Virginia Water Central

Virginia Water Resources Research Center Blacksburg, Virginia December 1998

FEATURE ARTICLE

Fitting Drinking Water Amendments into Place

"I just keep thinking of the ol' days when if you got one call a year asking what was going on, then you were surprised."

Glenn Tillman, director of utilities for Berryville (Clarke County), says times have changed at the water plant. Nowadays, people call relatively often to ask what's in their water and how it's being treated. The relatively small Berryville operation (about 1,000 connections serving about 3,200 people) is one of hundreds in Virginia faced with complying with the federal Safe Drinking Water Act (SDWA) and its most recent set of major amendments, passed in 1996.

To gauge how the 1996 amendments are affecting Virginia, we interviewed six water plant operators, at large systems (tens of thousands of customers) and at small ones (as few as 2,000 customers). We also spoke with the Virginia Department of Health (VDH), the agency directly involved with drinking-water systems, about implementation of some key aspects of the 1996 amendments. To set the stage, we begin an overview of the SDWA's development.

SDWA Overview[1]

The diagram at the top of page 2 outlines the major developments in federal drinking-water law. The SDWA was enacted in 1974 to protect the quality of drinking water nationwide. U. S. Environmental Protection Agency (EPA) literature states that the act "focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources. The act authorized the EPA to establish safe standards of purity and required all owners or operators of public water systems to comply with primary (health-related) standards. A "public water system" (PWS) is *any* water system (publicly

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INSIDE

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[1] A list of drinking-water acronyms used in this article is on page 6. The full text of the Safe Drinking Water Act and ensuing amendments is available at the U. S. EPA's Office of Water Web site: **www.epa.gov/ogwdw/sdwa/sdwa.html/**.

Key Points in the Development of the Federal Safe Drinking Water Act

Pre-1974—State responsibility for safe water, with growing federal role.

Since 1914, the U. S. Public Health Service had set some bacterial and chemical standards. States are responsible for protecting drinking water from bacterial contamination. In 1970, a national survey of water systems details widespread water-system problems and deficiencies in the system of Public Health Service standards and state programs.

December 1974—Federal Safe Drinking Water Act (SDWA) enacted.

Federal government sets goal of safe drinking water for *all* public water system above a certain size. Main focus is on setting standards (maximum-allowable levels) for contaminants, with a limited focus on source-water protection strategies.

1974 to 1986—Implementation.

Increasing compliance with existing standards, but slow development of standards for new contaminants.

June 1986—First major revision.

EPA required to develop a schedule for regulating many more contaminants. Certain treatment techniques mandated (e.g., for lead). Monitoring for unregulated contaminants required. Wellhead protection is emphasized as a source-water protection strategy. Some provisions to help small systems.

1986 to 1996—Implementation.

Regulations developed for a wide range of substances. Complicated regulations result to deal with surface water treatment, monitoring, and disinfection by-products. Extent of regulation creates compliance problems for states and public water systems, along with concerns about priority contaminants.

August 1996—Most recent major revision.

Billions allocated for improving water systems, mainly smaller ones.

Source-water protection programs *greatly* expanded.

Public water systems required to report yearly to customers on contaminant levels.

Small water systems are to work to develop their financial, managerial, and technical capacity.

Source: Cox, William E. "Evolution of the Safe Drinking Water Act." *William and Mary Environmental Law and Policy Review*, Winter 1997.

or privately owned) that serves at least 25 people or has at least 15 connections.

President Clinton signed the second major set of SDWA amendments into law on August 6, 1996. Four aspects of the amendments are particularly noteworthy: source water assessment, source water protection, public education, and capacity development and funding. Before we turn to those issues, the following list briefly describes other aspects of the amendments.

- **Risk assessment, management, and communication**: Cost-benefit analysis required for each new regulated contaminant.
- **Groundwater disinfection**: May require some groundwater systems to incorporate disinfection treatment techniques.
- **Arsenic, sulfate and radon**: Requires studies on health effects on these three contaminants, and requires an upper limit to be set for arsenic by January 1, 2000.
- **Small System Variances**: Many systems, based on the system's size and resources, will be allowed to exceed legal contaminant levels.
- **Waterworks Operator Certification**: Within a certain time period, all water operators must earn state certification.

•**Contaminant Occurrence Database**: States must create a publicly available database of the occurrence of contaminants in public drinking-water supplies.

Source Water Assessment Program

According to Dr. William E. Cox, a professor in civil engineering at Virginia Tech who specializes in water resources policy, planning, and management, the SDWA's emphasis is changing. "[There is a] subtle movement away from [the] basic premise...that safe drinking water can be attained solely by application of treatment technology...," he said. This "retreat from sole reliance on treatment" is seen in increased emphasis on preventing contamination of **source water**.

If you could trace your drinking water back through the faucet, into the pipes, and (perhaps) through storage tanks and a treatment plant, you would eventually arrive at the source water. Source water comes in several forms, including rivers, reservoirs, or groundwater aquifers. A **source water assessment's** purpose is threefold:
•delineate the area around a water source that could affect water quality;
•inventory land-use activities in the delineated area to identify possible sources of regulated and unregulated contaminants[1] that may threaten public health;
•determine the susceptibility of the source water to the potential contaminants in the delineated area.

Jerry Peaks, project supervisor in the VDH's Division of Water Supply Engineering, outlined the assessment program in Virginia. Three committees are drawing up Virginia's program: the Waterworks Advisory Committee (WAC), which has a wide array of technical and citizen involvement; the Source Water Protection Team (SWPT) made up of Virginia Department of Health (VDH) representatives and members of the WAC; and the Source Water Assessment Technical and Citizens Committee (TAC), created to meet the act's public participation requirements. Recent and upcoming developments in the process are as follows:
•The TAC had its final meeting on November 17, 1998, and, aside from minor changes, approved Virginia's program.
•Once prepared in its final draft, the document will be available for the public.[2]
•In the 42 months following the program's approval, the state will complete assessments of all drinking-water sources. Peaks said the health department's staff will do all of the assessments.

