in food for growth, movement, and other functions. The more active a fish is, the more energy it needs, and consequently the more oxygen it needs.

To get sufficient oxygen for their life functions, fish must move water past their gills, either by moving their mouth and their gill cover to pump water, or by swimming. These oxygen-getting activities themselves require energy. In general, the more oxygen dissolved in the surrounding water, the less energy fish use getting oxygen, and the more energy they have for other life functions.[5]

The available dissolved oxygen in water can vary considerably as environmental and biological conditions change daily or seasonally. (Please see box on page 8 for more details.) A fish can tolerate a certain range of dissolved oxygen levels, but each species has a lower limit below which the fish will not be able to get sufficient oxygen. Fish can, to some extent, compensate for low

[1] Worldwide, there are over 20,000 species of fish.

[2] From west to east, Virginia includes these settings: Appalachian or Cumberland Plateau, Valley and Ridge, Blue Ridge, Piedmont, Fall Line Zone, and Coastal Plain.

[3] For example, the Tennessee basin has 16 fish species that live in no other Virginia basins.

[4] Several different kinds of fish, however, *are* able to breathe air, using certain organs to transfer oxygen from the air to their blood.

[5] Fish can, however, suffer from prolonged exposure to water with too *high* a level of dissolved oxygen.

What Lets a *Fish* "Breathe Easier"?

Three factors affect the water's **solubility** for oxygen, that is, how much dissolved oxygen a given volume of water can hold:
the temperature of the water;
the salinity of the water; and
the pressure of the air above the water.

Other things being equal, cold water can hold more oxygen than warm water; fresh water more than salty water; and water under higher air pressure more than water under lower air pressure (e.g., water at high altitude).

Besides these three factors, other things affect the amount of dissolved oxygen that water actually *does* hold at any one time, known as the **concentration**:
•mixing of the water with air;
•production of oxygen by plants and algae; and
•use of oxygen in respiration by plants, animals, and bacteria.

Saturation occurs when the actual concentration of oxygen in water equals the water's solubility. **Percent of saturation** values are often used to describe dissolved oxygen levels.

dissolved oxygen. If exposed *gradually* or from a young age to lower oxygen, some fish may be able to increase the amount of oxygen they can take from a given volume of water, or adapt to a lower level of normal activity. Fish exposed *suddenly* to lower oxygen can try to swim to a better area, increase the volume of water passing over their gills, or increase the blood flow to the gills. If the oxygen level remains too low, however, eventually the fish will no longer be able to compensate and will die.

<u>Dissolved Oxygen Standards in Virginia</u>
•Virginia's *minimum-allowed* dissolved oxygen standards range from 4.0 milligrams of oxygen per liter of water (mg/l) for estuaries to 6.0 mg/l for natural trout waters; *daily-average* standards range from 5.0 mg/l for estuaries to 7.0 mg/l for natural trout waters.

Temperature

With luck, no one will ever call you a "cold fish," but if they do, you could retort that the cold has nothing to do with the *fish* and everything to do with the *environment*. A fish's temperature varies with the temperature of its surrounding water. As a result, fish are "cold-blooded" only when the water is cold; when the water is warmer, so are the fish's body and blood, and the fish can be more active.

As a group, freshwater fish in temperate climate areas normally live in waters between 0C and 30C (32—86 F). As with oxygen, however, species differ in the range of temperatures that they can tolerate.[1] Fish require certain temperatures not only for daily activities (feeding, for example), but also for reproductive activities, such as spawning and egg development. Reproduction often requires *lower* temperatures and a *narrower* range than other activities. Adult Brown Trout, for example, feed and show no stress at temperatures of 4—19 C (39—66 F), but temperatures of 15 C (59 F) and above lead to the death of eggs.

Freshwater fish are often classified into coldwater, coolwater, and warmwater habitats, referring primarily to the optimal range for juveniles and adults. Based on temperatures during sampling in warm seasons, authors Jenkins and Burkhead in *Freshwater Fishes of Virginia* (1994) grouped the 210 Virginia fish species into these three temperature categories, *as shown on page 9*.

