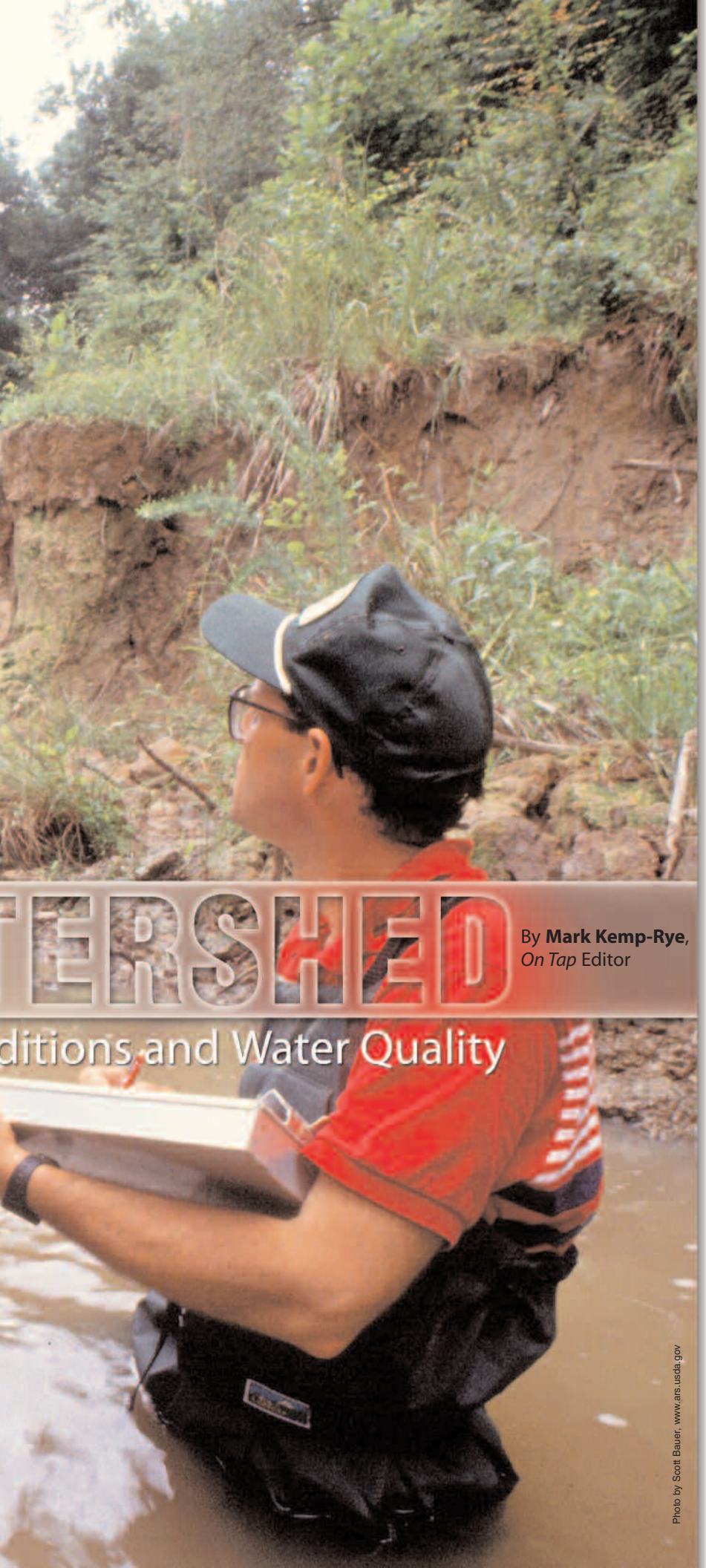
Assessing Your WAT

Techniques for Measuring Con

Editor's Note: *Many experts see watershed planning and management as being an effective way to deal with water and wastewater issues. In* On Tap *during 2007, we are presenting a four-part series about watersheds that will provide an overview about how to start a watershed initiative, how to assess problems, how to develop a workable plan, and how to implement these watershed efforts. This article is the second of the series; the first is available on the National Environmental Services Center Web site at* www.nesc.wvu.edu/ndwc/ndwc_watershed.htm.