The assessment program is designed to use existing data collected under the Clean Water Act and other water monitoring efforts. The Virginia Department of Conservation and Recreation (DCR) will provide studies on groundwater sources in karst areas, and the United States Geological Survey (USGS) will study the susceptibility of groundwater sources to contamination. Nine federal agencies have agreed to cooperate to assist state and local efforts by sharing computer databases and other information.[3]

Source Water Protection

EPA literature on the 1998 amendments states that source water protection is "a cost-effective strategy for ensuring safe drinking-water supplies..." because "a poor water source supply increases the costs of treatment" and "development of a new water supply often is expensive."

Source water protection encompasses several methods and strategies to prevent contamination of drinking-water supplies. Specific protection activities depend on what

[1] Unregulated contaminants are those may pose a threat, but are not regulated under federal law.

[2] Two public hearings have already been set: in Roanoke, January 11, 1999, 1 p.m. and 7 p.m. at the Southeast Rural Community Assistance Project, 145 Campbell Avenue; and January 12, 2 p.m. and 7 p.m. at Richmond's Virginia War Memorial, 621 S. Belvedere Street.

[3] The cooperating agencies are the EPA, the U.S. Postal Service, the Tennessee Valley Authority, and the departments of Agriculture, Commerce, Defense, Energy, Interior, and Transportation.

source water assessments identify as potential water contamination problems. “Source water protection is completely open and dependent on what land-use activities are [in the area],” said the VDH’s Mr. Peaks. Buying land to protect it from contaminating uses, stricter zoning laws that limit development, and stricter stormwater management in new subdivisions all fall under the heading of source water protection. Public education and involvement will be necessary ingredients in any strategy.

Protection Efforts Already Underway

At the federal and state level, the wellhead-protection program is an example of an existing source water protection program. This program seeks to protect groundwater supplies by managing potentially contaminating activities within the land area that influences well’s groundwater source. In Virginia, the Groundwater Protection Steering Committee (GWPSC)[1] is encouraging municipalities to start as soon as possible on implementing programs to protect groundwater supplies, and the committee offers a report that outlines how to write wellhead protection ordinances. (Please see the Notices section of this newsletter for information on how to order the report. Another relevant publication, *A Guide to Protecting Virginia’s Valuable Resource: Ground Water*, is available from the Water Center.)

Some *local* water systems, moreover, began source water protection programs years ago. Their work gives them an advantage as the 1996 amendments take effect: they will make changes to an established program, rather than building one from scratch.

One such system is in Albermarle County. David Hirschman, the county’s water resources manager, described the county’s program. Because of problems such as algae blooms in their Rivanna River reservoir, Albemarle began an extensive program in 1980. The program first delineated watersheds, then followed with a variety of source water protection rules, such as local ordinances requiring buffers of natural vegetation along undeveloped streambanks. The new assessment program will certainly mean some change for the county, Hirschman said, but the changes may be only minimal.

In the City of Roanoke, source water protection is an established practice. The water system owns the entire watershed surrounding Carvin’s Cove reservoir and tightly monitors recreational users of the water, according to Jesse Perdue, water manager for Roanoke’s Water Department. Perdue noted, however, that source water protection requires educating the public about its importance, not always an easy task. He says most people that he encounters believe any contamination can be handled at the treatment plant, so that they don’t necessarily see a need for source water protection. As an example, one part of the source water protection efforts at Carvin’s Cove include keeping the zebra mussel out of the water system. (A non-native species, zebra mussels can clog water-intake pipes.) Recreational boaters on Carvin’s Cove must follow various requirements to prevent the zebra mussel from getting into the water. Perdue said trying to convince the public that such an animal exists, however, is difficult.

Kit Kiser, director of utilities and operations for the city of Roanoke, said source water protection must be balanced against other needs in the community, but it is certainly cost-effective for water plants. “We, like anyone else, try to make sure our raw product is as pure as possible,” he said. “Keeping something from getting in lowers the cost to [treat] water.”

Public Education

According to the EPA, “Consumer awareness/right-to-know was a major theme of the [1996] amendments [and symbolized] a significant shift toward more public

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[1] The GWPSC is an advisory committee whose mission is to strengthen, and coordinate groundwater- protection activities in Virginia. The committee includes representative from 10 relevant Virginia agencies and the U. S. Geological Survey.

involvement in drinking-water protection activities." The 1996 amendments clearly state that the public must be informed about its drinking-water quality. Citizens are to have access to scientific data that relates to public health and water contaminants, and they are to be made aware of "expected risks" from specific contaminants. Local officials must "ensure that the…information on public health effects is comprehensive, informative, and understandable."

One part of the education requirement is notification of water-system performance through "Consumer Confidence Reports," to be issued annually to water customers. The reports must include information on any failures to meet contaminant level standards, potential health effects of contaminants, and opportunities for the public to become more informed and involved. The first annual reports must be sent to public water system customers by October 1999. Besides the annual reports, the law also requires more timely notice any time a water system fails to meet federal or state water quality standards. Severe problems are to be announced by local media within 24 hours; less severe problems may be noted in water bills.

For more general public education about source water assessment and protection, states are taking various steps. In New York, for example, Cornell University produced a satellite-broadcast videoteleconference titled "Source Water Assessment for NYS." Between 900 and 1,200 people viewed the video in Summer 1998.[1] In Virginia, meanwhile, the VDH is working through established organizations, such as the Virginia Rural Water Association, to promote source water protection.

