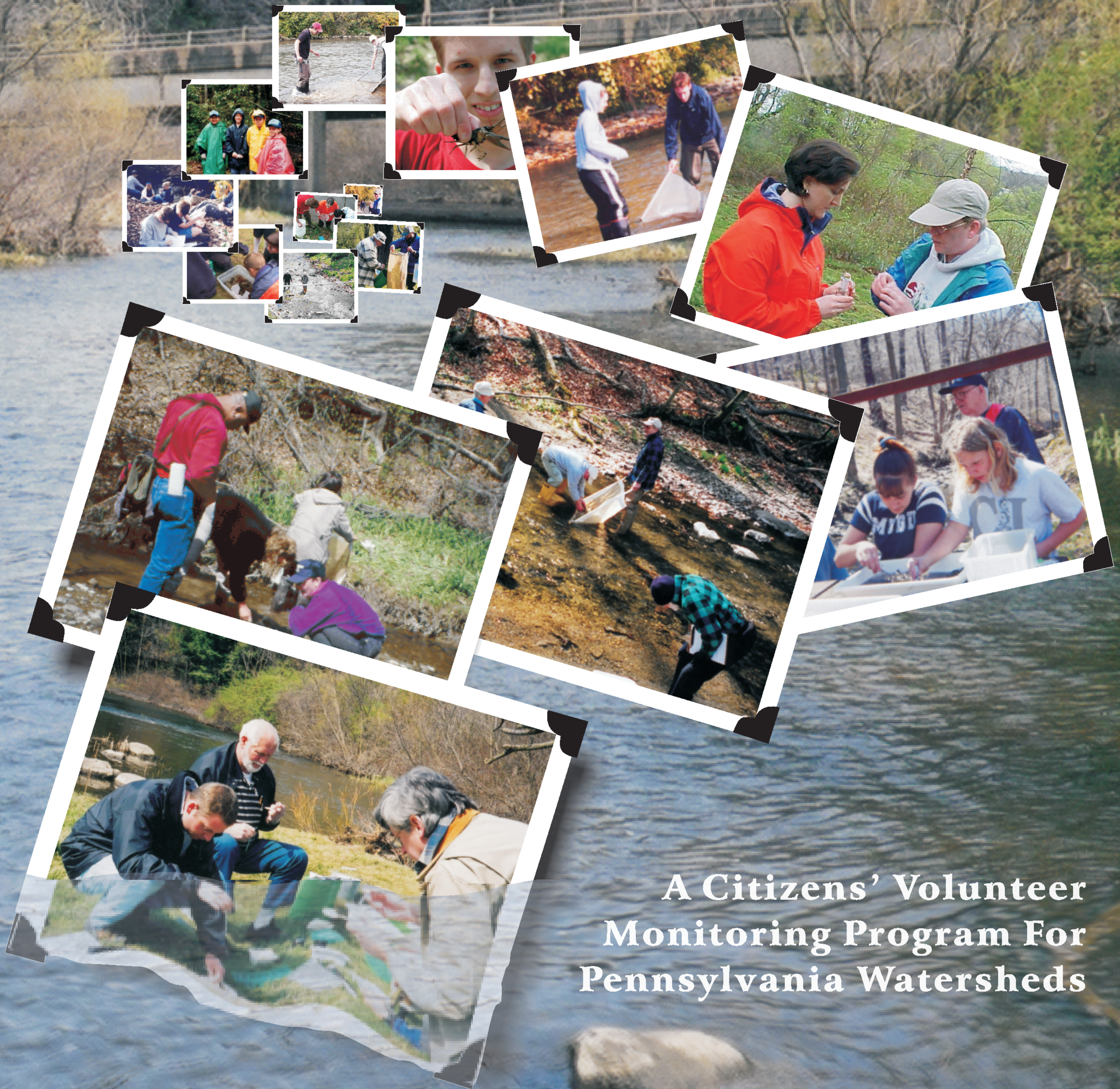
Watershed Snapshot 2001 & 2002



A Citizens' Volunteer Monitoring Program For Pennsylvania Watersheds

The Pennsylvania Department of Environmental Protection, Citizens' Volunteer Monitoring Program, prepared this report. It follows the format of previous *Snapshot* editions.

For information on participating in *Watershed Snapshot* or other citizens' volunteer monitoring programs, contact:

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For riparian buffer and Stream ReLeaf program information, email Melanie Wertz at mwertz@state.pa.us.

Foreward

A Letter from David E. Hess, Secretary

Thank you to all the participants of ***Watershed Snapshot 2001*** and ***Watershed Snapshot 2002***! There was tremendous interest and enthusiasm displayed by volunteers throughout Pennsylvania. We estimate that more than 11,000 Pennsylvanians participate in some form of environmental monitoring. ***Snapshot*** is the largest single monitoring event with more than 3,000 individuals participating and generating the hundreds of field data sheets used to develop this report. Citizen involvement in community-based monitoring is an important step as Pennsylvanians strive to understand their precious water resources.

Watershed Snapshot is an ongoing program that occurs each year during Earth Week. The goal of ***Watershed Snapshot*** is to increase watershed awareness across Pennsylvania. Numerous volunteers, schools and both private and public organizations participate each year by collecting water chemistry data, aquatic organisms, habitat data and land use information for their watershed of interest. A lake field sheet was added to ***Watershed Snapshot 2002*** allowing for more input from lake monitors.

Watershed Snapshot 2001 took place from April 20-29 and ***Watershed Snapshot 2002*** occurred from April 19-28. This report combines the data from both 2001 and 2002 to provide a more extensive overview of Snapshot results. The report also serves as a reminder to people to be aware of their water resources and highlights the role volunteers' play in protecting our waters. This is a very timely reminder as we celebrate the 30th anniversary of the Clean Water Act this year.

In celebration of the 30th anniversary of the Clean Water Act, October 18, 2002, was set aside as National Water Monitoring Day. The goal of National Water Monitoring Day was to get as many people out monitoring nationally as possible. Pennsylvania has played a very prominent role in the formation of National Monitoring Day since this event was modeled after Pennsylvania's Watershed Snapshot. More information can be found at www.yearofcleanwater.org.

Again, thank you for your participation in Watershed Snapshot and for making it the model for a national event. The continued involvement of citizens in watershed stewardship plays an integral part in protecting Pennsylvania's water resources.

David E. Hess
Secretary
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CONTENTS

Watershed Snapshot 2001 & 2002

In the 1940s, 50s and 60s, there were only a few people talking about land ethics and about pesticides and other chemicals in the environment harming birds, fish and human health. We tended to place little importance on most of what they said. Throughout the 1970s, 80s and 90s, we saw the oil-soaked birds, poisoned fish and heaps of "throw-away" trash, and what we saw we remembered. Many people became more environmentally aware. This formed the beginnings of a new personal environmental ethic. We began to do something about trash along highways, birds killed by poorly managed pesticide use and creeks turned black with coal dirt or orange with mine drainage. Along with this new awareness came an appreciation and better understanding of the complexity of ecosystems.

Years ago there were very big and easily noticed frequent fish kills, thick suds on lakes and even cases of rivers catching on fire. Many environmental conditions have improved in the past 30 years. Thankfully, most towns, industries and farmers no longer regard waterways as repositories for waste that will be magically washed away. Many individual citizens and citizen's groups have recently made a great deal of progress toward restoring the health of our waters through their own efforts and by demanding results from public employees and political leaders. Today's eco-problems are very complex. We no longer have the luxury of focusing only on the shocking or immediately obvious issues. We understand that we must now begin to use foresight and science to prevent pollution and health risks. Beginning now, everyone should take steps to develop a lifestyle with less long-term impact. Through stewardship we must lessen the problems of people and wildlife. Earth is our only habitat– home to us all.

Snapshot volunteers began monitoring environmental conditions in 1996. Environmental monitoring is one area where citizen groups now lead the environmental charge. Thousands of Pennsylvanians are taking pride in local watershed stewardship. Citizens are promoting protection and watershed planning. Every spring, ***Snapshot*** volunteers are going streamside, learning more about their watersheds, and becoming better stewards of their local environment and the earth. While ***Snapshot 2001 & 2002*** volunteers worked in their streams, and despite some occasional spring rains, newspapers carried headlines referring to the worst drought in the history of some regions of the state. It's hard to believe. We still have green lawns, but over the winter many streams were reduced to a trickle and reservoirs dropped to alarmingly low levels. Many shallow wells completely dried up. Pennsylvania and several surrounding states issued drought emergencies calling for mandatory water restrictions on nonessential water use.

What We Found During WATERSHED SNAPSHOT 2001 & 2002

Amphibians and Reptiles: In the spring, when ***Snapshot*** participants are in the field they observe and report on many of nature's interactions. Some have seen trout rising to mayflies, heard turkeys gobbling and observed blooming bluebells, trout lilies and dogwood. The temperatures are rising. We've had days that reached 80^{o}F, and the warmth and lengthening days have caused amphibians and reptiles to awaken and find one another for the mating rituals. The last of the late breeding wood frogs, spotted salamanders and Jefferson salamanders are traveling back from the vernal ponds (spring temporary forest ponds) to resume life on the damp forest floor. The adult mole salamanders are returning to their underground tunnels and are occasionally seen under rotted logs. Some are seen walking about on warm rainy nights. Their eggs are hatching into small minnow-like larvae.

In time, some of these larvae will grow into adults and they will migrate back to the same ponds to breed. On damp or rainy days, and early hours of most nights, the spring peepers call out by the hundreds. The individual high-pitched "peep peep" becomes a chorus sounding like distant sleigh bells. In the past two years, fifty-seven ***Snapshot*** volunteers reported either seeing or hearing a variety of amphibians including peepers, pickerel frogs and toads. The trilling song of the American toad is unmistakable as is the child-like cry of the Fowlers toad. Most reports of Fowlers toads come from along the Susquehanna River, while American toads are spaced out across the state along streams, rivers, wetlands, gutters, detention basins and temporary ponds. Some have been sighted along woodland paths and lawns where the toads search for insects and slugs to eat.

Citizen monitoring of amphibians is rapidly on the increase since malformed frogs were noticed first by Minnisotan schoolchildren in August 1995. Since then, deformed amphibians have been found by citizen monitoring groups in many states including Pennsylvania. Citizens, universities and agencies are very interested in using amphibians as indicators of environmental health. Currently, the North American Amphibian Monitoring Program attempts to track amphibian populations primarily through surveys of "vocal amphibians". You can find out more about that program and get information on volunteering at their website: www.mp2-pwrc.usgs.gov/naamp/ If you find amphibians with deformities, report it to the North American Reporting Center for Amphibian Malformations at www.npwrc.usgs.gov/narcam/ or call NARCAM at 1-800-238-9801.

Wood turtles are easily identified by the deep markings on their carapace.

Twenty-five ***Snapshot*** participants also reported seeing reptiles, such as water snakes, garter snakes and spotted turtles, making their first appearances of the season. The snakes have spent the winter underground, sometimes grouped up and hidden away in special niches called hibernacula. Turtles spend the winter underwater or under mud. In order to warm up and get their bodies to function quickly and efficiently, they like to bask in the sun. That is why during the spring, when ***Snapshot*** participants are noting snakes and turtles, they frequently report that the animals are seen during sunny daylight hours lying on warm rocks or fallen trees. Garter snakes and Northern water snakes are the two snakes most active in the early spring and are seen more often by ***Snapshot*** volunteers than all other snake species combined. Garter snakes have distinctive, length-wise, light-colored stripes on a darker background making this a very recognizable species. The northern water snake is usually dull brown, or grayish, with dark crossbands on the neck region, and alternating dark blotches on back and sides at midbody. The pattern gets darker with age. Their belly is white to yellow or gray and usually has dark crescent-shaped spots. Water snakes are usually seen swimming or basking along rip-rap, rocky banks or bridges. Neither garters nor water snakes are poisonous, but both will happily dump their bodily wastes on anyone who catches them and the smell can be terrible. Water snakes, if harassed, will strike repeatedly, and wounds caused by the bite will bleed profusely because of the anticoagulant quality of the snake's saliva. They are often misidentified and killed by uninformed visitors to their habitat. But, every year, ***Snapshot*** volunteers can and do safely observe some of these interesting animals.

The kinds of turtles that volunteers see while doing stream work include snapping, painted, box and if very lucky, spotted and map turtles, and these too are often basking on logs, rocks or stumps. Several years ago we had one report each of a bog turtle and a mud turtle. This was a very fortunate and unusual sighting, as both species are very rare. Favorite basking sites may provide sunny spots for dozens of painted turtles. Painted turtles sometimes climb on top of one another forming a pile of turtles, but more often they are seen neatly lined up on a partly submerged log.