TERSHED

ditions and Water Quality

By **Mark Kemp-Rye**, *On Tap* Editor

Photo by Scott Bauer, www.ars.usda.gov

Once your fledgling watershed group has formed and come up with some ideas about what it wants to accomplish, it's time to get a better understanding of the actual conditions in the watershed. Although the particulars will vary from project to project, most groups will need to know more about water quality and the sources of pollution in the water, and then go on to delineate the scale of the project and begin documenting the issues at hand.

In this article, we'll take a look at ways of assessing the health of a watershed so that planning and restoration can proceed in a logical fashion. First, though, we need to understand some basic watershed concepts and terminology.

The Geography of Watersheds

"A watershed is the area of land where all of the water that is under it or drains off of it goes to the same place," says Dale Kemery, press officer, U.S. Environmental Protection Agency (EPA). Sounds simple enough but those who work in watershed planning have specific terms and concepts that they employ.

Typically, the largest watershed management unit is a *basin*, which drains to a large river, estuary, or lake. Basin drainage areas—such as the Ohio or Mississippi Rivers—often encompass thousands of square miles.

Basins are then made up of *sub-basins*, which can be several hundred square miles. Sub-basins consist of groups of *watersheds*, which in turn comprise *subwatersheds*. Watersheds typically range from 20 to 100 square miles, while subwatersheds are most often 10 square miles or less.

Within subwatersheds, *neighborhoods* are geographic areas that share similar land uses and other characteristics. The *project site* is the smallest watershed management scale and is the location where a single restoration project is implemented. A watershed project often has dozens of these sites. (See Figure 1 and the Friends of Deckers Creek overview on page 25.)

While wanting to improve the entire Mississippi River is a noble goal, it wouldn't be a practical pursuit for a volunteer watershed group. Better to start small. As the *User's Guide to Watershed Planning in Maryland* notes, "Watersheds and subwatersheds are the most practical units for preparing local plans. Each watershed is composed of many individual subwatersheds that can have their own unique water resources objectives."

This isn't to say that smaller projects shouldn't lose sight of larger objectives. "A watershed plan is a comprehensive framework for applying management tools within each subwatershed in a manner that also achieves the water resource goals for the watershed as a whole," the *User's Guide* states.

Photo by Brian Prechtel, www.ars.usda.gov

Photo by Peggy Greb, www.ars.usda.gov

DATA SOURCES

When assessing the water quality in a watershed, gathering information from existing sources is a good way to begin. A good place to start is with the state agency that has oversight for surface water quality. Specific data sources include:

- source water assessment plans,
- the 303(d) list, a biennial list of streams that do not meet water quality standards,
- the 305(b) report, showing the quality of a state's streams,
- Total Maximum Daily Load (TMDL) plans, and
- National Pollutant Discharge Elimination System (NPDES) reports submitted to the states.

At the national level, agencies such as the U.S. Geologic Survey (*www.usgs.gov*), the Natural Resources Conservation Service (*www.nrcs.usda.gov*), and the U.S. Environmental Protection Agency (*www.epa.gov*) are sources of water quality data. See the special watershed section on the National Environmental Services Center Web site (*www.nesc.wvu.edu*) for a listing of useful Internet resources.

Using Existing Information

Once you've identified a watershed or subwatershed with a manageable scale, it's time to start collecting data. Fortunately, a wealth of information is usually available to get started, often through local, state, and federal government sources. Watershed experts sometimes call the process of finding and compiling this information a desktop assessment.

"Desktop assessments fall into the 'don't-reinvent-the-wheel category,'" observes Craig Mains, a training specialist at the National Environmental Services Center and a leader in several watershed assessment efforts. "Watershed groups will want to piece together enough data to get a good picture of the overall health of their stream. It only makes sense to gather as much data as possible from all sources. It may take some research on the part of the watershed group to find not just what data exists, but also who knows about different sources of data, and where the data can be found."

There are many potential sources of information but not all will be applicable to the situation at hand, so watershed groups will have to be flexible in their searches. A good place to start is with the state agency that has oversight for surface water quality in your state.

As part of complying with the federal Clean Water Act, state water quality agencies have to file a biennial list of streams that do not meet water quality standards (impaired waters) with EPA. The list is known as the 303(d) list. These agencies also have to file a biennial report on the quality of the state's streams known as the 305(b) report. In the past, these reports were typically published separately, but they are increasingly being integrated into one report. These reports don't typically include much raw data, but those data should be readily available from the state agency that compiled the report.