Funding and Capacity Development

Treating water is an expensive proposition. It has long been the complaint of many smaller suppliers that complying with the SDWA is a financial burden, if not at times an outright impossibility. The 1996 amendments are designed to help smaller plants get the financial, managerial, and technical resources they need to improve their capacity to meet demand and comply with regulations.

A new loan fund, the Drinking Water State Revolving Loan Fund, was initiated by the 1996 amendments. The fund is meant for loans to water systems that need to upgrade their infrastructure and improve compliance.[2] The amendments authorized (that is, gave Congress permission to appropriate) about $6 billion through 2003 for the fund, with an annual cap of $1 billion. In fiscal year 1997—the first year of allocation—Congress actually appropriated $1.25 billion to the states, with Virginia's share being about $30 million. In fiscal year 1999, the appropriation was $775 million. [3]

Capacity development was a major part of the 1996 amendments, and it dictates in part how much money each state receives from the loan fund. The law says that each state will only get 80 percent of what it would otherwise receive "unless the state has [ensured] that all new…[water systems]…commencing operation after Oct. 1, 1999, demonstrate technical, managerial, and financial capacity with respect to each national primary drinking water regulation in effect…" Capacity development applies not only to *new* water systems, though. Another section of the law dictates a reduction in funds for states that do not establish capacity development for *older* water systems, too.

[1] This video is available for $50 from Cornell University: (607) 255-2090, or e-mail to dist_center@cce.cornell.edu.

[2] No more than 15 percent of each year's fund allocation can be used for any other needs. Acceptable uses for that 15 percent include source water protection, land purchase for conservation easements, assistance for capacity development, wellhead-protection programs, and operator-certification programs.

[3] For more on this fund and other issues facing small systems, see the article "Virginia's Small Public Water Systems: Can They Tap the Help They Need?" in the Summer 1998 issue of *Virginia Issues and Answers* (published by the Virginia Tech Office of University Relations).

Focusing on Virginia's Small Water Systems

The Virginia Water Resources Research Center is currently involved in three studies on capacity development as part of its "Initiative for Sustainable Small Drinking Water Systems." The three projects address capacity-development guidelines, remote monitoring (telemetry) to facilitate centralization of systems, and Internet-based information of small systems. For more information on this initiative, contact Tamim Younos at the Water Center (contact information is on page 16 of this newsletter).

What Does "Safe" Mean to You?

A November 6, 1998, article in *USA Today* claimed that "Each day, millions of Americans turn on their taps and get water that exceeds legal limits for dangerous contaminants." The article stated that most people are served by large water systems and get safe drinking water, but many customers of smaller water systems do not.

A nationally distributed story like that can, of course, significantly affect the public's perception of drinking-water safety. Certainly our ideas of "safe" drinking water—especially the judgment of what is *acceptably* safe—have changed many times before, as the development of the SDWA itself proves. The public information requirements of the 1996 amendments, along with ever-expanding information technology, will likely begin a new chapter in how people view, and respond to, drinking-water quality.

Some people strike a note of caution about the oncoming expansion of public information. Some water operators, for example, fear that the public information campaign, in particular the Consumer Confidence Reports, will unnecessarily raise fear in people who, they claim, do not "understand the water industry." For example, people may not understand that better measuring today can detect much smaller amounts of substances, potentially resulting in violations today that would not have been detected in the past.

How safe is drinking water to the water professionals we interviewed? Roanoke's Mr. Perdue was emphatic that drinking water is safer today, but he added that it does depend on the water source used. He said Carvin's Cove is as safe or safer today than ever, but a growing population means more contaminant threats, so water systems have to do a better job. Gene Potter, water and sewer director for the Rivanna Water and Sewer Authority (Albemarle County), disagrees with people who say drinking-water quality is poorer today, claiming that any negative image is due to increased public awareness and faster national dissemination of news about problems, rather water-system performance. "Are we doing a less professional or rigorous job—I don't think so," he said.

Mr. Peaks of the VDH emphasized the need to balance risks and costs, and said the risks of his daily commute are much greater than those from his drinking water. "After being in the water business for 30 years, it doesn't bother me in the least to turn on the tap and drink the water," he said.

After 24 years "in business," however, the Safe Drinking Water Act continues to exert a major, and evolving, influence on how water reaches that tap, and on what we mean by "safe" water.

–By Lisa Garcia

Water Central thanks William Cox for his assistance with this article.

Drinking-water Acronyms

CPWS—Community public water system.
NCPWS—Non-community public water system.
PWS—Public water system: supplies drinking water to the public and has 15 connections or more or serves at least 25 people
SWAP—Source water assessment program.
SWPT—Virginia's Source Water Protection Team.
TAC—Virginia's Source Water Assessment Technical and Citizens Committee
WAC—Virginia Waterworks Advisory Committee.

(SWPT, TAC, and WAC are the three committees developing Virginia's source water assessment program.

SCIENCE BEHIND THE NEWS

In Drought or Deluge, Hydrology Shows Where the Water Goes

HEADLINES

"Drought Prompts Governor to Ban Burning in Open," *Roanoke Times*, 10/30/98.
"Stafford to Sell Water to Dry Spotsylvania," *Washington Post*, 11/7/98.
"Manassas Water at New Low," *Manassas Journal Messenger*, 11/17/98.
"AEP May Reduce Dam Outflow Levels," *Lynchburg News & Advance*, 12/3/98.