Temperature Stress. Temperature stress occurs when a temperature change disturbs a fish's normal functioning. Temperature stress depends to a significant degree on the temperature to which a fish is **acclimated** (or accustomed), as well as how rapidly and how long extreme temperature is applied. Extreme temperatures, hot or cold, can be lethal. Temperatures that are not lethal but are nevertheless above or below a fish's preferred range can limit the energy available for growth (for example, a fish in unusually warm water has to use more energy just to get enough oxygen), or jeopardize its reproductive cycle (a sub-lethal

[1] At the narrow extreme are polar species that live within a range of -2.5—6 C (28 –43 F). At the broad extreme is the North American Desert Pupfish, with limits of about 2—44 C (36—111 F).

Habitat Temperatures for Virginia Fish Species (Adults and Juveniles)

←"Cold water"→ ←"Cool Water"→ → "Warm water"

~12 C (54 F) ~17—18 C (63—64 F) ~25 C (77 F)

Cold water only:
1 species (Slimy Sculpin)

Cool water only:
1 species
(Swannanoa Darter)

Warm water only:
124 species. (Example: Yellow Bullhead)

Cool to cold: 11 species. (Example: Tennessee Dace)

Cool to warm: 54 species. (Example: Smallmouth Bass)

Cold, cool, and warm: 19 species. (Example: Common Carp)

Source: *Freshwater Fishes of Virginia* (1994). *The degree limits above are general approximations only.* Authors Jenkins and Burkhead caution that temperature groupings in general are difficult because fishes' temperature relations are complex and may actually reflect other influences.

temperature for an adult might be lethal for its eggs). Because fish reproduction is often more temperature-sensitive than other activities, temperature extremes can affect not only individual fish but the *population* of a fish species in a certain area.

Temperature Standards in Virginia

- Virginia's maximum-temperature standards for aquatic life use are 32 C (90 F) for non-tidal waters, 31 C (88 F) for mountain zone waters, 21 C (70 F) for put-and-take trout waters, and 20 C (68 F) for natural trout waters. (There are no temperature standards for ocean or estuarine waters).

Chemical Environment

If a person tried get water by "drinking like a (freshwater) fish," they would get thirsty indeed. Freshwater fish actually *drink* very little water, because fresh water constantly diffuses through their gills.[1] This water contains many dissolved substances, any of which can potentially enter the fish, as well. Dissolved substances—to which fish are constantly exposed—are aspects of a fish's **chemical environment**. How a dissolved substance affects a fish—beneficially, harmfully, or with no significant effect—depends on the substance, its concentration, and its impact on the fish's *own* solutions.

pH. A solution's pH influences the solubility of the substances in the solution (for example, certain potentially toxic metals, such as aluminum, are more soluble at lower pH). By doing so, pH affects the types and amounts of substances to which a fish is exposed. An extreme pH, by drastically altering the water's chemical environment, can disrupt a fish's normal balance of dissolved substances in its blood and other fluids, upon which many essential functions depend (for example, transmission of nerve impulses).

The pH scale, ranging from 1 to 14, measures whether a solution is neutral, acidic, or basic.[2] A neutral solution has a pH of 7; a pH below 7 indicates acidic conditions

[1] In fact, freshwater fish have to use energy to eliminate *excess* water, *and* to retain essential elements that the fish needs but that are in relatively low concentration in fresh water. Saltwater fish have the opposite problem.

[2] A change of one pH unit indicates a 10-fold change in the strength of the acid or base. For example, pH 5 solution is ten times more acidic than pH 6.

(as in oranges, pH = 3—4); and a pH above 7 indicates basic conditions (as in household ammonia, pH 11-12). While the pH of natural waters can range from less than 2 to 12, the range of 6.0 to 9.0 is commonly found in inland waters and is often used as acceptable range for aquatic life.