Other possible sources of information at the state level include source water assessment plans, total maximum daily load plans, national pollutant discharge elimination system reports, and special reports generated for specific watersheds. At the local level, land use plans, flood management plans, and water and sewer facility plans usually have applicable information.

"Water quality data have both a spatial and a temporal dimension," Mains adds. "Existing data are especially valuable because they can provide historical information that might allow the watershed group to determine if there are trends in the quality of the stream over time."

Dirty Hands, Wet Feet

Most watershed groups, after reviewing the information available to them, discover that they need more specific data to help address the unique problems they are trying to solve. "While mining existing data is a good place to start, there is no substitute for developing an on-the-ground, in-the-stream knowledge of your watershed," says Mains. "Usually some additional assessments will be needed to get a clear picture of what is going on in the watershed.

"Some information will likely be available," he continues, "but it is unlikely that this data will provide all the information that a watershed group might want.

Photo by Scott Bauer, www.ars.usda.gov

FIELD TESTING FOR WATER QUALITY

Methods for assessing water quality are typically grouped into three categories:

1. Chemical—measures the pH of the water and pollutants and other chemicals found in it.
2. Biological—gauges the extent of microbial plant, insect, and animal life in water.
3. Physical—examines the characteristics of the watershed, including streambed materials and banks.

Testing will vary depending on the problems inherent in the watershed and the goals of the restoration effort, as well as the resources available to the watershed group.

State agencies, for example, will have a body of data, but because they have such a wide geographic area to cover, their data on a particular watershed is likely to have some gaps either in terms of the number of sampling locations, the frequency of sampling, or the parameters measured. Assessments by the watershed group can fill in any gaps."

Field tests can be divided into three general categories:

1. **Chemical**, which includes measurements such as pH, conductivity, dissolved oxygen, biochemical oxygen demand, and nutrients such as phosphorous and nitrogen.
2. **Biological**, which measures some aspect of aquatic life, including tests for bacteria, benthic macroinvertebrates (e.g., insects, snails, crustaceans, worms), algae, rooted aquatic plants, and fish.
3. **Physical**, which includes measurements of some characteristic of the structure of the stream bed and banks such as the relative composition of stream bed materials according to particle size (silt, sand, pebbles, cobbles, boulders, etc), the extent that larger particles are embedded by fine sediment, the extent to which the stream bed and banks have been altered by human activity, and the overall condition of stream banks, including measuring the extent of eroded or unstable banks. Measurement of stream flow is also a physical indicator and involves measuring stream width and depth to develop a cross sectional profile and measuring stream current velocity. Other physical indicators include water clarity, water color, and temperature. Stream temperature is critical because it affects the metabolic rate of aquatic organisms and also limits the saturation concentration of oxygen in water.

Information gathered about a specific watershed or subwatershed can have utility beyond just measuring water quality. Mains says that