Amphibians and reptiles are some of the Commonwealth's most interesting, yet seldom seen, animals. Seeing them is always an exciting added bonus for ***Snapshot*** volunteers and others who visit wet environments in the spring. We are just beginning to understand the important role these animals play in the watershed and how their presence or absence can help us determine the health of the environment.

Watersheds and Water Systems: A watershed, also called a catchments or basin, is a land area that drains water into a stream, river or lake. Watersheds can vary in size from a small land area draining into the little run in your back yard to a vast land area encompassing hundreds of square miles, as is the case with the Chesapeake Bay watershed. No matter where you live, work or play, you are always in a watershed.

Chartiers Creek, Allegheny County

Water within a watershed is interconnected and is both on the surface and underground. Water on the surface can be divided into two groups based on water speed and the input of organic matter: (1.) moving water or rivers and streams (called *lotic* systems), and (2.) still water or ponds and lakes (called *lentic* systems). Lentic systems (ponds and lakes) are of increasing concern to many volunteer monitors in Pennsylvania. Accordingly, citizens' volunteer monitoring programs and this year's ***Snapshot*** are being expanded to address and compliment this concern.

Streams and Rivers (Lotic Systems): River waters are typically deeper than streams, although the Susquehanna River is noted for its shallowness - often less than two feet deep. This is in notable contrast to its width of up to a mile! Most other major Pennsylvania rivers are more "normal" and sufficiently deep and turbid to prevent most light from reaching the riverbed. This, together with rapid currents, restricts the growth of aquatic plants. Submerged aquatic vegetation (SAV) are plants that are ecologically important in lakes and to a lesser degree in some parts of rivers. They provide fish breeding sites and good hiding places for many organisms.

The cooling effect of shading by riparian trees is small due to the great width of major rivers. Very wide rivers such as the Susquehanna River warm-up faster in the summer than do narrower and deeper rivers.

Despite a river's gentle gradient, the current is surprisingly fast and strong - faster than streams having similar slope. This is because rivers are usually deeper and have a smaller percentage of their water getting caught and dragged along the rocky bottom. Beds of rivers are generally smoother too. During periods of high water, river water frequently zooms along at ten feet per second. No one can overcome such currents if they should get caught in them. Never enter deep or swift water. No data that you could possibly collect is worth taking risks that end in tragedy!

Raymond Jarosh and Monique DaSilva measure the width of the Lackawanna River at Condella Park, Lackawanna County.

The abundance of life in lotic systems (streams) is very dependent on the energy from the surrounding land. Living and dead vegetation (leaves, wood, etc.) and animal bodies (mostly insects) fall into the water helping to supply the stream with food. If the stream is well shaded, this detritus from the riparian area accounts for almost all of the stream's organic matter. In shaded small streams this debris from the land, called *allochthonous* matter, is the primary source of nutrition for aquatic life. Of course, when direct sunlight reaches moving water, algae and aquatic plants can play an important role in providing energy to the stream. Still, the role of aquatic plants in streams and rivers is not usually of great importance except maybe behind dams and in other deep, slow-moving parts.

In streams, benthic macroinvertebrate organisms (bottom dwelling, spineless animals) especially insect larvae, make up most of the animal life in both actual numbers and weight. Fish, of course, are normally the most numerous of the vertebrates, that is, animals with backbones.

The lotic systems (streams and rivers) are often further divided into other more specific habitats such as cool-water and warm-water, or shallow-water and deep-water, freestone (soft-water) and limestone (hard-water), or stony bottom and muddy bottom. In one stretch, you may find a stream flowing over shallow stony areas creating *riffles,* and in the next stretch, you may find deep pools collecting the once living detritus of the surrounding land. Many of the healthiest streams are made up of broken patterns of four different flow regimes: slow/deep, slow/shallow, fast/deep, fast/shallow.

Rivers are usually streams of higher stream order, muddier, bigger, deeper, warmer, with less variation in flow patterns, often lacking the fast/shallow regime, and therefore, lacking the riffle habitat.

Stream habitats can be placed into four large groups that are useful in describing characteristics. They are *riffles, runs, pools* and *glides*. Coldwater, rocky bottom, mountain and ridge streams, and any streams with gradients greater than about two percent, usually have primarily riffle/run habitat. Streams with steeper gradients may also contain plunge pools and less steep streams usually have long, even regimes called glides. Warmer streams, typically in valleys and areas of flat terrain, usually have primarily glide and pool habitat. Most streams and sections of streams with little change in gradient will have muddy beds and plenty of glides and pools.

Riffles are often the most biologically diverse areas within streams. Therefore, riffles are the first choice of biologists looking for sites from which to collect stream macroinvertebrate life. Look for stream sections where the water is fast-moving and shallow. Water crashing into a streambed of rock and gravel creates riffles and oxygen-rich water as it breaks the surface and captures air from the atmosphere.

Runs are areas of intermediate depth and speed where the interactions of the current and substrate do not usually cause breaking to the water surface. In most streams, *runs* cover several times the area of the riffles. Runs are expected to contain less dense and less diverse forms of life amongst a substrate of various sized stones and finer sediments than are typically found in the faster moving riffles.

Pools are the deepest and slowest sections of a stream and they most often have bottoms of small particles of mud as well as sand, gravel and organic material such as sticks and leaves. Pools are often preceded by riffles, and they empty into either riffles or runs in rocky bottom streams or into glides in muddy bottom streams.

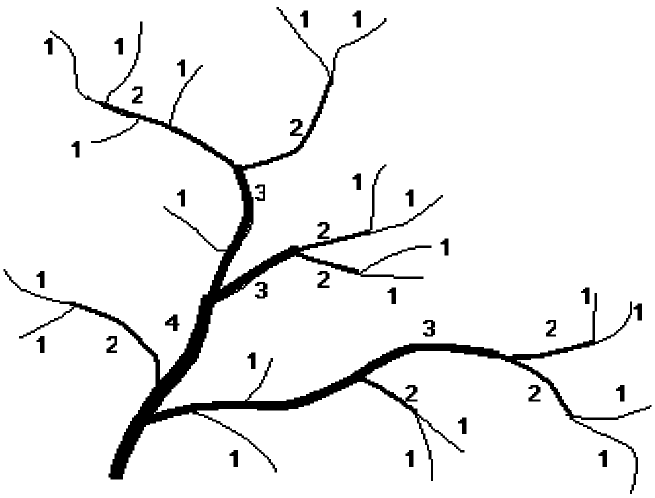
Upstream view of the test site on Sandy Creek used by the McKeever Environmental Learning Center.

"*Flow*" affects and controls much of the physical and biological properties of streams. The speed of water is not uniform throughout streams. Water moves fastest just below the surface in mid-channel. It moves slower as it drags along the substrate and slowest of all near the bottom along the edge of the shoreline. The amount of water flowing in a stream can be figured out and expressed as gallons per minute, or millions of gallons per day, or some other designation of some quantity in a certain period of time. This is "*discharge*" and discharge depends on how much rain has recently fallen, melting snow, the size and geologic composition of the watershed, the gradient of the streambed, the amount of wetlands in the watershed, dams, the riparian vegetation, and lots of aspects of human activities, such as the amount of rooftop and pavement in the watershed.

Freestone/Soft-Water and Limestone/ Hard-Water Streams: Soft-water and hard-water streams are separated and defined by the minerals and metals naturally dissolved in their water. The groundwater's composition is in turn a function of the watershed's rocks. Hard-water contains a lot of buffering elements such as calcium, magnesium, carbonate and/or sulfate, and has a pH greater than seven. True limestone streams frequently have a pH near nine. Soft-water or acid water streams are often called freestone streams and they don't contain much calcium or magnesium because the rocks in their watershed are usually made up of sands, quartzites, shales and other rocks lacking buffering elements.

Hard-water and soft-water typically also correspond to nutrient-rich and nutrient-poor. The soils in hard-water watersheds supply more nutrients (nitrogen and phosphorus) than do soils in soft-water regions and this is one reason why we might expect to find more blue-green algae in alkaline areas. Likewise, naturally nutrient rich watersheds historically contained denser growths of terrestrial vegetation. Dense vegetation along waterways means that more (and more diverse) vegetation falls into streams, and to help perpetuate the cycle, microbes process the carbonaceous detritus. Invertebrate organisms and fish are typically more abundant (though often less diverse) in hard waters.

Stream Order: Rivers and streams also are classified by their order. First-order streams have no tributaries. The smallest permanently flowing streams - even trickles - are first-order streams. When two first-order streams join they become a single second-order stream. When two second-order streams join they become a single third-order stream. Notice in Figure 1, below, that no increase in order occurs if more lower-order streams join a higher-order stream. A third-order stream would have to join another third-order stream to create a fourth-order stream.



(Figure 1)

Fourth-order streams are typically large streams, but the process continues to still higher orders. The highest order stream in the United States is the Mississippi River. It becomes 12th order. In Pennsylvania, the Susquehanna River is ninth order before entering the Chesapeake Bay.

Most of Pennsylvania's streams and rivers are at their highest water levels during spring snow melt, although winter rains (and other unusual amounts of rain at other times of the year) can lead to flooding. Much of the bank erosion and most of the sediments and organic debris transported by the stream occurs during these high flow events. Small sediment particles carry attached nutrients and metals. Typically, during high water events, there are more dissolved substances in the water. Streams fed by snowmelt can have big, daily (diel) variations in flow as well as water chemistry, particularly pH. Spring-fed streams tend to vary less in chemical composition, temperature and flow (discharge) than do those fed by groundwater seepage, runoff and smaller tributaries. Groundwater seepage is sometimes referred to as *baseflow*.

Geologic formations and their associated rock types have a tremendous affect on the water chemistry of the groundwater seeping into streams as well as on the vegetation native to the basin. In turn, the vegetation plays a role in determining the quality of runoff water, and as mentioned earlier, vegetation is totally responsible for the quality and quantity of all of the allochthonous matter (vegetative debris from the land).

Many of Pennsylvania's world-famous trout streams are '*limestone*' or '*hard-water*' or *'alkaline'* streams. They are often spring-fed, and therefore, cool in the summer. They are naturally highly productive, rich in aquatic plants and algae, and heavily populated with scuds and sowbugs, though usually not especially diverse. In the healthiest of these limestone and sedimentary rock watersheds, the riparian area and much of the basin is vegetated with diverse herbaceous plants and highly productive deciduous trees (trees that lose their leaves; e.g., maples, birches, all nut trees) providing the necessary nutrients for aquatic plants and algae growth.

Most of Pennsylvania's *'freestone'* or '*soft-water'* or *'acidic'* streams form from, and flow over, hard acidic sandstone, slate and shale, and in some cases granitic rocks, which are not easily eroded. Those rocks release their meager minerals and nutrients far more slowly than softer calcium based rocks. The best of these freestone streams are no less healthy than limestone streams. In fact, they usually have greater biodiversity, but are far more susceptible to acid degradation because they have much less calcium to help buffer any acid that gets into them.

If the riparian area and much of the basin of your stream is vegetated with mosses and coniferous forests (trees with needles and cones; e.g., pines, spruces, hemlock), you can be sure you are working in an acidic watershed. Evergreens tend to deposit much less detritus into the water than deciduous trees. In extremely nutrient poor and acidic water, the streams will have relatively low productivity and appear to be exceptionally clear.

All of the dead floral (plant) and faunal (animal) material in the stream, whether originating from the land (allochthonous) or from within the waterbody (autochthonous) is colonized and modified by aquatic fungi and bacteria. The bacteria rich biofilm on the detritus, and to a lesser extent the detritus itself is eaten by other stream life – primarily aquatic insects. The action of the bacteria increases the nutritional value and digestibility of the materials for the insects. Most 'raw' detritus is not digestible, but it is broken down into smaller pieces as it passes through animal guts, much like roughage in our own diet. Eventually the process repeats itself on a more 'micro' level and smaller life forms such as caddisfly larvae ingest the particles excreted by larger life forms such as crayfish. This is the basis of a concept called the *River Continuum.* This idea suggests that a higher percentage of organisms that shred the big pieces of detritus will live upstream and in the small headwater streams, and more of the insects utilizing the tiny pieces that are passed on will live downstream. In many relatively undisturbed watersheds, the concept seems to hold true, but the concept has lost favor to other methods of analyzing the health of a watershed.