As with other factors, fish have different tolerances for pH. *Freshwater Fishes of Virginia* lists 26 Virginia species that are apparently tolerant of pH between 4.5 and 6.0; all except Brook Trout live in lowland areas of Virginia.[1] Observations for other species, *shown on page 11*, indicate some of the range of pH tolerance by Virginia fish.

In general, however, below about 4.5 to 5, water is too acidic for fish; above about 9.5, too basic. Once again, eggs and immature fish can be more susceptible than adults.

Dramatic changes are seen in fish communities in response to extreme pH values. For example, acidic conditions below about pH 5.0, attributed to years of acid precipitation, have eliminated fish from some lakes and streams in the northern United States and other parts of the world. A dramatic example of the impact of *high* pH (basic conditions) occurred in June 1967 in the Clinch River in Russell County, Virginia. A large spill of a high-pH slurry from a waste-settling pond at an electric-power plant resulted in an estimated 216,000 fish deaths in Virginia and Tennessee. The pH of the pond water was 12.0-12.7, the Clinch River initial pH was 7.8-8.5, and the spill raised the river pH to as much as 11.0.

Changes in pH can affect other aquatic organisms, too, which have their own tolerances and responses to pH. Through various ecological relationships, effects on other organisms eventually can reach fish (and vice versa). For example, in Dismal Swamp, rooted vegetation reportedly is less abundant in the more acidic waters, affecting fish that rely on the vegetation for cover.

[1] The group of 26 acid-tolerant freshwater fish in Virginia are such relatively familiar fish as Brown Bullhead, Yellow Bullhead, Brook Trout, Bluegill, Pumpkinseed, and Yellow Perch.

pH Standards in Virginia

- Virginia's pH standards for aquatic life use are 6.0—9.0 for all classes of waters.

Toxic Substances. *Many* substances, even ones that are essential at the proper level, can be toxic to fish and other aquatic organisms. A toxic substance's effects may be **acute**, **chronic**, or both. Acute effects occur relatively quickly from a relatively high concentration (or dose). Chronic effects occur when an organism is exposed to a relatively low concentration (lower than the *acute* toxicity level, for example), but over a longer period (days or weeks). Under Virginia's current water-quality regulations for aquatic life, an acute standard refers to a one-hour average concentration, while a chronic standard refers to a four-day average concentration (except for ammonia's 30-day average concentration). For instance, the acute standard for cyanide is 22 micrograms (22 millionths of a gram) per liter, while the chronic standard is 6 micrograms per liter.[2]

The effects of toxic substances are complicated, and much is unknown about specific effects, on specific organisms, in specific aquatic systems. Given these cautions, however, here are a few well-documented aspects of five important types of toxic substances monitored in Virginia:

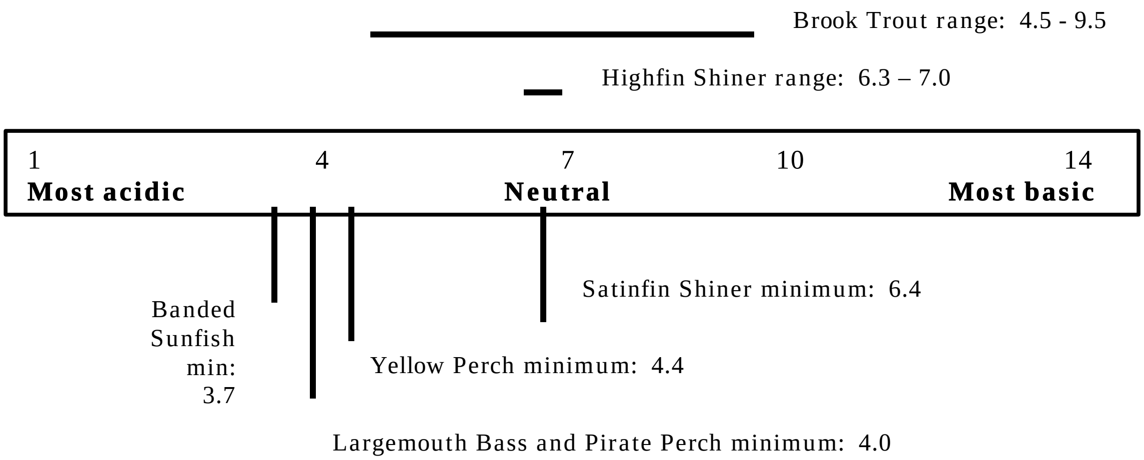
ammonia—Varying in its effects with pH, temperature, and salinity, ammonia can damage fish gills and reduce the ability of blood to carry oxygen.