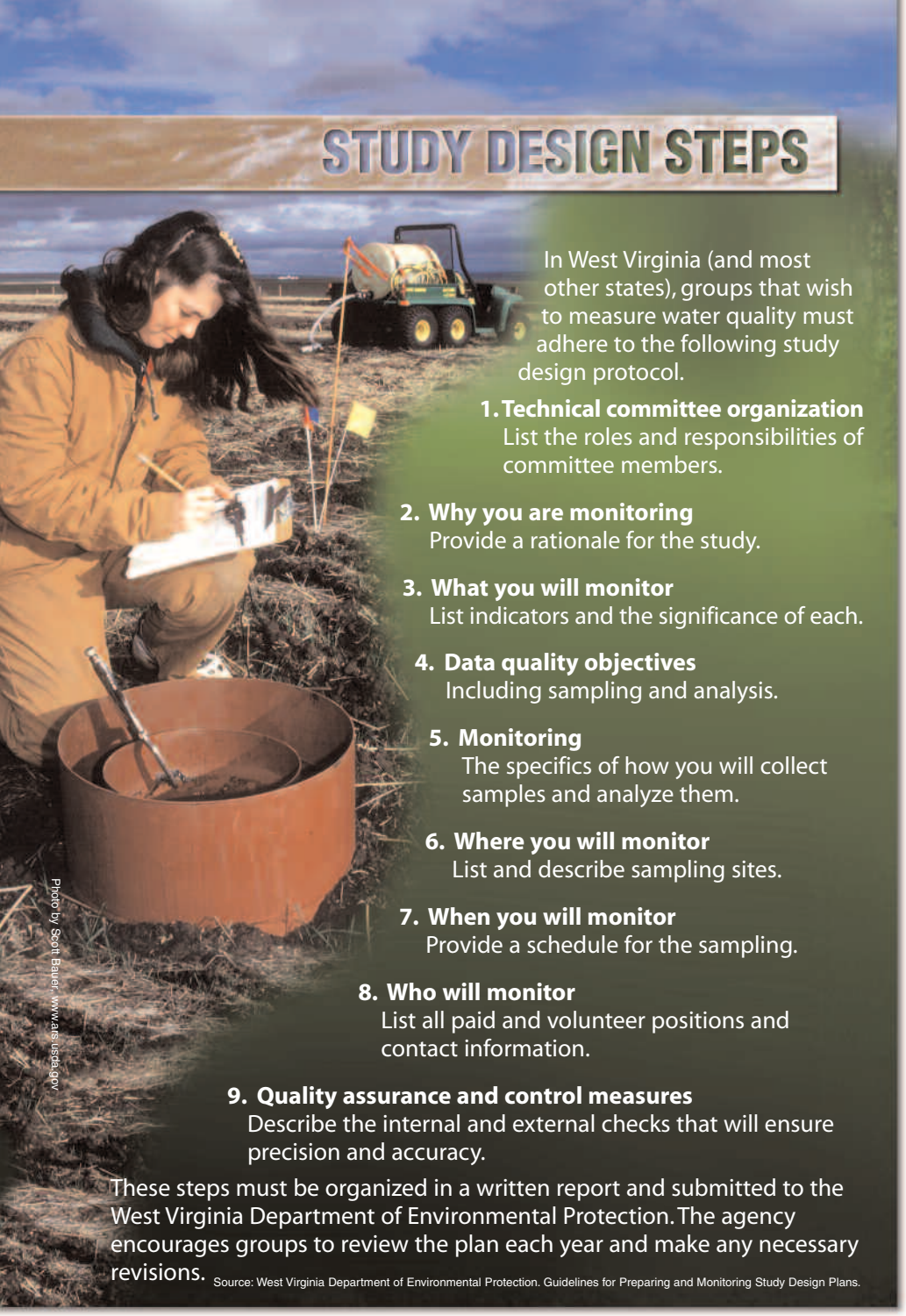


Photo by Scott Bauer, www.ars.usda.gov

STUDY DESIGN STEPS

In West Virginia (and most other states), groups that wish to measure water quality must adhere to the following study design protocol.

1. **Technical committee organization**
   List the roles and responsibilities of committee members.
2. **Why you are monitoring**
   Provide a rationale for the study.
3. **What you will monitor**
   List indicators and the significance of each.
4. **Data quality objectives**
   Including sampling and analysis.
5. **Monitoring**
   The specifics of how you will collect samples and analyze them.
6. **Where you will monitor**
   List and describe sampling sites.
7. **When you will monitor**
   Provide a schedule for the sampling.
8. **Who will monitor**
   List all paid and volunteer positions and contact information.
9. **Quality assurance and control measures**
   Describe the internal and external checks that will ensure precision and accuracy.

These steps must be organized in a written report and submitted to the West Virginia Department of Environmental Protection. The agency encourages groups to review the plan each year and make any necessary revisions. Source: West Virginia Department of Environmental Protection. Guidelines for Preparing and Monitoring Study Design Plans.

this information is also useful in public awareness efforts.

"Well-designed assessments can provide an antidote to misconceptions that might exist about a particular stream," he says. "Local residents sometimes feel they know everything about a stream, which is not always the case. They may believe that the entire stream is impaired, when the impairment may be localized. Or, they may believe that a historically high quality stream is in pristine condition, while some gradual degradation may have actually occurred without much notice. Actual stream data can end such misconceptions."