The Habitat Factors We Observed In The Stream Environment During WATERSHED SNAPSHOT 2001 & 2002

Very basically, "habitat" is the place where something lives along with the environmental conditions that occur there. As you can see from the list below, the habitat assessment area that ***Watershed Snapshot*** participants are primarily concerned with is restricted to the stream, its banks and floodplain or riparian area. Together, this is the area that primarily affects the life structure of the stream.

The habitat factors we looked at are:

- ***Instream cover (fish and aquatic bugs)***
- ***Fine particle sediments (sand, silt and mud)***
- ***How many flow patterns does the stream have?***
- ***Condition of banks and coverage***
- ***Disruptive pressures to riparian (land bordering stream banks) area***
- ***Riparian vegetative zone width***
- ***Human land use in the watershed***
- ***Litter***
- ***"Overall" rating***

You can survive only six days without water.

The Penns Valley Conservation Association assesses the physical characteristics of Elk Creek in Centre County.

Mike Pascuzzi and Andy Ferguson use a kick net to collect a macroinvertebrate sample.

Pennsylvania agencies, organizations, groups of all kinds, and individuals have worked at restoring riparian zones in many areas over the past few years. Still, the most critical concerns facing riparian zones are disruptive pressures and narrow riparian zone widths. Forty-four percent of sites surveyed in 2001 and twenty percent in 2002 are rated ***poor*** or ***marginal*** in disruptive pressures to the riparian area, and two out of five have ***poor*** or ***marginal*** riparian zone widths. Your assessments show that there are many healthy habitats out there, but there is still a lot of work to do in restoring riparian areas, picking up litter and properly disposing of the trash, and working to prevent sediments from degrading our waterways. Discussion of each habitat factor and the graphed results of your assessments are on the following pages.

Instream cover for fish and aquatic bugs

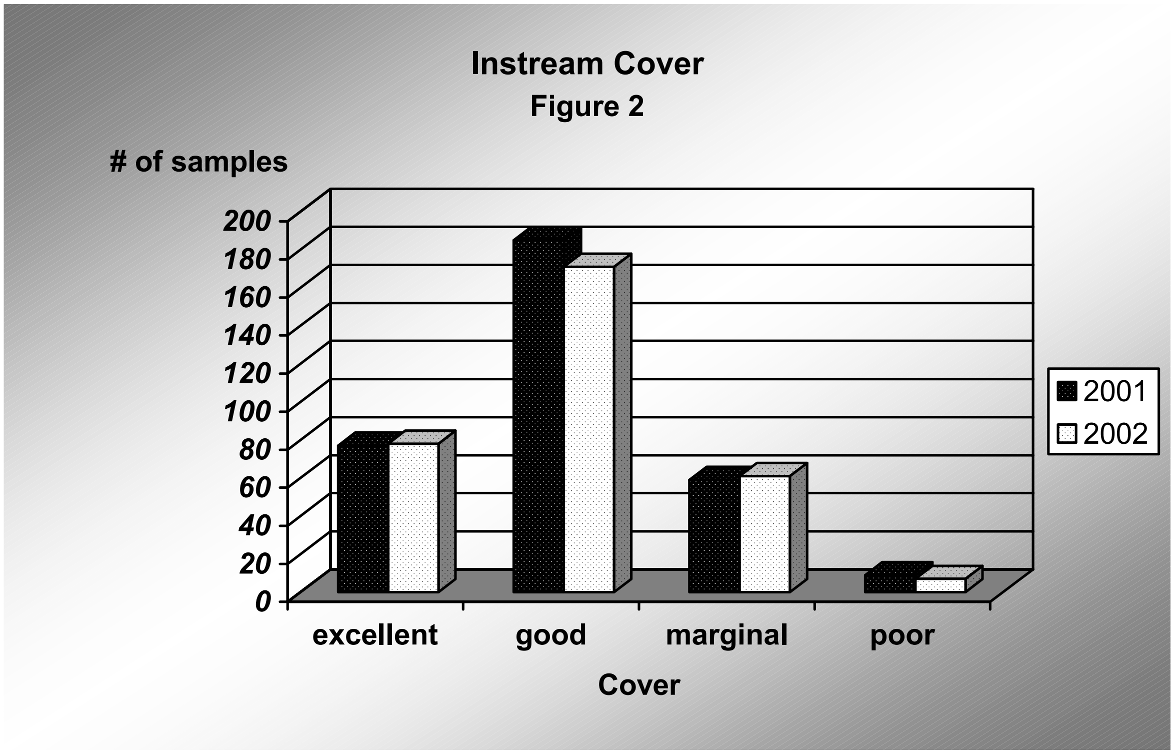
ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
Instream cover (fish & aquatic bugs)	The stream contains lots of boulders (over 10”), cobble (2-10”), submerged logs, undercut banks or other stable habitat	There is adequate habitat of both rock & wood for maintenance of diverse populations of fish & bugs	Some rock and wood or other stable habitat but much less than desirable	Not much stable habitat; lack of habitat is obvious

Snapshot participants look at their segment of stream and report on the presence of instream cover for fish and aquatic bugs. This assessment factor focuses upon the cobble, large rocks, wood and undercut banks. These are the places where fish and bugs feed, live, hide and raise their young. The more kinds and amount of cover, the better, because this equates to an increase in habitat diversity. It’s often easy to see that as cover increases, the diversity of life increases. Submerged logs and other pieces of wood are among the most productive habitat structures for fish and aquatic insects. When other needs are met, excellent habitat providing abundant cover will support greater biodiversity than will habitats that lack cover.

Jennifer Baer, Megan Laudenslager and Sara Davis have an interest in the aquatic habitat and life forms of Maple Creek, a stream in their Washington County neighborhood.

The physical shape and make-up of the streambed is determined by the underlying geologic formations and the forces of flowing water. A slow current velocity (distance/time) allows silt to drop out and fill in gaps between cobble and boulders. This influences the amount of living spaces for aquatic creatures. Limited habitat translates to limited biomass and limited diversity of organisms. Generally, a good variety of stone sizes and woody debris on the bottom is ideal. Specifically, coffee cup and dinner plate-sized stones provide some of the best habitat for algae, fish, salamanders and invertebrates. Degradation to habitat from many causes (primarily runoff from agriculture and drainage from mining) has lowered the quality of habitat to hundreds of miles of rivers and streams in Pennsylvania.

Three quarters of the weight of a living tree is water.

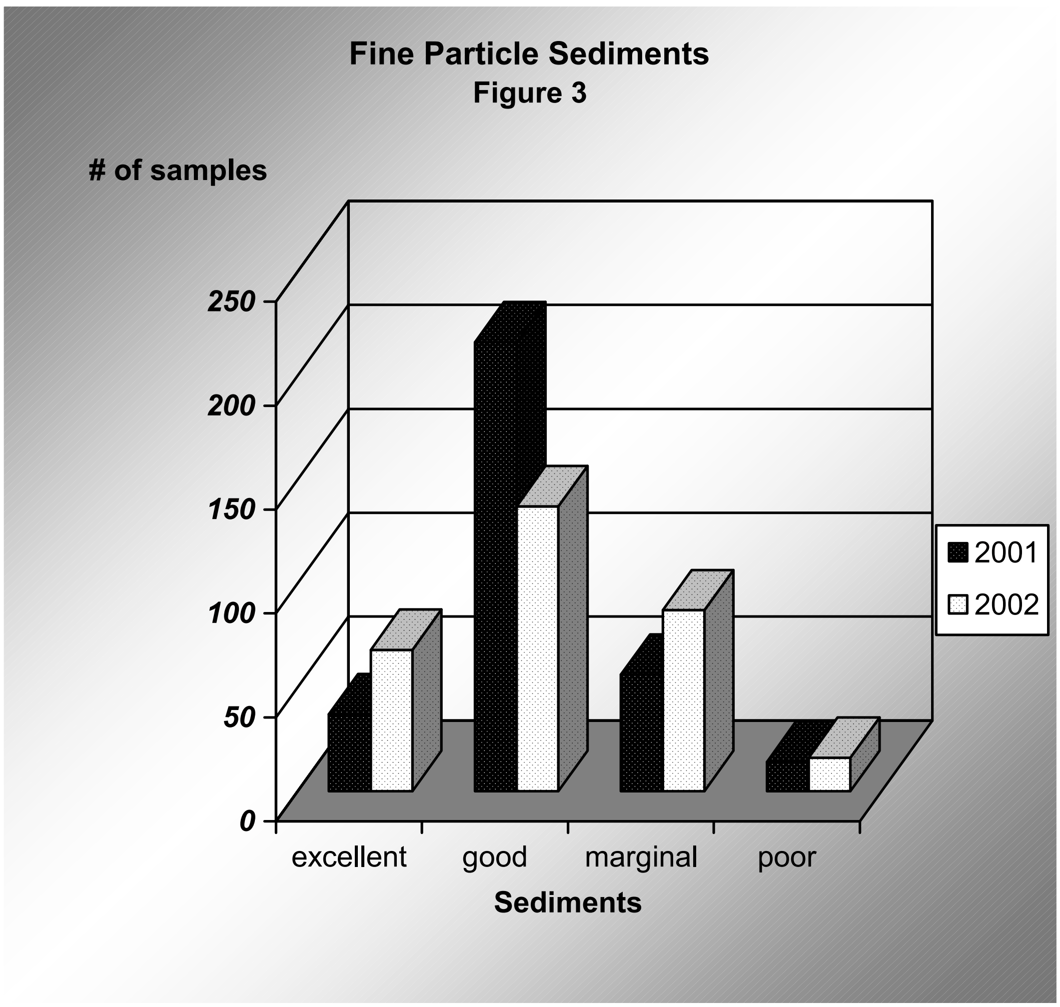


Fine Particle Sediments (sand, silt, mud)

ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
Fine particle sediments: (sand, silt, mud)	The rocks in the stream are not surrounded by fine sediments; I see very little sand, silt, or mud on the bottom	Rocks are partly surrounded by fine sediments. I could easily flip over the rocks on the bottom	Rocks are more than half surrounded by fine sediments; rocks are firmly stuck into sediments	Rocks are deeply stuck into fine sediments; bottom is mostly sand, silt, or mud

Substrate characteristics are often good indicators of the effects of human activities on streams. The discharge (volume/ time) and the water or velocity determine the quantity and size of the silt, soil and stone eroded from the stream channel and carried downstream. The substrate, or bottom characteristics, including aquatic vegetation, plays a big role in determining the species of macroinvertebrate organisms, periphyton and fish that will live in the stream. Decreases in the size of the average particle on the streambed, and / or increases in the percentage of sand, silt or mud may indicate changes in the rate of upland erosion and sediment load going into the stream. If, over a period of months or years you notice that your stream bottom changes in that you see average substrate particle size getting smaller, you may suspect some sort of watershed or streamside disturbances going on upstream. Look for areas with altered hillsides, areas of raw erosion or other runoff problems leading to mobile sediment. Accumulations of fine substrate particles fill the crooks and crannies of coarser bed materials, reducing habitat space and its availability for benthic (bottom dwelling) fish and macroinvertebrate organisms, and salamanders. In addition, circulation of well-oxygenated water is impeded when fine particles embed coarser, more permeable substrates. Assessing how 'stuck' the rocks are (substrate embeddedness) can tell you more than you would first guess. While you're at it, take hints from the aquatic plants and filamentous algae. They play an important role as substrates and their presence may be a useful indication of water velocities and whether or not the stream has a nutrient enrichment problem.

Fine particle sediments (specifically siltation) are a problem in more than 3,000 miles of our rivers and streams, and more than 100 miles are impaired by excessive algal growth. However, the good news is that 73 percent of ***Watershed Snapshot 2001 and Watershed Snapshot 2002*** participants rated **fine particle sediments** as ***good*** or ***excellent*** (Figure 3).