chlorine—Chlorine reacts with ammonia to produce highly toxic chloramines, which can inhibit the blood's ability to carry oxygen. At low pH, chlorine itself exists in a toxic form that also can inhibit use of oxygen.

metals—The very toxic metals (such as lead and mercury) can bind with essential biological substances (proteins, for example) and inhibit their function.

[2] Considerable research is needed to identify toxicity levels. Some reasons for this are the differences among substances, among organisms, among aquatic systems, and between natural systems and the laboratory.

pH Ranges and Tolerances for Some Virginia Fish



Source: *Freshwater Fishes of Virginia* (1994). These values are *not necessarily definitive* for the species shown. Also, the minimum values given for Yellow Perch and Pirate Perch were not observed in Virginia, but rather in the New Jersey Pine Barrens.

organochlorine insecticides—This group includes aldrin, dieldrin, DDT, endosulfan, heptachlor, kepone, and methoxychlor, all monitored in Virginia. They all interfere with a fish's nervous system.
organophosphorus insecticides—This group includes chlorpyrifos, malathion, and parathion, all monitored in Virginia. These can disrupt a fish's nervous system.

Toxic Substances Standards in Virginia
•Each toxic substance has one or more maximum acceptable levels, depending on short- vs. long-term exposure and other complicating factors. For a list of the toxic-substances standards, please contact the VA DEQ Office of Water Quality Assessment.

The Benthic Community

"Bottom-feeding" may be disdained in some human endeavors, but the organisms inhabiting the bottom of water bodies are key components in aquatic food chains. Besides providing food, however, the benthic community is a good water-quality indicator, because the relative abundance of species on the bottom reflects the conditions to which the habitat has been exposed over time.

Using the U. S. EPA Rapid Bioassessment method, benthic monitors look particularly at the mayfly, stonefly, and caddisfly insect groups. These insects generally are intolerant of pollution and require high dissolved oxygen levels. Their presence in adequate numbers indicates that, *over a period of time*, the habitat's oxygen and overall chemical environment (and probably the flow, as well) have all been suitable for aquatic life generally.

Benthic Measurement in Virginia
•There are no numerical standards as such for benthic monitoring. Instead, measurements made at a sample site are compared to **reference sites** that, based on prior sampling, represent the "least impaired" conditions for the particular location and stream size. Physical habitat features are also measured and compared to the measurements at a reference site.

A Fish Needs Water, and…

At the "fish-eye" level, good water quality means the water provides conditions that support the daily business of being a fish—swimming, hiding, breathing, breeding, eating, and even being eaten. For any of these activities (except being eaten), fish need energy and the proper level of essential substances. Measurements of dissolved oxygen, temperature, pH, and the benthic community all contribute to assessing whether a water body is meeting those needs.

Fish are, of course, only one group of aquatic organisms affected by Virginia's water quality, and aquatic life is only one of five beneficial uses of concern. Yet a freshwater fish contends with many of the same basic water-quality factors that affect other aquatic life can affect the four other beneficial uses, as well. Looking through the "fish eye" can help bring into view the broader overall process of water-quality assessment.

Water Central thanks D. M. McLeod (VA DEQ/Roanoke), Reese Voshell (Virginia Tech Department of Entomology), and William van Wart (VA DEQ/Harrisonburg) for information they provided for this article; and Carl Zipper (Virginia Tech Department of Crop and Soil Environmental Sciences) for reviewing the article.