Ongoing Assessment Efforts

Assessing water quality is not a one-time activity. Watershed groups should develop a multi-year strategy to gather information about watershed conditions. "What tests or measures a group decides to conduct would depend on the mission or goals of the group, how much money they have to spend on equipment and/or lab analyses, and the capability of the group," Mains says.

"Ideally," EPA notes in their *Watershed Approach Framework*, a strategy "should recognize that responsibilities can be shared by many stakeholders and that monitoring must be done to fulfill distinct purposes: characterizing the watershed, identifying and locating specific problems, and determining if actions are effective and goals are met. A strong monitoring program should include:

- an inventory of key existing information on resources, including priority groundwater, sources of drinking water, habitat, wetlands and riparian acreage, function and/or restoration sites;
- a monitoring design that confirms or updates existing information or fills gaps and can report trends;
- reference conditions for biological monitoring programs to provide baseline data for water quality assessments and development of biological and nutrient criteria;
- data collected using comparable methods to allow aggregation of data at various scales and stored so as to be readily accessible to others (e.g., in EPA's database STORET);
- geographic references so that monitored waters can be mapped using a geographical information system (GIS), allowing information to be aggregated on a watershed basis;
- key information on condition of waters (e.g., impaired, in need of special protection, endangered species present, threatened sources of drinking water) and causes of impairment are reported in the national water quality inventory (305(b) report); and
- collaborative efforts on existing and planned monitoring activities with other public and private institutions to share information when goals are similar."

Invariably, watershed groups augment written plans with various maps showing water quality data. In recent years, this means using GIS. The hardware and software needed is expensive but often available at local engineering firms or colleges and universities. The ability to update geographic information and to examine different scenarios makes this technology very appealing.

Watershed Health Is Holistic

Water quality is, of course, hugely important for watershed planning and restoration. But, it represents only part of the picture. In reality, numerous activities impact the watershed, some obvious and some not so obvious.

"Formerly, when most people thought about surface water quality, they focused on the network of river and streams and the discharges of contaminants into those waterbodies," Mains says. "The watershed approach recognizes that what happens on the land surface can, directly or indirectly, affect water quality. Focusing on the stream network has been compared to analyzing the veins on a leaf, while focusing on the watershed would involve analysis of the entire leaf. Stream quality is a reflection of everything that is happening on the watershed."

For More Information

The National Environmental Services Center has a section of its Web site devoted to watershed issues. Go to *www.nesc.wvu.edu/ndwc/ndwc_watershed.htm* for a listing of watershed resources and articles. NESC Training Specialist Craig Mains may be reached at (800) 624-8301 ext. 5583 to discuss watershed planning and restoration efforts.

The U.S. Environmental Protection Agency's (EPA) publication *Volunteer Stream Monitoring: A Methods Manual* provides more information about chemical, biological, and physical assessments. Download the manual from the EPA Web site at *www.epa.gov/volunteer/stream/stream.pdf*. EPA's Watershed Web site (*www.epa.gov/owow/watershed*) has a great deal of

GLOSSARY

Benthic Macroinvertebrates
Organisms with no backbones that live on the stream, river, or lake bottom, and are large enough to be seen without magnification. They can be sampled to assess stream quality based on their numbers, diversity, and sensitivity/tolerance to pollution.

Biochemical Oxygen Demand (BOD)
The amount of oxygen consumed during the microbial decomposition of organic matter and the chemical oxidation of some inorganic compounds. It is measured under laboratory conditions by incubating a water sample under prescribed conditions and measuring the dissolved oxygen concentration before and after incubation.

Conductivity
The ability of water to carry an electrical charge. The conductivity of surface waters is largely determined by geology, so an abrupt change in conductivity may indicate a source of pollution.

Dissolved Oxygen (DO)
A measurement of the concentration of gaseous oxygen (O2) in water. Adequate dissolved oxygen is crucial for the maintenance of aquatic life. Oxygen is dissolved into water through diffusion from the atmosphere, by aeration, and as a product of photosynthesis. Oxygen is removed from water through the respiration of organisms and the decomposition of organic materials. As oxygen levels decrease, the types of aquatic organisms the stream can support may shift to less desirable species.