Flow Patterns

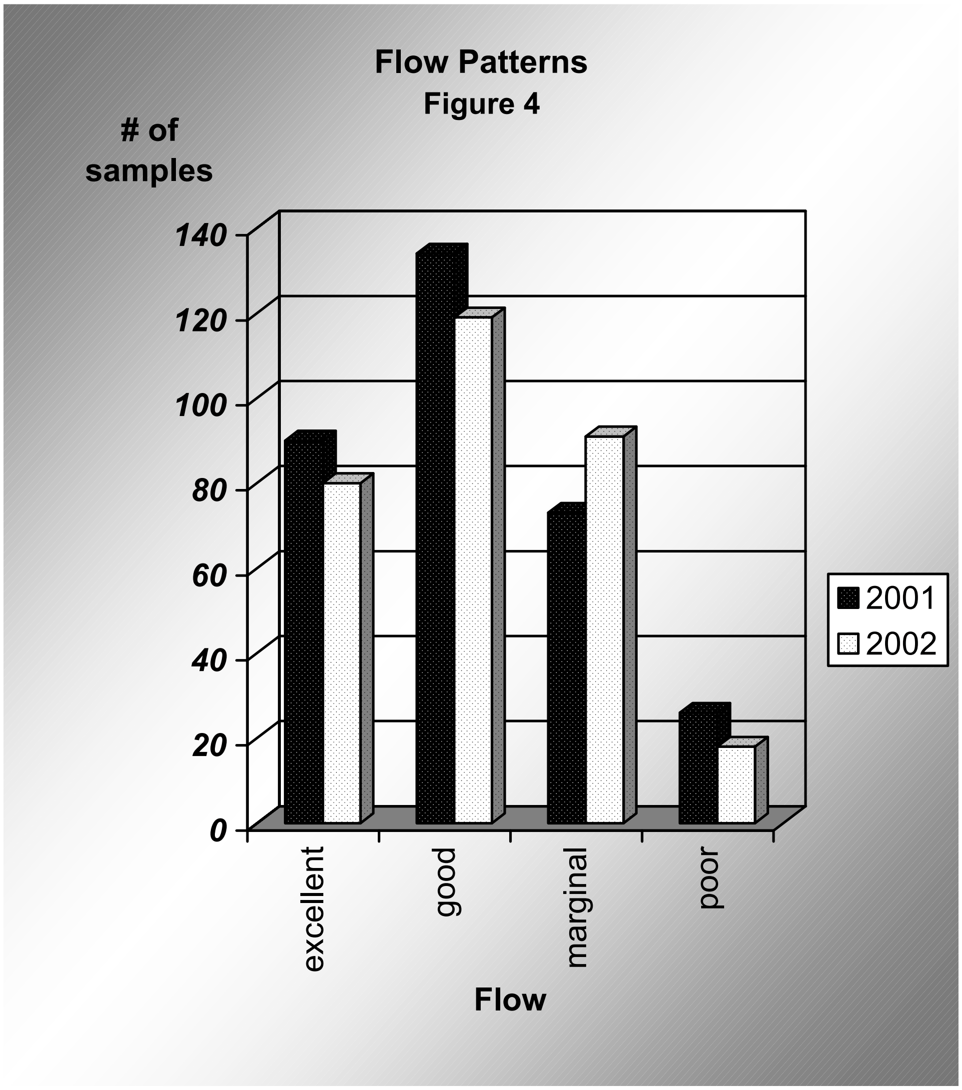
ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
"Flow patterns": How many does the stream have....	All 4 of these velocity/depth patterns are present within 50 yards upstream or downstream of this site: **slow/deep, slow/shallow, fast/deep, fast/shallow**	Only 3 of 4 regimes (flow patterns) are present	Only 2 of the 4 regimes present	Dominated by 1 velocity/depth regime

The best streams (as far as diverse habitat is concerned) will have all four patterns present: (1) slow-deep, (2) slow-shallow, (3) fast-deep and (4) fast-shallow. Flow patterns are associated with stream habitats. ***Snapshot*** participants look at their segment of stream and report how many flow patterns are present. Patterns of velocity and depth are observed, once again, as an important feature of habitat diversity. Along with the composition of the streambed, riffles, runs, glides and pools each provide their own unique niches and habitats.

The flow patterns influence water velocities in the stream channel. They also influence the size of particles that can be transported. Fine sediment particles determine the size of gaps that are exposed in the rocky streambed. It's the crooks and crannies that provide living space and cover for bugs, salamanders and many fish, especially sculpins, mad toms, stonerollers and darters. More patterns usually mean the stream is a stable aquatic environment with better habitat diversity.

Bill Dibert, Nick Granfield, Shane Fox, Ryan Berg and Ankit Patel of Bedford High School use a velocity bobber to measure the stream flow of Shober's Run.

There are some technical guidelines to tell fast from slow and shallow from deep; however, eyeballing the stream and making a judgment call works well. Sixty-seven percent of ***Watershed Snapshot 2001 and Watershed Snapshot 2002*** participants found at least three different flow patterns in their section of a stream (Figure 4).



> Water is the only substance on earth found naturally in three forms – solid, liquid, and gas.

Condition of Banks

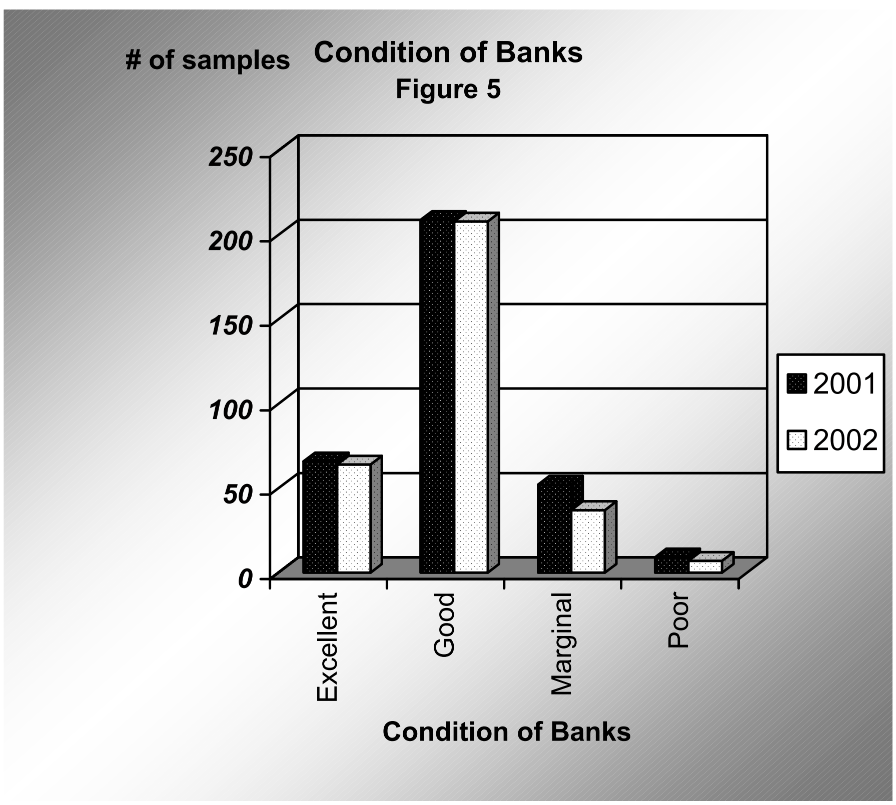
ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
Condition of banks and coverage?	The banks are stable; no evidence of erosion or bank failure; the whole bank is covered with vegetation or rock	Moderately stable; some small areas of erosion mostly healed over; most of the bank is covered by vegetation or rock	Largely unstable; almost half of the bank has areas of erosion or is NOT covered by vegetation or rock	Unstable; eroded areas; "raw" areas occur frequently; less than half of the bank is covered by vegetation or rock

Snapshot volunteers hope to find streambanks that are well protected by deeply rooted trees, groundcover or natural rock outcrops. Streambanks serve as habitat for a diverse collection of mammals, birds, reptiles and amphibians as well as a rich assemblage of wildflowers and other plants. Straightening of streams (channelization), bridge construction, and other modifications to streambanks accelerates erosion and diminishes biological community diversity while degrading habitat and, in general, lowering the integrity of the whole stream system. When channel straightening replaces a winding stream with a shorter and straighter channel, the new channel has a steeper slope because water makes the same elevation drop over a shorter distance. In reaction, gravity causes the stream to flow faster in order to adjust to these abrupt elevation changes. In turn, faster flowing water tends to cause the banks and bottom to erode. The water eats away at the banks and stream bottom in an upstream direction and the eroded material is deposited downstream. As a result, streamside landowners are faced with more problems after straightening a stream than they had prior to making alterations. Bank protection measures can minimize the problem. Sometimes inexpensive techniques, such as tree revetments, can help prevent a big erosion problem. An eroded bank on a straightened stream can rarely be repaired cheaply. This is one area where an ounce of prevention is worth much more than a pound of cure. Currently, damaged stream banks are directly affecting the health of at least 67 miles of our rivers and streams. More than 500 additional miles suffer from bank-related habitat alterations. Unstable and eroding banks have detrimental effects on stream health. Fortunately, only 16 percent of ***Snapshot*** participants in 2001 and 2002 rated the condition of the banks and bank coverage as ***marginal*** or ***poor*** (Figure 5).

It is not unusual for some Pennsylvania streams and rivers to have annual temperature change of 50 F (27^{o}C). Lakes do the same on an annual basis, but daily temperature changes in lakes are much less than streams, especially slow shallow, unshaded streams, which may heat up more than 15^{o}F (8^{o}C) at the end of a hot sunny day and then cool the same amount over night. It is due to these wide swings in temperature, caused mainly by poorly vegetated banks and floodplain (or the *riparian corridor*), that fish and insect populations are compromised.

Water temperature regulation and streambank and floodplain erosion control are good reasons for leaving vegetated buffer strips along the edges of streams when harvesting timber or clearing land for agricultural use. Many Pennsylvania watershed groups have received funds from Growing Greener grants and other sources to reestablish riparian areas. **Riparian Vegetative Zone Width and Riparian Disruptive Pressures** are assessed by ***Snapshot*** participants.

Shady Grove school students take and record the air temperature in the grassy riparian area of Prophecy Creek



Disruptive Pressures

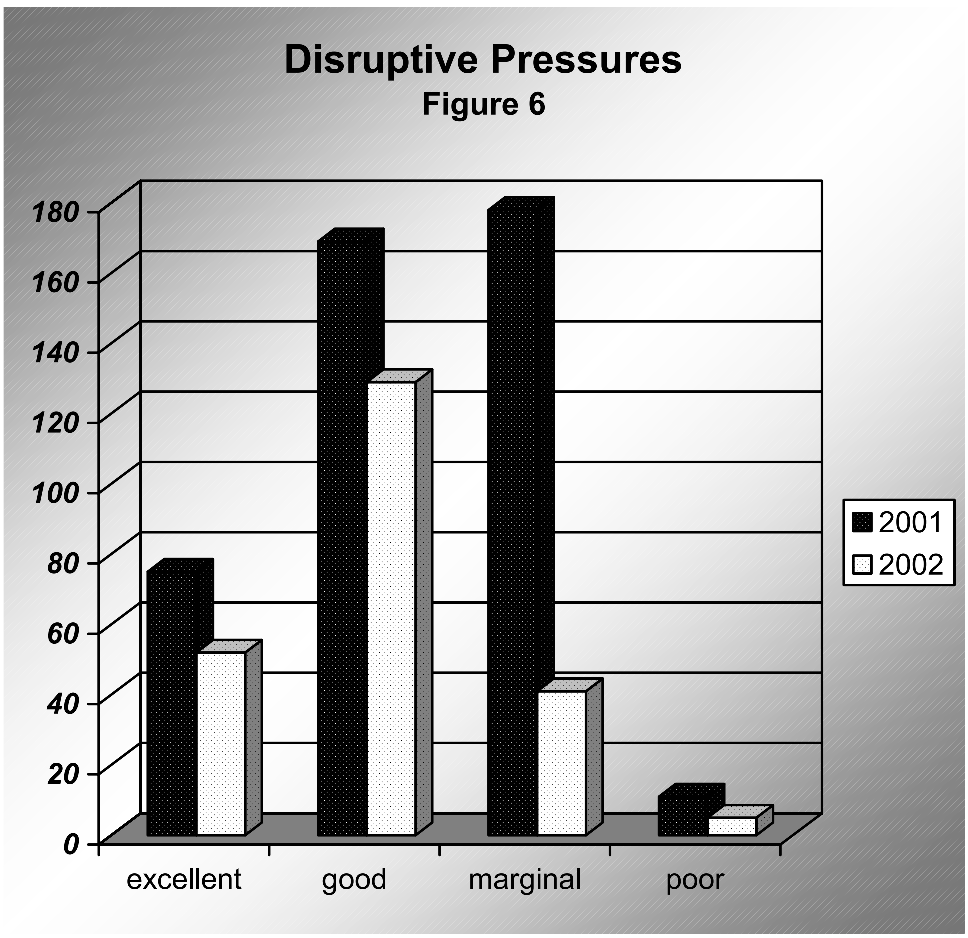
ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
Disruptive pressures to the "riparian" (land bordering stream banks) area?	Trees, shrubs, or grasses have not been disturbed through forestry, grazing or mowing; almost all plants are growing naturally. Mature trees, understory, and vegetation are present	Some disruption but not affecting full plant growth potential to any great extent; trees, woody plants, and soft green plants are dominant	Disruption is obvious; some patches of bare soil, cultivated fields or closely cropped vegetation are the norm	There is not much natural vegetation left or it has been removed to 3 inches or less in average stubble height

The riparian area and banks may be subjected to a variety of disruptive pressures including grazing, trails and paths, sidewalks, lawn and residential and urban development activities. When the growth of a *natural* plant community is lost, frequently the area becomes compacted, eroded or 'enhanced' with riprap, concrete and livestock crossings which further reduce the health and aesthetic value of the stream. The lack of canopy provides little shading, cooling or detritus to the stream.