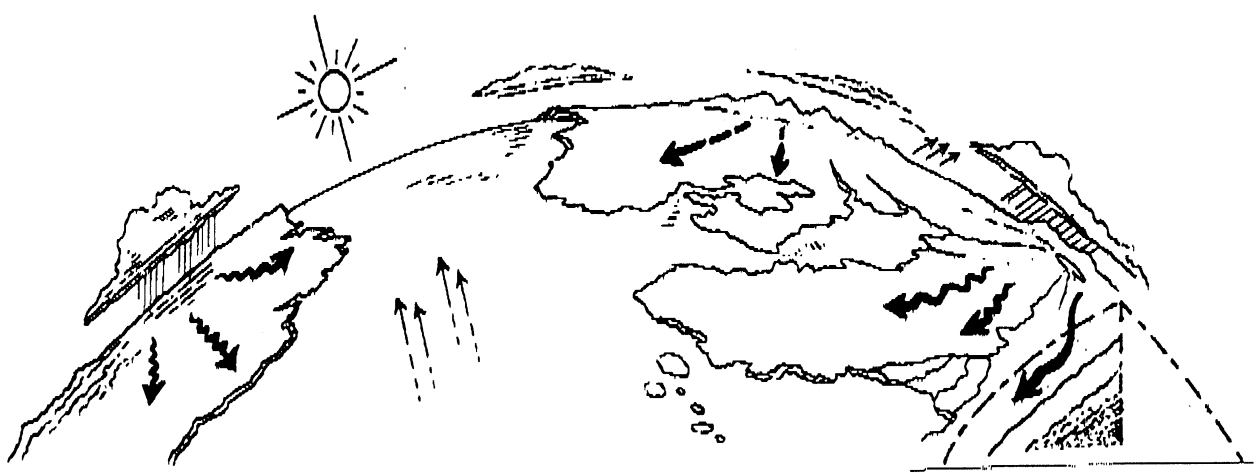
Standing beside a river in 1978, I heard a five-year-old child ask, "If the river's always running, how can it always be in the same place?" If that now 25-year-old had visited Virginia this dry summer or fall, he'd have seen plenty of dry stream beds that prove the water doing the actual "running" *isn't* always its expected places. A November 25, 1998, report from the Blacksburg National Weather Service office, for example, indicated that all monitored streams and rivers in the service area, "without exception," had flows below the "long-term median."

Dry streams are just one of the results of what may end up as the driest July-through-December on record for parts of Virginia and other eastern U. S. areas. Drought statements from the Weather Service on November 24 and 25 indicated "moderate" or "severe" drought in many parts of Virginia, as well as in Maryland and North Carolina. The headlines above show some of the water-management consequences.

But my five-year-old friend did have a good, insightful question. The answer to it, of course, is that, while the river *channel* stays put (except when altered by historic floods or human activities), the *water* in the channel at any given moment is on a never-ending, worldwide journey known as the **water**, or **hydrologic**, **cycle** (see diagram below).

The science of **hydrology** seeks to understand, describe, and predict water movement through the water cycle. Usually, few people pay close attention to water at all, much less to the water *cycle*. But when extreme events like droughts occur, water gets noticed, and so does hydrology's capacity to explain water's constant movement.

Water Follows



a Global Path

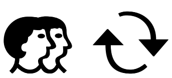
Hydrology involves not only surface water but also groundwater and water in the atmosphere. While primarily concerned with water *quantity*, the science also pertains to water *quality*, which essentially results from water's interactions with various substances, organisms, and environmental factors. Hydrology is also concerned with the *timing* and *energy* of water movements.

Put somewhat more simply, hydrology involves how much water there is, where it is, how it gets there, and what happens along the way. By studying how water within an area "behaves" under various circumstances, hydrologists can attempt to predict what will happen under other circumstances. For example, by describing how high a river will rise after receiving one inch of rainfall, a hydrologist can begin to predict the river's response to additional rain.

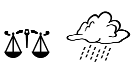
Making predictions about water movement, however, is *no simple task*, because many factors affect the water cycle. Besides the obvious factors of weather and climate, other non-living influences on water and its movement are topography (landforms and their location), soils, and rock types. Living influences are the organisms that can significantly affect water movements, especially trees and, of course, humans (by their uses of land and water). Principles from physics, chemistry, and biology are involved. Making hydrologic sense out of all these factors has required mathematics, statistics, and, more recently, computer models. Historically, hydrology has integrated and applied principles from these various fields to water-related scientific questions and problems (see the hydrology history diagram below).

Some Key Points in the History of Hydrology

BC: Ancient societies, such as Egypt, Greece, and Rome, practice water engineering, but leave few records of scientific hydrologic investigation.

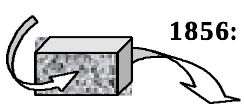


1680: Pierre Perrault and Edme Marriotte make first measurement of water cycle for a watershed (France's Seine River basin).



1693: Edmund Halley (of comet fame) estimates water balance of the Mediterranean Sea.

1838-1848: Earliest U. S. river-flow records are made on the Ohio River at Wheeling, West Virginia.



1856: H. Darcy describes principles of groundwater flow.

Notes on Hydrology

1904: Daniel Mead publishes the first U. S. textbook on hydrology.

1998: The science of hydrology now includes many specialties (including those shown below and others) and makes extensive use of computers to analyze water movements.