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Further Reading on the World Wide Web

The aquarium pages at the Virginia Institute of Marine Science (VIMS) site useful offering on both marine and freshwater fish, such as "The Fish Information Service": **www.vims.edu/aquarium/**.

The Virginia Tech Department of Fisheries and Wildlife Sciences site includes summaries of that department's ongoing research on stream and reservoir fisheries and on aquaculture: **www.fw.vt.edu/fisheries/**.

IN AND *OUT OF* THE NEWS
Newsworthy Items You May Have Missed

•In August, officials from Arlington and Fairfax Counties and the cities of Alexandria and Falls Church signed a long-term agreement to address water quality in **Four Mile Run**, a nine-mile-long tributary of the Potomac River. The stream has had a history of water-pollution problems, including the recent discovery that sewer lines in one development were improperly installed 27 years—and some six million gallons of wastewater—ago. The agreement provides for permanent, regular testing to replace the somewhat inconsistent current efforts. One goal of the joint effort will be to determine the sources or sources of fecal bacteria contamination. To help do so, the jurisdictions may decide to use **DNA testing**, which can distinguish different sources (dog, human, goose, etc.). *Fairfax Journal*, 9/1/98, and *Washington Post* , 10/1/98)

•**More on DNA testing for bacteria**: Virginia Department of Environmental Quality (DEQ) officials hope to use DNA testing to find the source of fecal contamination in Muddy Creek in southwestern Rockingham County. Muddy Creek is the first "impaired water" receiving attention under a "TMDL" plan by the DEQ and the Virginia Department of Conservation and Recreation (for more on Muddy Creek and TMDLs, see the Feature article, p. 4). The state needs a $30,000 federal grant to proceed with the DNA testing. Water samples from the creek would be sent to the University of Washington for testing. (*Richmond Times-Dispatch*, 9/6/98)

•The **Chesapeake Bay population of blue crabs** continues under scrutiny, with apparently contradictory data generating some differences of opinion between scientists and commercial crabbers. Crab catches in Maryland dropped from 9 million pounds in July 1997 to 4.6 million for July 1998, and Virginia's April—June catch was also down from last year. In addition, 12 aquatic scientists and fishery managers at a September 3 meeting expressed concern about research data showing a reduction in the crab population and in submerged vegetation that provides important crab habitat. On the other hand, the April—June Virginia catch was *up* compared to 1996, and Virginia's July catch was expected to be about average. (*Richmond Times-Dispatch*, 9/4/98)

•According to a U. S. Public Interest Research Group report on **toxic pollution** between 1992 and 1996, Virginia ranked 16th in the nation for discharge of toxic chemicals into waterways. The report, entitled "Troubled Waters," was based on industry figures reported to the U. S. EPA. **Gravelly Run** in Hopewell received the most chemical inputs in Virginia, some six million pounds directly and three million pounds from sewage-treatment plants. The Mississippi River received the most of any waterway in the country, an estimated 300 million pounds. The Potomac River received an estimated 315,000 pounds. Nationwide during the five-year period, industries discharged almost one billion pounds directly into waterways and 1.4 billion pounds into sewage systems. (*Associated Press*, and *Prince George's Journal*, 9/11/98)

•Virginia Delegate Ted Bennett and State Senator Charles Hawkins have appointed a citizen's advisory committee to look into **PCB contamination in the Staunton River**, following the Virginia Department of Health's fish-consumption advisory issued in July. The committee includes local residents, members of community groups, and elected officials. (*Danville Register & Bee*, 9/21/98)

•In July, President Clinton signed the **National Drought Policy Act of 1998**. The Act established the National Drought Policy Commission to advise Congress on creating a coordinated national policy for drought-emergency preparation and response. (*Natural Hazards Observer*, September 1998)

•As part of the Virginia Fall River Renaissance, **volunteer monitoring** groups across the state sampled sites in late September and early October. The data collected—chemical, biological, and photographic—was to be compiled into a "reflection of water quality in Virginia." (*Information from Virginia DEQ and Virginia Izaak Walton Save Our Streams program*)

•***Pfiesteria* update:** Only two possible Pfiesteria events were seen in Maryland this summer, in the Wicomico River and in the Chicamacomico River. No fish kills were reported and only a small number of Atlantic menhaden were found with sores.