If you are good at plant identification, you should note if shrubs, trees and herbs are 'exotics' or 'native'. Some exotics (non-native or introduced species) are invasive and tend to 'take over', eliminating nearly all the native vegetation. Monocultures (typically exotic vegetation) reduce the diversity of the habitats, and therefore the diversity of life living in that community. Land use, buildings and other evidence of human activities in the watershed, especially near the stream channel and its riparian zone may, in themselves, serve as habitat quality indicators and indicators of human caused stress upon the stream.

McMichaels Creek – Students from Pleasant Valley Intermediate School learn about the physical and chemical properties of a stream, and how they affect stream health.

When doing a habitat assessment we should be aware of the frequency and extent of both in-channel and near-channel human activities and disturbances. In-channel disturbances include using rock or concrete, straightening and restrictions by bridges and culverts. This was discussed in some detail in the ***Condition of Banks*** section. Another in-channel problem and eyesore is trash – especially big trash such as car bodies, grocery carts and construction blocks. (Trash is addressed in the "***Litter***" section of the ***Snapshot*** stream assessment field form and later in this report). Near-channel riparian disturbances include buildings, lawns, roads and many sorts of agriculture such as pastures, orchards and row crops. Fifty-six percent of streams and rivers assessed for ***Watershed Snapshot 2001*** had little or no disruption, indicated by a score of ***good*** or ***excellent***. Reports for ***Watershed Snapshot 2002*** showed that 80 percent of the areas assessed that year were assessed as ***good*** or ***excellent*** (Figure 6).



Old-style toilets use 3.5 to 7 gallons per flush. New toilets use 1.6 gallons of water.

Riparian Vegetative Zone Width

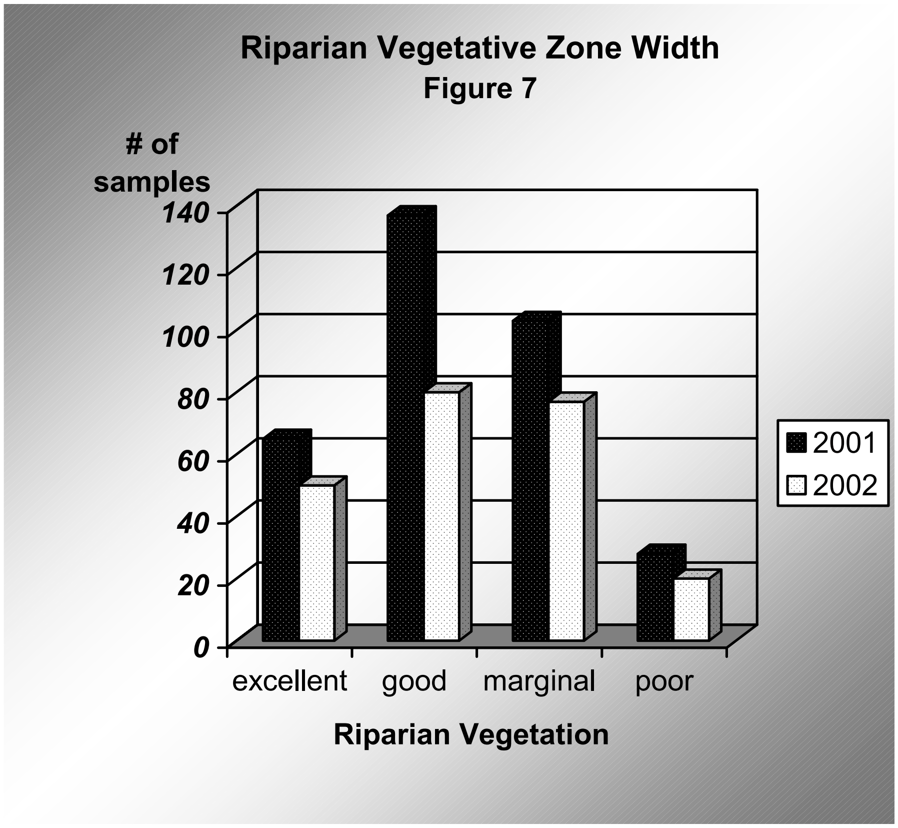
ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
Riparian (land bordering stream banks) vegetative zone width	Riparian zone is more than 35 yards wide; human activities (parking lots, roads, clearcuts, lawns, or crops) have not impacted zone	Riparian zone 12-35 yards wide; human activities have impacted zone only minimally	Width of riparian zone 6-12 yards; human activities impacting zone are commonly evident	Width of riparian zone is less than 6 yards; lots of nearby human activities

This habitat factor measures the width of natural vegetation from the edge of the streambank out through the vegetated 'riparian' or 'buffer' zone. The zone reduces the amount of runoff pollutants entering the stream. The buffer zone also controls erosion, provides leaf-litter to the stream and habitat for many desirable species of amphibians, reptiles, mammals and birds. In some cases, wide riparian zones function as corridors for migrating large and small animals. One could make the case that smaller streams can make due with narrower riparian zones, but we think wider is better in all cases. A width of 35 yards or more allows the zone to function better in its varied roles than does a lesser width. Therefore, we utilize the simple and effective means of determining quality based upon width and disruptive pressure. Again, it is gaining favor to evaluate each bank separately and arrive at a consensus for the score.

The riparian vegetation affects the stream channel shape and structure, as well as the stream's canopy cover, shading, nutrient inputs and amount of large woody debris entering the stream. Riparian canopy cover (branches and tree crowns overhanging a stream), is important not only for its role in moderating stream temperatures through shading, but also as an indicator of conditions that control bank stability, and as an energy source from the leaves that will fall into the water. Stoneflies and other aquatic macroinvertebrate organisms eat, shred and break the leaves into coarse and fine particulate organic material (CPOM and FPOM). CPOM and FPOM, originating from riparian vegetation becomes food for other stream organisms, and it provides structure that creates and maintains complex habitat in pools and sometimes in channels.

Properly vegetated riparian areas are a big asset in reducing the amount of nutrients (phosphorus and nitrogen) entering the waterway. Trees also reduce bank erosion and sedimentation problems. Loss of plantlife on streambanks leads to erosion, which in turn leads to increased stream width, which in turn leads to warmer, less oxygenated, shallower water and degraded habitat. We are left with a system supporting fewer forms of aquatic life. Many desirable species of fish and macroinvertebrate organisms are no longer able to sustain life under these unnatural conditions.

Riparian areas have been seriously disrupted over the past century. Farming, forestry, construction and home and commercial development have been major stressors. There is currently a statewide effort underway to replant and restore stream buffer zones. One initiative is called "Stream ReLeaf." The goal of Stream ReLeaf is to restore 610 miles of riparian buffer along streams in the Chesapeake Bay drainage basin by the year 2010. This goal will soon be expanded to include all of Pennsylvania's streams. If you'd like to help with this effort, contact the Pennsylvania Department of Environmental Protection (DEP). Contact information is in the front of this book. With the help of these programs, Pennsylvania hopes to see a significant increase in riparian areas. Presently, 42 percent of the sites assessed for this report had a riparian area that was rated as ***poor*** or ***marginal*** (Figure 7).



One gallon of water weighs approximately 8 pounds. As the saying goes, "a pint is a pound – the world around."

Human Land Use in the Watershed

ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
Human Land Use in the Watershed	Nearly all the land is unmodified. A total of 0 – 25% is farmed, residential, commercial and industrial AND impervious, hard surfaces such as blacktop parking, roofs, and highway cover less than 2% of the watershed	The watershed is slightly modified. 25 – 50% of the land is used for 'human uses' OR impervious, hard surfaces cover 2 – 10% of the watershed.	The watershed is modified. 50 – 75% of the land is used for 'human uses' OR impervious surfaces cover 10 - 20% of the watershed.	Nearly all the land is modified. 75 – 100% of the land in 'human uses' OR impervious surfaces cover more than 20% of the watershed

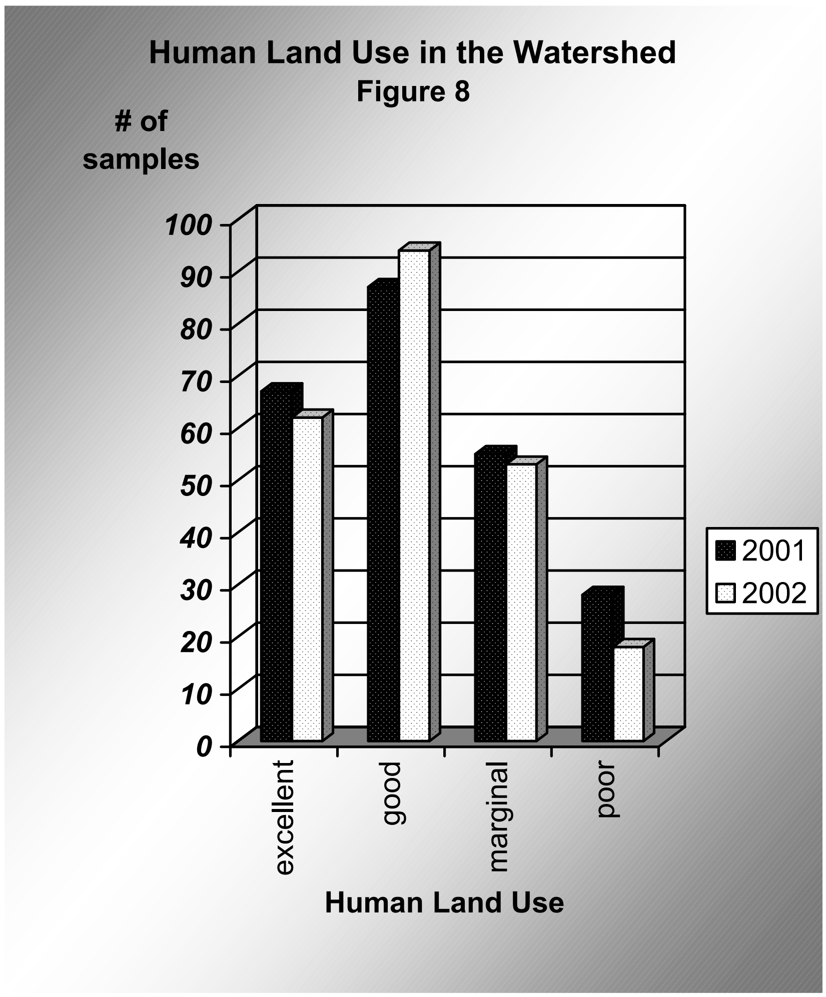
This habitat assessment factor asks ***Snapshot*** investigators to estimate the percentage of the land in the watershed that is developed for residential, commercial, agricultural or industrial use areas. It also requires the investigator to consider the amount of impervious, hard surfaces such as blacktop parking lots, roofs and highway in the watershed. This gives a fair estimate of the potential for nonpoint source pollution (NPS) within the watershed, that is, the contamination of our waters from many sources other than the typical end of pipe pollution with which most of us are familiar.

As communities grow, the desire for more development and pavement follows. As more land is paved with traditional, economical blacktop and concrete, or covered by roofing, ground surface is decreased and absorptive ability is lost.

Mike Jackson takes a water sample from Sideling Hill Creek in Bedford County.

Runoff from areas with poorly managed fertilizer use and animal wastes contributes to the nutrients in the water, often leading to problems of excessive algae growth and its associated problems. Also, when water runs over disturbed soil, sediment enters waterways. Sediments can carry harmful chemicals attached to the sediment particles, and in its own right, sediment reduces the quality of stream-bottom habitat and reduces the clarity of the water.

Assessing the ***Human Land Use in the Watershed*** helps us to be aware of these potential problems and to modify our daily activities to avoid some of these problems in order to help assure a healthier environment. Sixty-seven percent of ***Watershed Snapshot 2001 and Watershed Snapshot 2002*** participants determined that human land use in their watershed of concern fell into either the ***good*** or ***excellent*** categories (Figure 8).