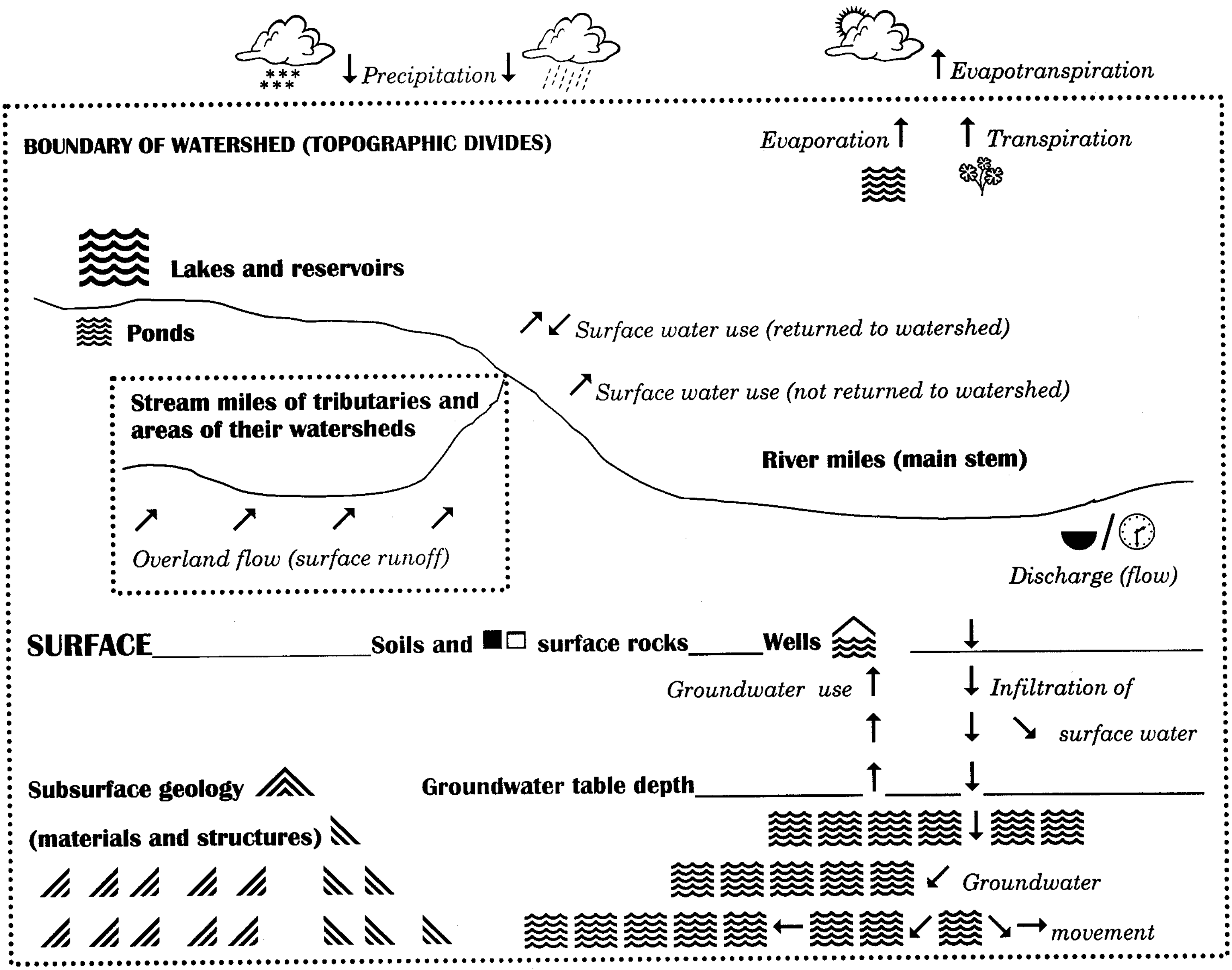
Forest **Agricultural** **Stream** **Groundwater** **Urban**

Sources: Hewlett, *Principles of Forest Hydrology*, 1982; and Ward, *Principles of Hydrology*, 1975.

Describing the Hydrology of an Area

The word "hydrology" refers not only to the science, but also to the water-cycle-related attributes of a particular area (for example, the "hydrology of Virginia"). In practice, the areas on which hydrologists often focus are particular **watersheds**, also known as **basins**, **catchments**, or **drainage areas**. A watershed of a particular water body is the land area from which water drains into that water body. A watershed can be small, such as that of the South Fork of Quantico Creek, in Prince William County, about eight square miles; or large, like that of the Chesapeake Bay, more than 64,000 square miles in Virginia, five other states, and the District of Columbia. The watershed of a given body of water includes the watersheds of all the tributaries to the body of water. For example, the Chesapeake Bay watershed includes the areas that make up the watersheds of the James, Potomac, Rappahannock, Susquehanna, and other rivers that flow to the Bay.

The following schematic drawing shows some key physical components (in bold) and processes (in italics) that are part of, or influence, watershed hydrology in Virginia. (Four factors not represented, but which have important effects, are vegetation, land uses, types of water uses, and topography).



Bold = Hydrologic components (water in place); *Italics* = Hydrologic processes (water movements)

Describing the hydrology of a watershed requires identifying, measuring, and analyzing the watershed's components and processes. Computer models developed by hydrologist have vastly improved the analysis, but the analysis still depends on having adequate data about the watershed or water feature in question. Adequate and reliable data collection is expensive, so only a small sample of sites are routinely monitored. The U.S. Geological Survey's (USGS) 1997 report on surface water in Virginia, for example, includes flow information from 161 gaging stations statewide; the groundwater report includes water-level measurements for 329 wells. While these are substantial networks, they cover only a small percentage of the state's stream miles and groundwater locations.

Describing the hydrology of Virginia *as a whole* presents two additional complications: the state includes all or part of nine major surface-water basins; and influences on the water cycle (especially topography, geology, vegetation, and land uses) vary significantly among the state's geographic regions. Fortunately, regional or statewide averages or ranges for various hydrologic factors are well-established and provide a fairly detailed description of Virginia's hydrology.