National Pollutant Discharge Elimination System (NPDES)
A program created as part of the Clean Water Act that works to control water pollution by regulating the discharge of point-source pollutants into U.S. surface waters. Facilities that discharge effluents directly into surface water must obtain an NPDES permit, which specifies what types and concentrations of waste may be discharged.

Nutrients
Typically refer to certain forms of phosphorus and nitrogen, which are essential nutrients for aquatic plants and animals. Under certain conditions, nutrients can stimulate plant and algal growth, which can potentially affect dissolved oxygen levels in the water and change the composition of aquatic life. Sources of nutrients may be from wastewater treatment plants, runoff from agricultural operations, runoff from urban and suburban areas, and failing septic systems.

pH
A measure of the intensity of the acid or base content of a water. pH is expressed as the negative logarithm of the concentration of hydrogen ions and is measured on a scale of 0 to 14. A pH of 7 is neutral, with lower numbers representing increasingly more acidic solutions and higher numbers more alkaline. Most aquatic life prefers pHs in the range of 6 to 9, with long-term deviations outside that range resulting in stress on aquatic life that may affect survival.

Total Maximum Daily Load (TMDL)
Calculates the maximum amount of the pollutant a water body can receive and still meet water quality standards. It identifies and quantifies the sources of the pollutant, both point and non-point source, and, using computer modeling, determines how the inputs must be reduced from the various sources in order for the water body to meet water quality standards. A water body may have multiple TMDL studies for different pollutants.

information about watersheds. The manual *EPA Requirements for Quality Assurance Project Plans* may be downloaded at *www.epa.gov/Region3/esc/QA/docs_qapp.htm* and the manual *The Volunteer Monitors Guide to Quality Assurance Project Plans* is available at *www.epa.gov/owow/monitoring/volunteer/qappcovr.htm.*

The Maryland Department of Natural Resources developed *A User's Guide to Watershed Planning in Maryland*, which may be downloaded from *http://dnr.maryland.gov/watersheds/pubs/planninguserguide/UserGuideCover-Ack.pdf* Although tailored to watershed efforts in Maryland, the guide is useful to groups in other parts of the country. A section of the site features tools and worksheets that can help document assessment efforts.

References

Center for Watershed Protection. 2005. *A User's Guide to Watershed Planning in Maryland.* Maryland Department of Natural Resources.

Mains, Craig. 2007. Interviews with author, 1/5/07 and 1/8/07.

U.S. Environmental Protection Agency. Date unknown. *Engaging and Involving Stakeholders in Your Watershed.* Washington, DC: U.S. EPA.

U.S. Environmental Protection Agency. 1996. *Watershed Approach Framework.* Washington, DC: U.S. EPA.

West Virginia Department of Environmental Protection. Date Unknown. *Guidelines for Preparing Monitoring Study Design Plans.* Charleston, WV: WV DEP.

On Tap Editor **Mark Kemp-Rye** lives in the Deckers Creek watershed, part of the Monongahela River sub-basin, in turn, part of the Ohio River basin.

NEXT INSTALLMENT

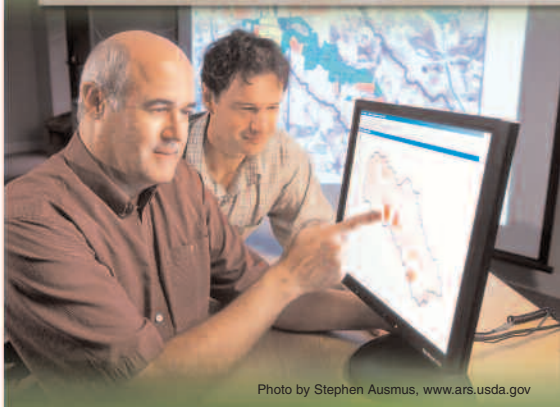


Photo by Stephen Ausmus, www.ars.usda.gov

The third article in our watershed series—coming in the Summer 2007 *On Tap*—deals with the specifics involved when crafting a watershed plan.

WATERSHED PLANNING WP

A Modest Beginning

Friends of Deckers Creek Measures Water Quality

Editor's Note: *In each segment of the four-part series about watershed groups, we'll show how the Friends of Deckers Creek, a successful watershed organization in West Virginia, has implemented the ideas presented in this article in their restoration efforts.*

Founded in 1995, the Friends of Deckers Creek (FODC) watershed group has worked diligently to restore an impaired waterway in northern West Virginia.