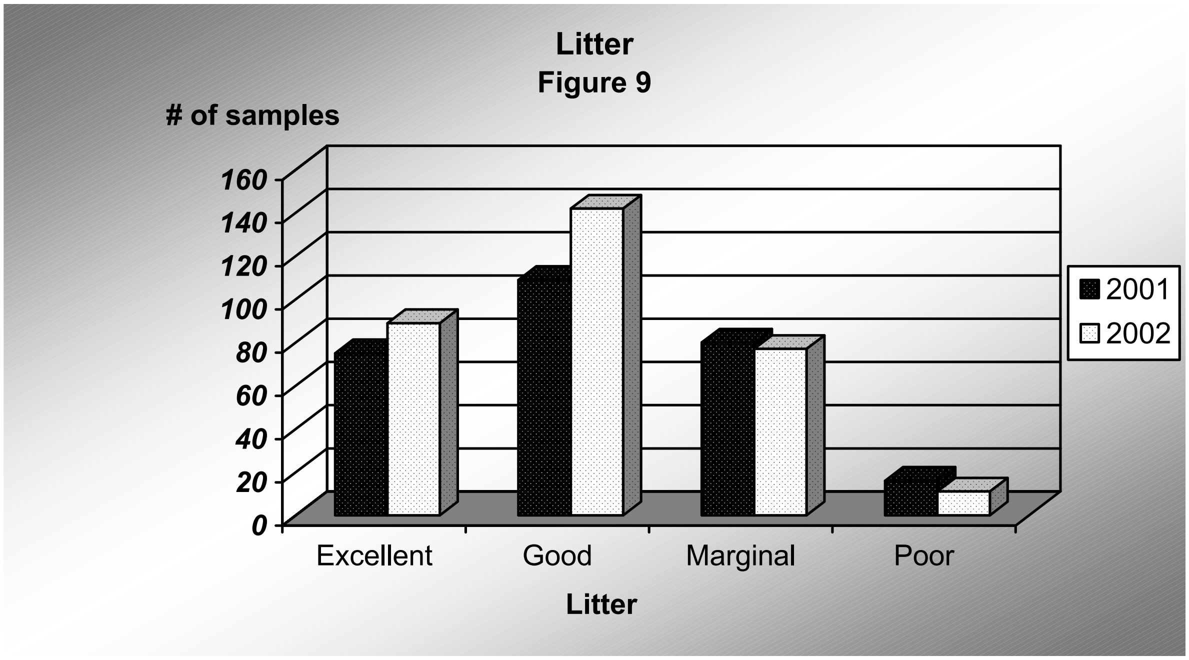
Litter

ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
Litter	There is no litter in the area	There is very little litter in the area; probably some degradable paper accidentally dropped by fishermen or hikers	Litter is fairly common and includes metal or plastic, obviously purposely dropped.	Area is a candidate for a clean-up project. Lots of litter, dumping, tires, or barrels present

Aesthetic quality characterizes the visual appeal of an area or site within a watershed, and it declines with visible signs of human use – especially when that includes trash. The guiding principle is: 'Do Not Litter'! Trash does not belong to mother nature. We may bring various kinds of stuff to the stream so that we can fish, hike or prepare a meal, and then end up with trash that we do not want. As a sensible and responsible person, we should always carry the trash back out with us and then dump it into a trash can/collection site. The three R's "Reduce, Reuse and Recycle" are essential elements of our solid waste (trash) management program. We must think about what we buy, how we buy it and how we use it.

Use what you buy and if at all possible, reuse everything. If trash is generated, recycle it! Recycling recovers valuable resources, reduces pollution and decreases our reliance on landfills and helps keep our watersheds more aesthetically pleasing. Please conserve energy and natural resources because it reduces the need for raw materials to be taken from the earth and processed. Litter in streams and along the banks is ugly and potentially dangerous. Common metal, rubber, glass and plastic items will endure for long periods of time – sometimes more than 100 years! Some of these components may directly affect aquatic life and water quality. Any trash and litter in our water or in our watershed reflects upon the values we humans associate with our streams and watersheds. Commendably, 75 percent of the sites assessed for ***Watershed Snapshot 2001 and Watershed Snapshot 2002*** had little or no litter. However, in 25 percent of the watersheds litter was common or heavy. In about five percent of the sites, the area was considered to be a potential candidate for a clean-up project (Figure 9).

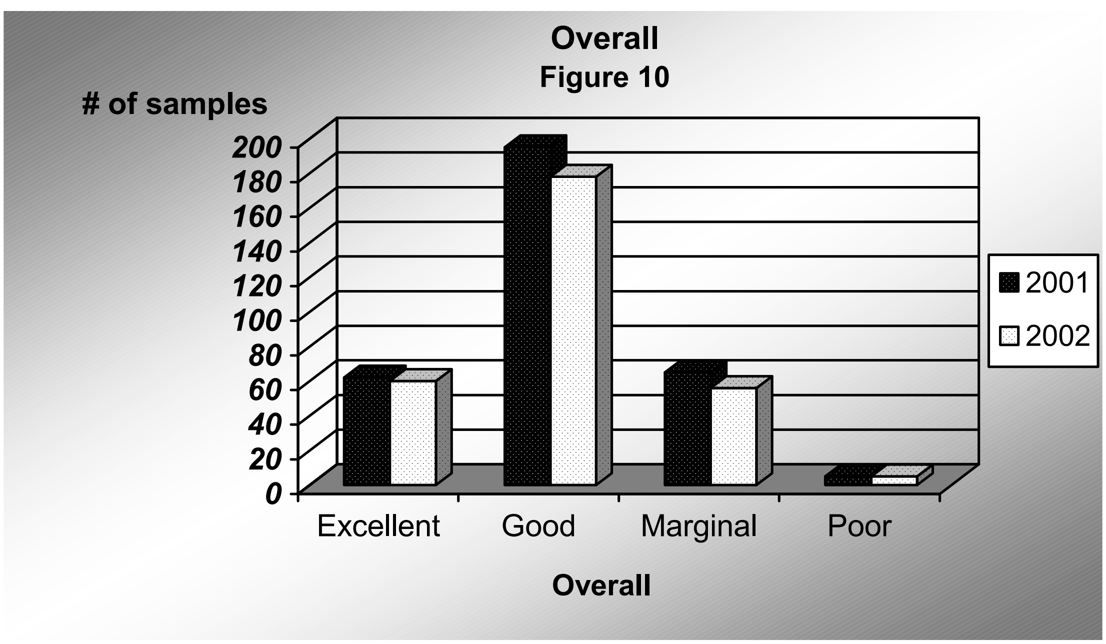
In Pennsylvania, each person uses about 62 gallons of water every day at home.



Overall Habitat Rating

ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
Overall I Rate the VISUAL ASSESSMENT of this site.	EXCELLENT	GOOD	FAIR	POOR

Seventy-nine percent of sites surveyed in 2001 and 80 percent in 2002 were assessed as ***good*** or ***excellent*** in the "Overall" category (Figure 10). This is consistent with the percentages reported in previous years.



It's a Bug's Life

In addition to learning about habitat factors and water chemistry, we like to look at what lives in the water. Fish, amphibians, plants, algae, bugs and other life forms all have their story to tell. The story that is most studied is that of the group called *benthic macroinvertebrates*. "Benthic" means under water and on the bottom. "Macro" means "large" and in this case "large" means big enough to be seen without a magnifying glass - sort of the opposite of "micro." "Invertebrate" means without a backbone. So, benthic macroinvertebrates, or "bugs" are any form of animal life, big enough to be seen, not having a backbone, and living at least part of its life on the bottom under water.

David Goldstein and Michael Brant use a kick net to collect a macroinvertebrate sample.

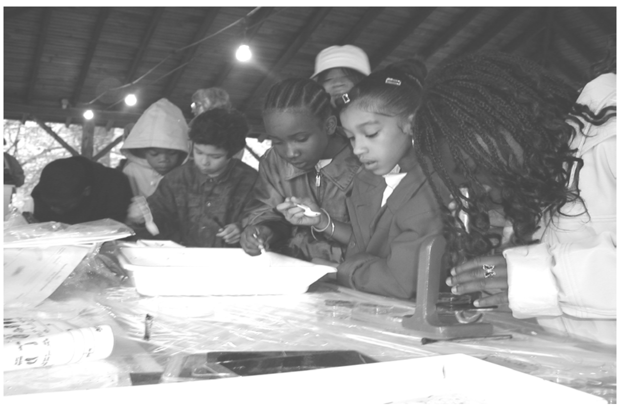
Pennsylvania is blessed with more than 2,000 species of aquatic insects! We have at least 312 species of caddisflies (Trichoptera), and six kinds of hellgramites (Megaloptera), 136 species of stoneflies (Plecoptera), at least 150 species of mayflies (Ephemeroptera), and 150 or more species of dragonflies and damselflies (Odonata). Some biologists say that taking into account all of the lotic, lentic and semiaquatic species, as well as those that remain to be discovered, there may be 1,000 species of midges (part of the order Diptera). If true, the order Diptera is the biggest aquatic insect order of all. We know for sure that Pennsylvania has well over 500 species of flies including 60 species of mosquitoes.

The exact number of aquatic insect species isn't known, but we do know that no other forms of stream wildlife can compare to the diversity of insects. Aquatic insects live and grow under water through at least one of their life stages. As adults, most will have wings and they may fly for long distances inland, often attracted by the bright lights of gas stations, malls and streetlights. Their lifestyles, also are diverse. Some eat bacteria, some eat plants, some prey upon other insects, tadpoles and fish. Nearly all insect species are eaten by many other forms of wildlife.

Sandy Voorhees, Lee McCoy and Dave Irco search for macroinvertebrates in a sample taken from Sandy Creek in Mercer County.

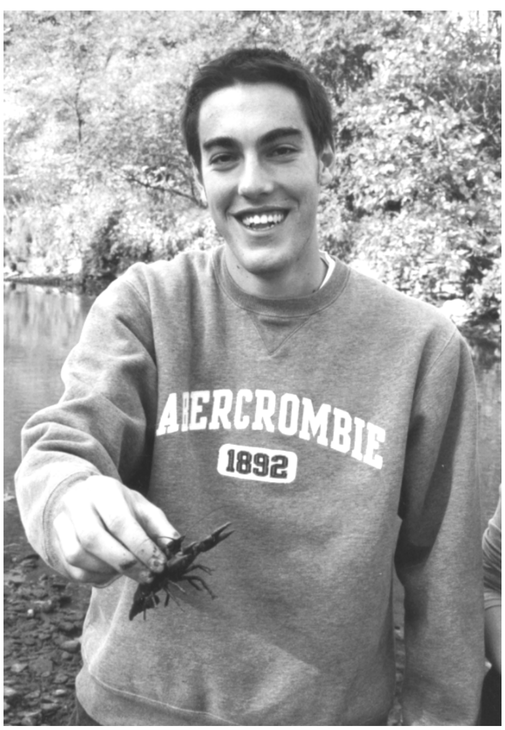
Caddisflies dobsonflies, alderflies, aquatic moths, flies and beetles all have four life stages: Egg – Larvae – Pupa – Adult. Having four life stages is called ***complete metamorphosis***. They usually molt (shed their skin) five to seven times in their life, which is typically one year, although number of times molting and life expectancy varies between orders and according to environmental conditions. (Dobsonflies are usually on a two or three year lifecycle.) Each stage between molts is called an instar. Most of life is spent as a larva. Transforming into an adult requires a relatively short (two-week) period as a pupa, which is usually sealed off in some sort of 'house' or skin-like or silk case (cocoon) in which the transformation takes place. The adult emerges from the case, and often the role of the short-lived adults is to mate, lay eggs and die – often serving as food for fish, birds, amphibians and predatory and scavenger insects.

Fulton Elementary students looking at aquatic insects.

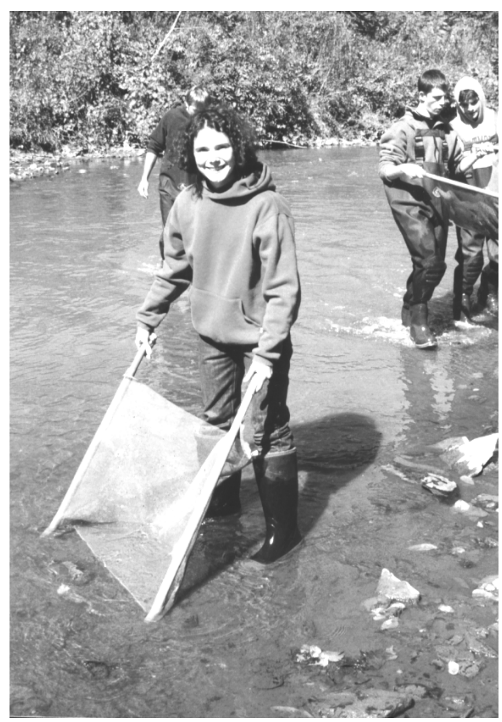


Fulton Elementary students looking at different species of aquatic insects.