Meanwhile, University of Maryland scientists have received a $2.4 million grant to clarify how nutrients may promote the growth of *Pfiesteria*. (*Associated Press*, 9/30/98, and *Baltimore Sun*, 10/6/98)

•**More on menhaden**: According the Chesapeake Bay Acid Rain Foundation, the Atlantic menhaden population has dropped 58 percent since 1991. Menhaden, which filter-feed on floating, mostly microscopic organisms, are themselves an important food for Striped Bass. The Maryland Department of Natural Resources is concerned that the menhaden population decrease may be a factor in a number of reports of Striped Bass in poor condition. The Atlantic States Marine Fisheries Commission has agreed to review its Atlantic menhaden management plan and reassess the accuracy of population estimates. In 1994, menhaden harvested for their oil and as livestock feed were worth over $30 million in Virginia. (*Washington Post*, 10/6/98)

•On October 7, President Clinton outlined **proposed new wetlands rules**. The rules would require greater environmental review of requests for so-called "fast-track" permits to fill wetlands. According to the president's remarks, the rules would be intended not only for environmental benefits but also for reducing damage caused by flooding. These rules are part of a wetlands-regulations review that the U. S. Army Corps of Engineers has been conducting since 1997. (*Washington Post*, 10/8/98)

•Finally, take a look at this, Barney! TV personality **Andy Griffith**, a native and current resident of North Carolina, has donated 319 acres of forested wetlands near Virginia's **Great Dismal Swamp** to the Nature Conservancy for permanent preservation. The tract is in the headwaters of the Northwest River, a drinking-water source for Chesapeake. With this acquisition, the Conservancy, whose Virginia chapter is located in Charlottesville, now has acquired for preservation over 3,000 acres in a large marshy area between Virginia Beach and Dismal Swamp known as "The Green Sea." The Conservancy approached Griffith in 1997 about the land, as part of it ongoing effort to preserve wetlands in southeastern Virginia. (*The Virginian-Pilot*, 10/16/98)

This section and "For the Record" (page 15) were compiled by H. Elizabeth Donegan. Liz, a junior at Virginia Tech, was an intern at the Water Center in Fall 1998.

N O T I C E S

•**The 10th Virginia Water & Sewer Rate Report** was released October 1 by Draper-Aden Associates. To request a copy, contact Draper-Aden at 8090 Villa Park Drive, Richmond 23228; (804) 264-2228; e-mail wssurvey@daa.com.

•The U. S. EPA has opened the floor for **debate on the entire national water-quality standards program**. An advance notice of proposed rulemaking, issued by EPA on July 7, is "intended to initiate discussions on what if any changes are needed in the...program to improve the effectiveness of water quality standards..." This is a "profound turning point in the national program," according to the EPA assistant administrator for water. For more information, contact Rob Wood, U. S. EPA Standards and Applied Science Division (4305), 401 M. St. SW, Washington, D.C. 20460; (202) 260-9536; e-mail wood.robert@epa.gov.

•The 1998 Virginia General Assembly established a **Subcommittee Studying the Future of Virginia's Environment**. The group has met several times, and will meet again on December 17 at House Room D of the General Assembly Building in Richmond. The subcommittee chair is Delegate Thomas Moss, Jr. There is also a sub-group looking particularly at the Water Quality Improvement Act. For more information on the subcommittee's work, contact the Division of Legislative Services, 910 Capitol Square, General Assembly Building, Richmond 23219; (804) 786-3591.

•**At the Water Center**, two new reports on Virginia water quality are now available:

Report of the Water Quality Academic Advisory Committee, an evaluation of the scientific merits of the Virginia Department of Environmental Quality's water-quality assessment procedures. Virginia residents may receive one free copy of this publication, while supply lasts, by calling the Water Center at (540) 231-5624, writing to 10 Sandy Hall (0444), Blacksburg, VA 24061; or sending e-mail to water@vt.edu.