The Deckers Creek watershed, although relatively small, has several factors that influence water quality. Primarily, there is a legacy of acid mine drainage from abandoned coal mines that adds acidic water and iron to the stream resulting in stretches with very sparse aquatic life. However, a sizeable limestone quarry and runoff from the stockpiles of crushed rock has a neutralizing effect on the acid water. (See the map at right.)

To get an initial idea of what was going on in the water, the group conducted a benthic macroinvertebrate survey of the watershed. "We chose this type of survey because we wanted an overall assessment of the health of the watershed," recalls Craig Mains, a training specialist with the National Environmental Services Center and a founder of the FODC. "Because the benthic organisms have extended life spans in the aquatic environment they are exposed to the entire range of water quality conditions and because different organisms range from pollution tolerant to pollution sensitive they are excellent indicators of stream health. Also, because they don't require much investment in terms of collection equipment, this type of study made sense for a group that had more time than money."

Mains and other volunteers collected samples at 40 sites in the watershed, once in the spring and once in early fall. They also measured pH, conductivity, and temperature, but the focus was on the benthic macroinvertebrates. After analyzing the samples for diversity, pollution tolerance/sensitivity, and overall numbers, the group assigned a stream quality rating for individual stream segments and created a color-coded stream map that graphically showed stream quality for the watershed in a way that the general public could understand.

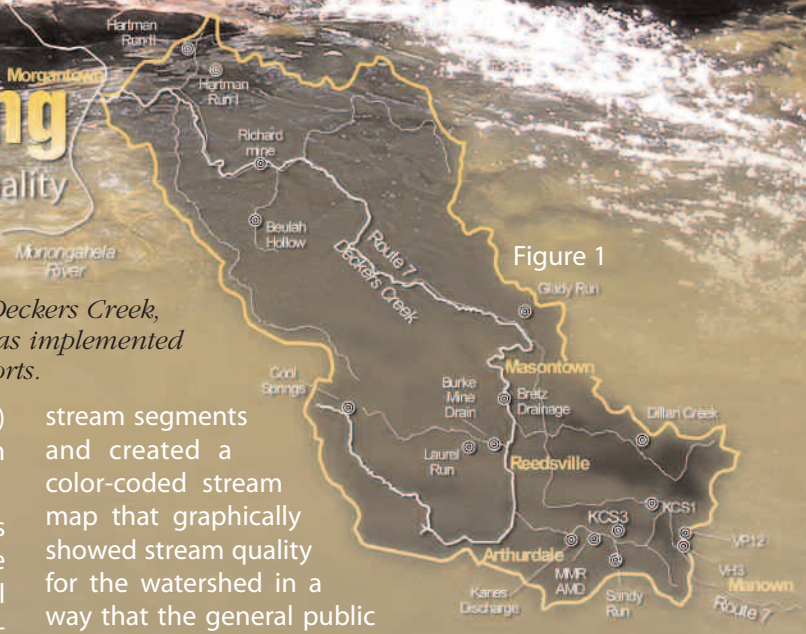


Figure 1

"The general public impression of the creek was that, while some of the tributaries were in fairly good shape, the main stem of the stream was polluted from beginning to end to the extent that it supported almost no life," Mains says. "We knew that the upper section of the main stem was acidic and that there was some recovery in pH levels below the limestone quarry, but that the pH readings dropped once again further downstream below where additional acid mine drainage entered. The benthic survey, however, showed that, far from being lifeless, aquatic life had recovered considerably downstream of the quarry. This led us to believe that if the primary source of acid mine drainage in the lower watershed was treated the lower section would become fishable."

Since 2002, FODC has conducted quarterly chemical monitoring and semi-annual biological monitoring for benthic macroinvertebrates and fish at fixed sites across the watershed. By publishing these data in annual *State of the Creek* reports, the group has educated the local community and agencies about the true conditions of the creek. FODC data has also been valuable in securing funding to mitigate several acid mine drainage sites in the watershed.

To learn more about the Friends of Deckers Creek, visit their Web site at **www.deckerscreek.org**.

FRIENDS OF DECKERS CREEK