Key Terms and Concepts in Hydrological Measurements

Discharge: The volume of water that passes a certain point within a given time period (often used synonymously with "flow"). In the United States, discharge is often measured in **cubic feet per second (cfs)**. One cfs = 7.48 gallons per second.

Divide: A land features, such as a mountain ridge, that separates water flow between adjacent watersheds. For example, the Continental Divide separates surface water flow between the Pacific Ocean and Mississippi River drainage areas.

Evapotranspiration: The combined processes of **evaporation** (water lost to the atmosphere from open surfaces) and **transpiration** (water lost to the atmosphere from plants).

Groundwater level: As used by the USGS, the distance in feet from a given **datum** down to water in a well. The datum indicates the land elevation above sea level at the well.

Hydrologic unit: Used by the USGS and other professional hydrologists to refer to all, or a distinct part of, a watershed. Hydrologic units are identified by eight-digit numbers.

Infiltration: The movement of water from the surface into the ground (compare to surface runoff, below).

Instantaneous measurement: A measurement recorded at any one moment (*not* averaged over a period of time), such as "instantaneous peak flow."

Mean: The average of several measurements, such as "annual mean flow."

Median: The value in the numerical middle of a series of measurements (half of the remaining measurements are greater, half are less), such as "median flow." For example, 5 is the median of the series 1, 2, 5, 7, 30 (note, however, that the mean, or average, is 9).

Period of record: The time for which published records exist for a location at which stream flow or some other process is measured. Records of flow at a given river location, for example, may go back only a few years, or as far as a hundred years or more. The longer the period of record, the more accurately one can describe the expected or possible variation of the river flow (or other feature).

Return period: The *average* time interval between events of an equal or greater magnitude. For example, a "100-year/24-hour rainfall" would be the amount of rain, falling within 24 hours, that existing records indicate occurs *on average* once in 100 years. Put another way, however, a 100-year rainfall has a one-percent (1 in 100) chance of occurring or being exceeded in *any* one year. Return periods are *based on statistical analysis of existing records*, so calculating an accurate return period depends on having an adequate period of record (which is not always available).

Stage: The depth of water in a stream or river at a given time and location. One often can find *stage markers*—looking like a large, vertical ruler—painted on the streamside of a highway bridge support. Because stage is easier to measure than discharge, hydrologists often determine discharge for a specific river location from a stage reading at that location, based on a previously established **stage-discharge relationship** for the location.

Water Year—By convention, the water year in the United States begins October 1 and ends the following September 30. For example, Water Year 1997 ran from October 1, 1996 to September 30, 1997.

A Tale of Three Watersheds

To help give some perspective on some of the hydrological terms used above, the following table compares precipitation and streamflow for three Virginia watersheds:

- a small one—Copper Creek, at a point near Gate City (Scott County);
- a medium-sized one—Rappahannock River, at a point near Remington (Fauquier County);
- a large one—James River, at a point 0.5 miles southwest of Richmond.

Feature	**Copper Creek at Gate City**	**Rappahannock River at Remington**	**James River at Richmond**
Hydrologic Unit number	06010205 (tributary of Clinch River)	02080103	02080205
Watershed area (upstream)	106 square miles	620 square miles	6,758 square miles
Physiographic area(s) included in the watershed	Valley and Ridge	Piedmont	Valley and Ridge (source), Blue Ridge, Piedmont, Fall Zone, Coastal Plain
Precipitation (average annual, 1950-1980, in inches)	46-50 for watershed region; 48-50 at Gate City	36-50 for watershed region; 40-42 at Remington	36-50 for watershed region; 42-44 at Richmond
Flow (**discharge**) <u>(cubic feet per second)</u> a. Overall annual mean b. Highest annual mean c. Lowest annual mean d. Highest daily mean e. Lowest daily mean f. Instantaneous peak g. Instantaneous low h. Period of record	 a. 142 b. 208 c. 80.7 d. 4,580 e. 10 f. 6,940 g. 3.6 h. 1947-72, 1996-97	 a. 698 b. 1,231 c. 251 d. 64,000 e. 2.9 f. 90,000 g. 1.1 h. 1943-97	 a. 6,834 b. 13,540 c. 2,666 d. 296,000 e. 10 f. 313,000 g. Not available h. 1937-97

Sources: U. S. Geological Survey's *Virginia Water-Data Reports for Water Year 1997*, and *Water Atlas of Virginia* (see References section of this article for full citations).

Predicting Responses to Changing Conditions

If enough is known about how a stream or watershed has responded to conditions in the past, one can make reasonable predictions about how the stream will respond when conditions change. Obviously the weather changes constantly, but other conditions that can change and affect hydrology are the surrounding plant life (such as a field growing up into a woodland), land uses, water uses, and development of water projects (such as construction of a reservoir).

The 1998 drought is providing a clear example of the importance and value of hydrologic predictions. Some localities are having to consider drastic measures such as restricting water use. Let's consider the type of hydrological prediction such a locality might need to make.

Consider a the locality that uses water from a nearby stream. For the locality's withdrawals and instream uses, the flow in the stream has to stay above, say, five million gallons per day (5 MGD). The December monthly average flow for this stream, over its 37-year period of record, is 71.5 cubic feet per second (cfs), which equals about 46 MGD. But, due to drought, precipitation for July to December has only been 7.4 inches, about 40 percent of normal. The locality needs to predict the flow over the next few weeks in order to decide if restrictions are necessary. If the local water-decision-makers have good data about their watershed, they should be able to estimate (with the aid of a watershed-modeling computer program) how much rain they'll need for their water supply to stay adequate. Comparing their estimate to rainfall predictions for the next 30 days or so, they can make their decision.