Long-Term Water-Quality Trends in Virginia Waterways, is available now *at the Water Center's web site only* (**www.vwrrc.vt.edu/vwrrc/vwrrc.htm**; click on "Publications," then "Special Reports"). A print version will be available later this year or in early 1999.

FOR THE RECORD
Sources for Selected Public-interest Topics

For the Record Schedule

1998
This issue – Finding Water Quality Information
December – Finding Hydrologic, Weather, and Climate Information and Data

1999
February – Tracking Virginia General Assembly Legislation
April – Following State Water Regulatory Processes
June – Tracking Federal Legislation and EPA Regulations
August – Finding Drinking Water Information

Schedule subject to change

Finding Water Quality Information

Virginia's Department of Environmental Quality (DEQ) monitors water quality in surface water and groundwater. Reports currently available include *1997 Ambient Water Quality Monitoring*; 1996 305(b) *Water Quality Assessment and Non-point Source Pollution Watershed Report*; and the 1996 303(d) *TMDL Priority List* (the 1998 version has been submitted to the U.S. EPA for approval). Contact the DEQ Water Quality Assessment Office, P. O. Box 10009, Richmond, VA 23240-0009; (804) 698-4471. Report summaries are available at **www.deq.state.va.us/envprog/data.html#quality**.

The Virginia Water Control Board sets policies and regulations for Virginia's water resources. To request a list of publications of their data and research on water quality issues, write the Water Quality Assessment Program, P. O. Box 11143, Richmond, VA 23230; or call (804) 527-5179.

Internet users can get information about specific watersheds at the U.S. EPA's "Surf Your Watershed" site: **www.epa.gov/surf/surf_search.html**. The site has information collected by federal, state, and local government agencies, tribal agencies, researchers, and volunteer groups.

The U.S. Geological Survey maintains a National Water Information Center. Fact sheets, publications, and information on the national water-quality assessment program are available. Call (800) H2O-9000.

Several volunteer groups in Virginia monitor water quality. To learn about these groups and available data, contact Stacey Brown, Virginia DEQ Volunteer Monitoring Coordinator, DEQ/WQA, P. O. Box 10009, Richmond, VA 23240; (804) 698-4026 or (800) 592-5482; e-mail: stbrown@deq.state.va.us.

–By H. Elizabeth Donegan

TEACHING WATER
For Virginia's K-12 teachers

This Issue and the Virginia Standards of Learning

(Abbreviations: BIO-biology, CH-Chemistry, ES-earth science, LS-Life science, PS-physical science).

"Impaired Waters"
Science: 4.8, 6.11, LS.12, ES.9, BIO.9.
Social Studies: 7.4, 12.6, 12.7, 12.8, 12.10, 12.13.

"Fish-eye View of Water Quality"
Science: 3.6, 3.10, 4.5, 4.8, 5.5, 6.8, 6.9, 6.11, LS.3, LS.4, LS.7, LS.12, PS.2, ES.9, BIO.3, BIO.5, BIO.9, CH.6.

"In and Out of the News"
Science: 3.11, 4.5, 4.8, 6.11, LS.12, LS.13, ES.7, ES.9, ES.11, BIO.8, BIO.9.
Social Studies: 7.4, 12.10, 12.13.

"For the Record"
Social Studies: 7.4, 12.13.

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Please answer the following questions to let us know whether the newsletter is meeting your needs. Please mail this page to the Water Center address listed in the box to the left, or e-mail your responses to water @vt.edu. Thank you.

1. Would you rate the **content** of this issue as good, fair, or poor?

2. Would you rate the **appearance** as good, fair, or poor?

3. Would you rate the **readability** of the articles as good, fair, or poor?

4. Do you approve of the newsletter **name**? If not, please suggest an alternative.

5. Please add any other **comments** you wish to make.

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