Hydrologic information is crucial for making sound predictions and decisions about many other water resource issues, as well. The following give some further examples of various hydrologic measures related to predictions and decisions about water movements:

- maximum flows over the period of record help predict flood potential;
- average and minimum flows over the period of record help estimate minimum streamflows necessary for aquatic life;
- annual precipitation, and how much evaporates, runs off, or infiltrates to groundwater help estimate water supply potential from a reservoir;
- infiltration and groundwater movement (routes and rates) help delineate a groundwater protection zone.

Like Water, Hydrology's Not Static

The last half of 1998 in the Washington, D.C. area may end up being the driest since 1871, the period of record. While that's a long time, it's only a small fraction of the tens of thousands of years that Virginia's landscape has existed approximately as it does now. Seen in this context, our understanding of the possible extremes of the water cycle remains limited.

One response to this situation is the branch of hydrology known as **paleohydrology**. This field includes study of geologic formations for physical evidence of past floods; such study can at times extend the period of "record" as far back 10,000 years. This has posed a challenge to reliance on statistical analysis of historical records, as, for example, in prediction of potential maximum floods or their probable return periods. Moreover, some hydrologists argue that extreme events could occur that would exceed even what a 10,000-year paleohydrological record would predict.

Such debates might be quite "dry" to anyone besides a hydrologist or dam-safety engineer—until a record hydrologic event occurs. Then, our understanding of water on the move becomes as important as rainfall.

Alan Raflo, Water Central editor

Water Central thanks Llyn Sharp (Virginia Museum of Natural History at Virginia Tech) for reviewing this article.

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Further Reading on World Wide Web

Information on the current La Nina phenomenon—believed to be responsible for the 1998 drought—is available at the web site of the Southeast Regional Climate Center: **http://water.dnr.state.sc.us/climate/sercc/**.

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

The following summaries are based on information in the source or sources indicated at the end of each item. Selection of this issue's items concluded December 10.

If you have access to the Internet, you can follow water-related news with the "Daily News Update" at the Water Center's Web site (the Web address is listed on the last page of this newsletter).

NEWSWORTHY ADDITIONS AND CORRECTIONS FROM PREVIOUS ISSUES

1) The science article in the August 1998 *Water Central* indicated that **genetic testing** ("DNA typing") had been used to study the source of bacterial contamination in **Four Mile Run**, which is in Arlington and three other localities. According to a letter from the coordinator of the Four Mile Run program for the Northern Virginia Planning District Commission, genetic testing has been proposed for Four Mile Run but is not yet happening. The Planning District Commission is seeking funds for such testing. This reader also noted that permanent and regular water-quality monitoring has *not* been started for the Four Mile Run watershed, as the October 1998 *Water Central* incorrectly stated.

2) The feature article in the October 1998 *Water Central* included the viewpoint of the Virginia Association of Municipal Wastewater Agencies, which has intervened in support of the U. S. EPA in a lawsuit against EPA concerning TMDLs in Virginia. Only that organization has *formally intervened* in the case, according to the legal counsel's office of the American Canoe Association (one of the plaintiffs). But, as a reader's letter pointed out, various groups in Virginia and elsewhere have *informally supported* the Virginia-related lawsuit against EPA. (It is likely that still other groups have *informally opposed* the suit.)

•The **drought** that has persisted in many parts of the mid-Atlantic states since July 1998 is apparently due to a La Nina event, a cyclical, extreme cooling of sea-surface temperatures in the southeastern Pacific Ocean. (This is essentially the reverse of the El Nino event that concluded in Spring 1998). (*National Weather Service drought statements*, 11/24-25/98; and *University of North Carolina WRRI News*, Nov./Dec. 1998)

•**Henry County** has become the fifth locality in its region to **privatize its wastewater system**, saving an estimated $400,000 per year. The other localities in western Virginia to have done so are Clifton Forge, Danville, Galax, and Pearisburg. Meanwhile, a Maryland task force is studying privatization of the Washington Suburban Sanitary Commission. (*Roanoke Times*, 10/21/98; and *Prince George's Journal*, 10/19/98)

•**Update on fish kills and microbes**: Virginia Institute of Marine Science researcher Wolfgang Vogelbein has found that a fungus appears to be the cause of deep lesions found recently on Chesapeake Bay fish. The fungus is not considered a threat to human health. Vogelbein speculates that *Pfiesteria piscicida*, the alga suspected of causing several recent fish kills in Atlantic Coast states, may initially erode fish skin (it has been shown to do so in laboratory studies in North Carolina), giving an entry point to the fungus, which then causes deep skin damage. No major *Pfiesteria* problems occurred in Virginia or Maryland this summer. (*Associated Press*, 10/22/98; *Bay Journal*, 11/98; and *Richmond Times-Dispatch*, 11/6/98)

•The U. S. secretary of transportation has agreed to consider the feasibility of using **passenger ferries on the Potomac River** for Washington area commuters. A local company proposes 150-passenger (no cars) ferries traveling 40 miles per hour; a round-trip fare from Woodbridge to Washington might cost about $15. (*Washington Post*, 10/27/98)

•On November 5, the U. S. EPA Administrator announced an agreement among 20 agencies to **reduce the federal government's own effects on the Chesapeake Bay**. Among several dozen steps called for are restoring wetlands and planting stream-buffer strips on federal lands; improving storm-water controls at federal buildings along the Anacostia River; and siting new federal offices in already-developed areas to reduce land development. The federal government owns about 2.2 million acres in the Bay watershed. (*Washington Post*, 11/6/98)

•The U. S. Geological Survey has reported that **water use in the United States decreased** an estimated nine percent from 1980 to 1995. This occurred while the U. S. population *increased* 16 percent during the 15-year period. Conservation, new technologies, or better efficiency were responsible for decreases in industrial and irrigation use. (*New York Times*, 11/10/98)

•Under its **Stream Releaf** program, Maryland is giving landowners trees and assistance in planting them to establish forest buffers along the Chesapeake Bay shoreline. Maryland, Pennsylvania, and Virginia have a joint goal of establishing forest buffers on 2,010 miles Bay shoreline. (*Washington Post*, 11/22/98)

•As of December 22, 1998, **underground storage tanks** had to be upgraded or closed if not in compliance with groundwater protection regulations established in 1988. The regulation affects commercial, business, and public-sector tanks holding over 110 gallon of petroleum-based or hazardous materials. Exempted are farm and residential tanks of under 1,100 gallons of non-commercial motor fuel, and all tanks for heating oil used on the premises. Virginia has an estimated with 75,000 regulated tanks, with 40,000 in use and about 32,000 that needed attention before the deadline. (*Virginia Groundwater Protection Steering Committee Annual Report*, November 1998)

H. Elizabeth Donegan assisted in compiling these accounts.

N O T I C E S

•Groundwater-using Virginia localities facing new tasks resulting from the 1996 Safe Drinking Water Act amendments may want to order a copy of ***Implementing Wellhead Protection: Model Components for Local Governments in Virginia.*** The report is available from the Virginia Department of Environmental Quality, ATT: Mary Ann Massie, P. O. Box 10009, Richmond, VA 23240-0009; (804) 698-4042.

• **Citizens for Water Quality**, a new collaboration of groups interested in citizen water-quality monitoring in Virginia, held its first organizational meeting in Charlottesville in November. For more information, contact the Virginia Save Our Streams coordinator at (540) 377-6179, or the Virginia DEQ's volunteer-monitoring coordinator at (800) 592-5482.

•**At the Water Center**: The Southwest Virginia Water Symposium '98 was held in Abingdon in October. The proceedings of the symposium—a compilation of the papers presented—are available to the public. Virginia residents may receive one free copy, while the 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.

The papers' topics included the following: source water assessment; wellhead protection activities; watershed protection strategies; drinking water for isolated coalfield communities; mercury contamination of the North Fork/Holston River; hydrogeologic database for Scott County; Guest River assessment and suspended sediment; wetland restoration and science education; Southwest Virginia wetland communities; Save Our Streams for teachers; New River Valley Farm-a-Syst; Adopt-a-watershed; VA Agricultural Experiment Station water research; and water supply in the Virginia coalfields.

Mark your calendar now for the 1999
Virginia Water Resources Research Symposium
October 24-26, 1999 Richmond, Virginia

Researchers from Virginia's colleges and universities; staff from state, federal, and local government agencies; and water-resources professionals will participate in this conference. More information will be available in future issues of *Water Central*.

FOR THE RECORD
Sources for Selected Water Resources Topics

Hydrologic Information Sources

The most extensive source of information on water resources and their movements through the water cycle is the U. S. Geological Survey (USGS), Water Resources Division. This agency offers data—current, recent, and historical—and comprehensive reports on stream flows, watershed features, water use, and groundwater characteristics. A good starting point is the Division's annual *Water Resources Data—Virginia* report, which is available at many libraries. For Internet users, see the Web site at **http://water.usgs.gov/**; for Virginia specifically, go to **http://www-va.usgs.gov/**.

To request any USGS *publication* related to Virginia water, contact Martha Erwin at (804) 261-2623, or e-mail mlerwin@usgs.gov. For all Virginia-related *data* requests, contact Roger White at (804) 261-2605, e-mail rkwhite@usgs.gov.

A valuable introduction to Virginia hydrology data sources is in the report *Data Resources for Local Water Resources Management* (1992). Contact the Virginia Tech College of Architecture and Urban Studies, main office phone (540) 231-6416.

The National Weather Service's Hydrologic Information Center prepares national summaries of hydrologic conditions, with emphasis on floods and other extreme events. The Center can be reached at NWS Office of Hydrology, 1325 East-West Highway, Silver Spring, MD 20910; (301) 713-1630; e-mail HIC@noaa.gov. The Web site is **www.nws.noaa.gov/oh/hic**/.

Two other potential sources are the Virginia departments of Environmental Quality and of Conservation and Recreation (Division of Soil and Water Conservation).

"For the Record" Schedule

1998

This issue – Hydrology Information Sources

1999

February – Groundwater Information Sources
April – Weather and Climate Information Sources
June – Water Uses Information Sources
August – Water Maps: Types and Sources
October – Wetlands Information Sources
December – Water Law Sources

2000

February – Tracking Virginia General Assembly Legislation
April – Following State Water Regulatory Processes
June – Tracking Federal Legislation and EPA Regulations
August – Drinking-water Information Sources
October – Water Quality Information Sources

Schedule subject to change

TEACHING WATER
For Virginia's K-12 teachers

This Issue and the Virginia Standards of Learning

(Abbreviations: BIO-biology, ES-earth science, LS-Life science).

"Safe Drinking Water Act"
Science: 4.8, 6.11, ES.9, BIO.2, BIO.5.
Social Studies: 7.2, 7.4, 10.10, 10.13, 12.6, 12.7, 12.8, 12.10, 12.16.

"Hydrology Shows Where the Water Goes"
Science: 3.9, 4.8, 6.9, 6.11, LS.12, ES.8, ES.9, BIO.9.
Social Studies: 10.2, 10.8, 10.9.

"For the Record"
Science: 3.9, 4.6, 4.8, 6.9, ES.3, ES.8, ES.9, ES.13, 12.13.
Social Studies: 5.6, 10.5, 10.7, 10.8, 10.9, 10.10.

Virginia Water Central

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YOU GET THE LAST WORD

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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