Mayflies, dragonflies, damselflies, stoneflies and water bugs all have three life stages: Egg – Nymph – Adult. They are missing the Pupa stage. Having three life stages is called ***incomplete metamorphosis***. They usually molt more often than the insects with complete metamorphosis. Fifteen or more molts is common with mayflies, dragonflies, damselflies and stoneflies. The life cycle is typically one year, although dragonflies are a notable exception, sometimes living for five years. Nymphs look similar to their adult stage. One obvious characteristic of insects with incomplete metemorphosis is that as the nymphs mature, they develop stiff pouches on their backs called *wing pads*. The wings develop within these wing pads. Each stage between molts is called an instar. Most of life is spent as a nymph. Transforming into an adult is done quickly from the final instar, which usually crawls out of the water onto rocks or wood, splits open and the adult emerges. As with most aquatic insects, the role of the short-lived adults is to mate, lay eggs and die. Mayflies and stoneflies are extremely important sources of food for trout, especially nymph and egg laying females, which flutter on the water surface.



Adam Tishok shows a crayfish found while observing benthic macroinvertebrates.



Katie Barr and her fellow students from Mt. Lebanon High School look for macroinvertebrates to assess the health of the stream.

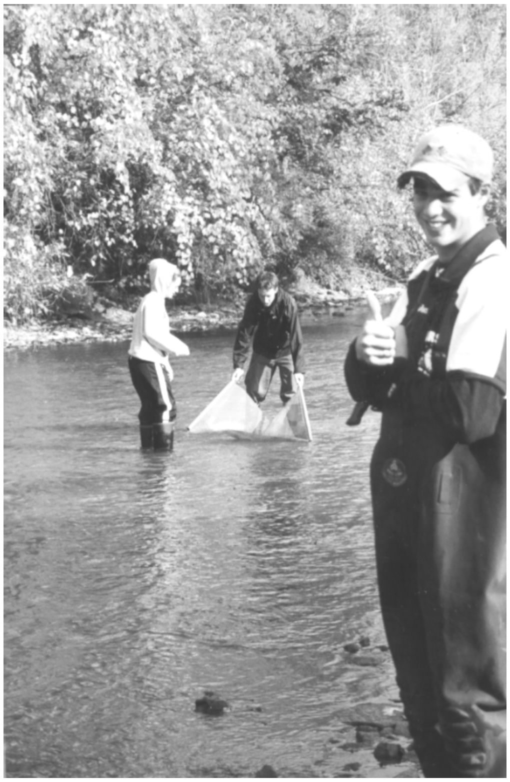
Some understanding of bug life cycles and natural history is important because some stages are secluded or evasive and not easy to observe. This could lead a casual observer to think that certain bugs aren't present. In reality, it may be that at the time of collection most are secluded in a resting stage or they are inconspicuous eggs or they may be adults that are terrestrial and in some cases, as with dobsonflies, only active at night. Many kinds of mayflies and stoneflies hatch at some point during the summer and spend the summer as aerial adults. For this reason, summer is not considered the best time to collect aquatic organisms. Now that we know that insect numbers actually present in the water are highly variable throughout the seasons, knowing a little about their life cycles helps us to plan the best times to go collecting. Snapshot participants are surveying their streams in mid-April, which is one of the best times to observe aquatic insects, as few insects have transformed into adults and left the water at this time.

Emily Mahon uses a kick screen to collect a macroinvertebrate sample.

Kevin Kelly, Luther Lengel and Larry Tropea collect a macroinvertebrate sample to assess Black Run, Dauphin County.

The most widely used collection device is the kick screen, though many monitors use D-frame nets or simply turn rocks and pick organisms from them. Some groups who are interested in more precise measurements and population densities use *Surber samplers,* which are fine mesh nets attached to a square frame that covers exactly one square foot of substrate. Surber samplers are only one foot high, so they should only be used in shallow waters that do not flow over the top of the net. If you are concerned with developing statistically valid results regarding densities and bug populations, usually at least 20 samples are collected for analysis. Most watershed stewards are not very concerned with those calculations and they leave such work to the professional ecologists. Most stewards are concerned with the clues and information they can gain from small samples. Indeed, a lot can be learned about a waterbody's water chemistry and overall health simply by knowing what kinds of aquatic organisms are present.

Except for a few volunteers who are beginning to monitor lakes, almost all of our ***Snapshot 2001 & 2002*** studies take place in shallow water. We sample shallow waters because some of the most diverse communities of aquatic macroinvertebrate organisms live in the riffles of streams, so we tend to target those areas. In addition, it is very difficult to sample deep water and there is the obvious safety hazard factor of working in deep water.



Bill Virgi supervises as his classmates collect macroinvertebrates.

The Bug Report: Water is one of life's requirements for all the organisms on earth. Clean water is crucial to achieving ultimate health for nearly every living thing. Congress passed the Federal Clean Water Act of 1972, hoping to restore and/or maintain the good integrity of the water throughout the United States. Since then, there has been an accelerated interest in the ways developed and used to 'score' the quality. It is very common to study the community of living things in the water as well as water chemistry. The idea simply being, if a certain kind of bug requires clean water and you find that kind of bug, the water must be clean. The bug is used by us to indicate the environmental conditions that exist. Such an organism is called an indicator organism - when presence indicates that certain environmental conditions required by the organism are being met.

For monitoring to have much meaning or value beyond establishing baseline data, we must find biological trends or patterns responding to outside influences - usually human activities. Understanding the relationship between the influence and response is the key. To do this we usually look closely at the bottom dwelling indicator organisms, (these are referred to as *benthic macroinvertebrate organisms*). We then use established scoring systems called *biological indexes* or *metrics*, to help interpret what we have found. Sometimes we are simply generating a score to help us understand how the macroinvertebrate organisms rate on a scale.

Sometimes we compare what we find at our site to another nearby site. The comparison site is called a 'reference site.' It is usually on the most pristine stream in the area having many similarities to the one we are monitoring.

These benthic macroinvertebrate organisms, (bottom dwelling aquatic 'bugs') possess several characteristics making them useful indicators of water quality. Bugs, as a group, are wide ranging in their sensitivity to physical and chemical changes in their habitat. Since macroinvertebrate organisms vary in their degree of sensitivity to degraded water, we are able to use their presence or absence to give an accurate and fairly precise indication of a stream's health. As we discussed earlier regarding aquatic insects, many bugs live in the water for nearly a year – some more than one year - and they cannot escape from pollution as easily as some fish, allowing them to be year-round sentries of water quality. Lastly, another reason we like to use bugs is because it's fairly easy to collect and work with them.

Tim Faust uses macroinvertebrates to help determine the water quality. Crayfish need fair-good water quality to survive.

Some macroinvertebrate organisms, such as certain worms and fly larvae, have high survival rates in polluted waters, whereas most stoneflies and mayflies are very sensitive even to small doses of most pollutants. Ranking each kind of bug's sensitivity onto a scale allows their use in interpreting water quality. One commonly used system, the Hilsenhoff Biological Index, assigns each kind of 'bug' a value from zero to ten, according to how well it can tolerate organic pollution. The scoresheet in the ***Snapshot*** packet was based on this system, though greatly simplified. Snapshot's scoring system breaks the bugs into just three categories: *Tolerant, Facultative* (somewhat tolerant) and *Sensitive*. A bug is considered *Sensitive* and scores three points if it tolerates almost no organic pollution, and it is *Tolerant* and scores one point if it can live in a polluted environment. The ones in between score two points. The primary indicator organisms (sensitive group) for water quality are aquatic insects: mayflies, stoneflies and caddisflies. Generally, these are usually among the most sensitive to pollution of the common aquatic insects. In general, the ones that are somewhat sensitive include: dragonflies, craneflies, fishflies and most aquatic beetles. And some of the most tolerant ones are black flies, midges and most of the aquatic true bugs (Order Hemiptera), as well as some worms, leeches and snails. The trick is in knowing who can tolerate which pollutants. Considering the simplicity of this system, it works well to determine the overall health of the stream. It is not really hard to identify insects but there are so many of them that it is seems like an overwhelming job. But, it is also fun to identify a lot of creatures who you've never seen before in your life! It's good advice to use simplified keys at first, and learn from other people. Fly fishermen are usually good aquatic entomologists - studiers of insects. More and more simplified keys and aids are becoming available through DEP, the Fish and Boat Commission, watershed organizations, environmental groups, universities and dozens of internet sites. One very good Internet site using photographic keys is http://www.dec.state.ny.us/website/dow/stream/index.htm.

Aditya Sanghui checks out a macroinvertebrate sample.

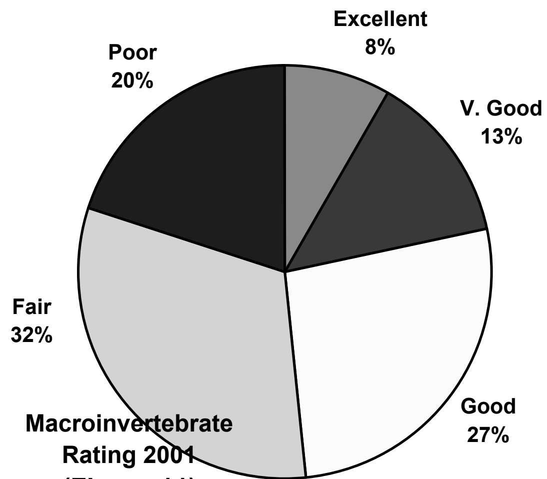
Snapshot participants went into riffle areas in their stream of interest and disturbed the streambed for an area of about one square meter or yard (that's three feet long by three feet wide). They caught all the organisms living in that square yard in their kick-screen net. Those participants who did not have a net, carefully turned over rocks and looked for organisms on and under the rocks and in the stream. Using an identification key, participants identified all the organisms found. Scoring the invertebrates and determining a "WATER QUALITY RATING" was done on the KEY sheet that came with the field sheets used by the volunteers.

Snapshot participants rated the water quality based on both score and presence of sensitive bugs using this rating scale:

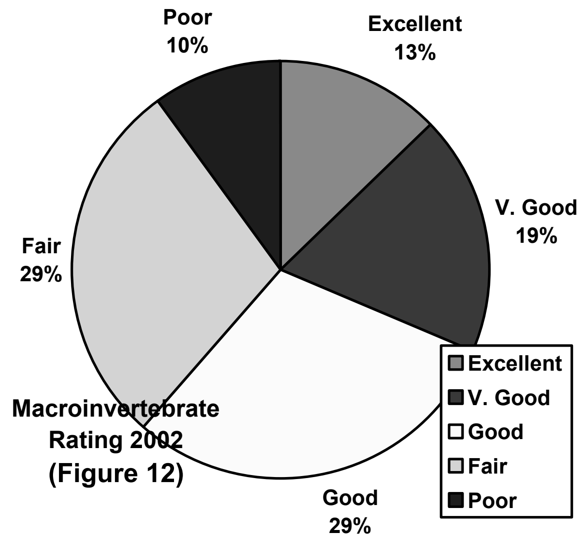
Scoring and Water Quality Rating:

- Excellent (score of 27+ or 5 or more Sensitive (S) taxa)
- Very Good (score of 22 - 26 or 4 Sensitive (S) taxa)
- Good (score of 17 - 21 or 2 or 3 Sensitive (S) taxa)
- Fair (score of 11 - 16 or only 1 Sensitive (S) taxa)
- Poor (score of less than 11 and no Sensitive (S) taxa)

Based on this rating scale, you reported to us that the biological health of our streams breaks out like this:

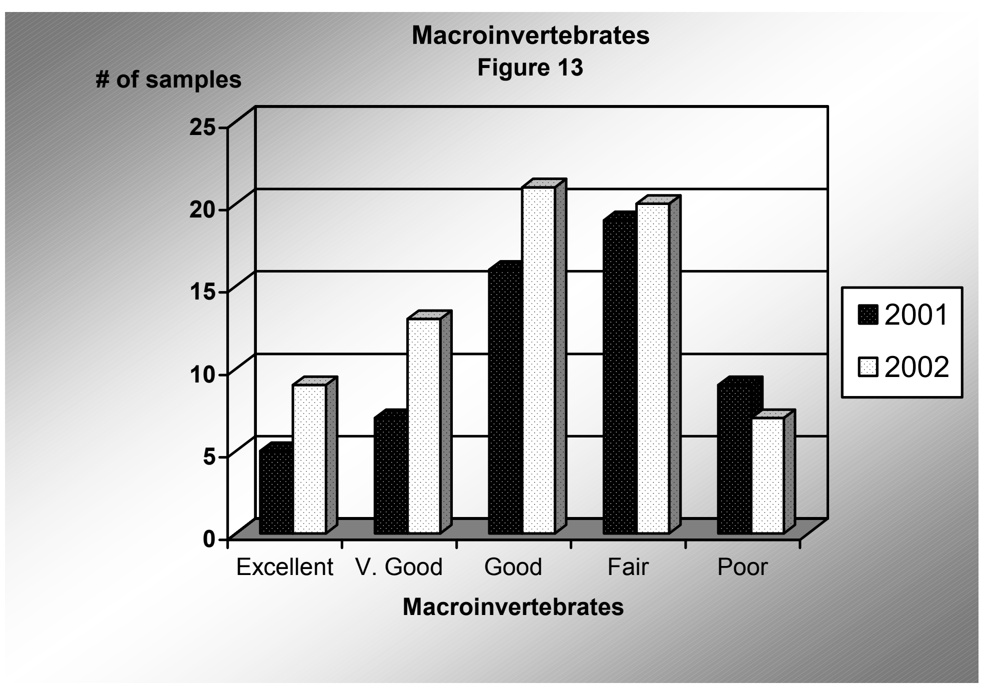


Macroinvertebrate Rating 2001 (Figure 11)



Macroinvertebrate Rating 2002 (Figure 12)

The Macroinvertebrate ratings saw an increase in streams that were rated as ***excellent, very good*** or ***good***. Forty-eight percent of streams in 2001 were rated good or better by ***Watershed Snapshot 2001*** participants. ***Watershed Snapshot 2002*** participants gave a rating of ***excellent, very good*** or ***good*** to 61 percent of their streams (Figures 11, 12 and 13).



Other indexes measure taxa richness (how many kinds) and various ratios of one group to another. Usually only the formula and some ability to identify the creatures is needed to use additional indexes. The "**EPT Index**" is a famous "index" that is used to decipher what the bugs are trying to tell us about the water. The EPT Index is so named because the order of mayflies is called *Ephemoroptera*, sometimes shortened to "E"; the order of stoneflies is called *Plecoptera*, sometimes shortened to "P"; and the order of caddisflies is called *Tricoptera*, sometimes shortened to "T".

To use the index, identify all E's, P's and T's to their genus (or family level). Then add up the total number of genera (or families) you found. Higher scores indicate better quality than lower scores.

To figure out **Percent EPT**, simply count the number of bugs in your sample that are E's, P's or T's, and divide by the total number of bugs in the sample. For example, if you collected 133 bugs and 40 were EPT's, divide 40 by 133 to get 30 percent. Usually, the percent decreases with degradation. So, a stream scoring 20 percent is likely not as healthy as a stream scoring 30 percent. One word of caution though is that there is a limit. Streams scoring much higher than 40 percent EPT may be raising their diversity (richness).

A chicken is about 75% water; a pineapple is 80% water; a tomato is 95% water.

Bill Ray and Jes Sunder of the McKeever Environmental Learning Center rinse macroinvertebrates collected from Sandy Creek.

Just as simple as the EPT Index is one called **Richness**. This is simply the total number of genera (or families) found at the site. Usually the number decreases with degradation, but small infertile mountain streams are often low in taxa richness even though they can be nearly pristine.

There are numerous biological indexes and the more of them you use, the surer you will be about the quality of the water, as indicated by the community living in it. If this is the kind of thing you have an interest in knowing more about, one recommended source of information is EPA's book, *Rapid Bioassessment Protocols For Use In Streams and Wadeable Rivers - Periphyton, Benthic Macroinvertebrates, and Fish.* You can view this exceptional document on the web at www.epa.gov/owow/monitoring/rbp/.

By learning to identify a few invertebrates now and a few later, you will soon amaze yourself and your friends with your ability. If you are enthusiastic about the topic of macroinvertebrate organisms and want to hone your identification skills, consider owning the best professional keys you can find. Books such as *Aquatic Insects of North America* by R. W. Merrit and K. W. Cummins or *Freshwater Macroinvertebrates of Northeastern North America* by Barbara Peckarsky et.al. or *Aquatic Entomology* by W. Patrick McCafferty are practically necessary to identify the organisms to the genus level. At first they can be intimidating to use, but they are excellent professional texts. Go slow. Don't give up. Don't worry excessively about making mistakes. Now and then we all get the wrong answer on the first attempt or two at identifying unfamiliar organisms.

Lakes and Their Watersheds (Lentic Systems)

Lakes and reservoirs make up some of the most valuable and utilized water resources of Pennsylvania. There are over 5,000 lakes and reservoirs of five or more acres in Pennsylvania.

A lake is any naturally impounded body of water, while a reservoir is a body of water that is created as a result of excavation or damming. In order to properly understand and manage your lake, you should understand lake ecosystem components and their interactions. Important components include: the watershed that contributes water to your lake and the physical, chemical and biological components and cycles of your lake.

The Lake's Watershed: A lake's watershed is that area of land that drains directly into a lake, either through rivers, streams, surface runoff or groundwater. A watershed can be envisioned as a funnel with a glass at the bottom representing a lake. Anything that falls into the funnel will find its way into the glass. Much the same occurs in a watershed. Therefore, watershed characteristics such as size, land use, slope and soils play an important role in determining both the quality and quantity of the water that drains to a lake. For this reason, getting to know your lake's watershed and the activities that go on in it are of primary concern to the individuals that manage and enjoy the lake.

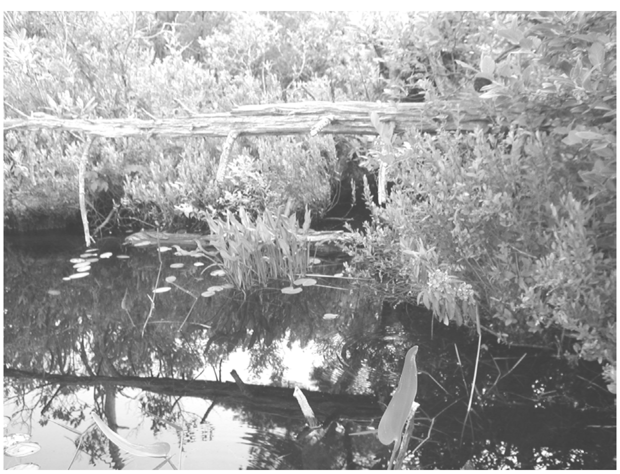
Throughout Pennsylvania, stewards are needed to develop a deeper understanding of shoreland ecosystems and natural shoreland and lake management.

A good place to gain a better knowledge of your lake's watershed is by obtaining 7.5 minute, 1: 24000 scale U.S. Geological Survey (USGS) topographic maps for the area, available locally either from the County Conservation District Office or some sporting goods stores. Reference copies also are available at most U.S. Department of Agriculture (USDA) and Planning Commission offices. One great (and free) web resource is www.topozone.com. There you will find topographic maps and be able to locate accurate coordinates (latitude and longitude) for your site.

Topographic maps contain valuable information about the area that drains into your lake, such as steepness of the land, physical characteristics, roads and trails and some general land use. By outlining the watershed that drains to your lake, you can begin to survey that area for possible water quality influences. The watershed size, along with the land use, slope, soils and precipitation will be valuable information should you want to determine runoff characteristics of your lake's water source.

The land use in a watershed affects the type of materials such as sediment, nutrients and other pollutants, that will wash from those areas and potentially into your lake. One may expect oils and salts from roadways, sediments and fertilizers from farms and gardens, nutrients from on-site septic systems, etc. The permeability of the land use affects how much and how quickly water will travel. For example, rain falling on closely mowed grass will travel faster and move more nutrients than if it were to fall onto a wooded area with otherwise similar characteristics. The slope of land within the watershed, together with land use and Geologic Composition determines how fast water and pollutants are carried to the lake.

Watersheds are made up of many types of soils. Soil type affects the rate and quantity at which precipitation soaks into the ground. A rich organic soil absorbs much of the rainfall, while a rocky clay soil may shed most of its rainfall. Soil types also have differing chemical make-ups and erodibility that affect water quality.



Unfortunately, some people still perceive lakeshores like this one, with dense riparian growth and lots of so-called "weeds", as messy and in need of cleaning.

The Lake's Physical Aspects: A lake's depth, length, width and physical shape all combine to influence how the water from the watershed moves through and reacts with the lake. The longer water remains in a lake, the longer it has to deposit the materials it has carried from the watershed and to interact with the water already in the lake.

A lake's depth affects the volume of the lake and determines to some extent how water will flow through the lake. A lake's depth also determines whether or not a lake becomes thermally stratified in the summer, with a layer of warm water at the top and a layer of cold water at the bottom. Therefore, depth affects lake water quality by influencing the fate (dilution and transport) of incoming pollutants.

A lake's length, width and physical shape also determine flow patterns and characteristics. A short uniformly-shaped lake will have a relatively short water detention time. Long lakes and lakes having many slow or isolated arms, bays and other backwater areas will have a much longer detention time.

Additional physical aspects of a lake that are important are: the locations of water control structures such as beaver dams or dikes; the location of submerged structures; and the location and characteristics of aquatic weed beds. Preparing a detailed bathymetric (lake depth) map of your lake is a useful exercise that will give you a tool for lake management.

Chemical/Physical Properties and Cycles: Chemicals entering your lake from the watershed and the atmosphere go through cycles that affect the overall quality of the lake's water. Some chemicals may flow through the lake unchanged, while others settle to the bottom, possibly to be reused again. Still others remain in solution. Understanding these cycles is often the key to managing or correcting water quality problems.

The plant nutrients phosphorus and nitrogen play a major role in plant growth, including macrophytes (aquatic vegetation) and algae. These nutrients enter a lake through atmospheric deposition (directly falling on the lake's surface as dust and as rain), dissolved in groundwater or attached to sediment particles in streams that drain the watershed. Under conditions of low oxygen, phosphorus may be released from the bottom sediments.

Without aquatic plants like these lily pads, lakes would have fewer aquatic insects, minnows and other wildlife.

The effect of acid precipitation on runoff is largely determined by the ability of the watershed and lake to neutralize the acidity. This varies by watershed and is determined largely by the parent rock material and subsequently the buffering capacity of the soil and type of dissolved materials in the water. Sediment carries many chemicals and directly affects water clarity.

It is possible that some of the water molecules in your glass of water are 250 million years old - they are from the dinosaur era.

Environmental Education Specialist John Jose, from Pike County Conservation District demonstrates how to collect a deep water sample with a *Kemmerer Bottle* sampler.

Deep lakes often experience thermal stratification. This is the condition where stable water layers develop, most notably during the summer, with warm water at the surface and colder, denser water at the bottom. This denser water at the bottom is essentially isolated from atmospheric sources of oxygen. The store of oxygen in the bottom water can be depleted by biological activity in the sediments, causing a number of reactions that affect chemicals in the water and sediments. Seasonal measurements of nutrients, oxygen and temperature will aid in understanding your lake's water quality status, in diagnosing problems and in developing your lake management plan.

Biological Cycles and Components: As with the chemical and physical aspects of your lake, the biological cycles and components play an important role in determining water quality. Food chains directly affect the lake's fisheries and wildlife capacity. The type and abundance of plants and algae can and do affect lake uses. Monitoring chemical, physical and biological components is important to understanding and managing lakes.

Monitoring Lake Water Quality: There are many reasons for performing a water quality assessment of a lake. Gathering information about your lake and its watershed is an important step in its management. The goal of a lake monitoring program is to determine the water quality and ecological condition of your lake. You may be concerned because you see excessive algae or aquatic weeds in your lake. You may have a pristine lake, but want to document the existing condition of the lake. You may want to determine and evaluate the long-term condition of your lake. The type, extent and cost of your lake study will depend on the reason for your study and the amount of information you want. Your monitoring program for your lake can be as simple as keeping a diary of observations or as sophisticated as a regular detailed scientific study. A detailed scientific study of your lake however, should be performed by an environmental scientist or engineer who is experienced and trained in lake ecology.

What To Monitor: In order to properly monitor the complete lake ecosystem, you should monitor the physical, biological and chemical aspects of your lake. Some of those elements are outlined here:

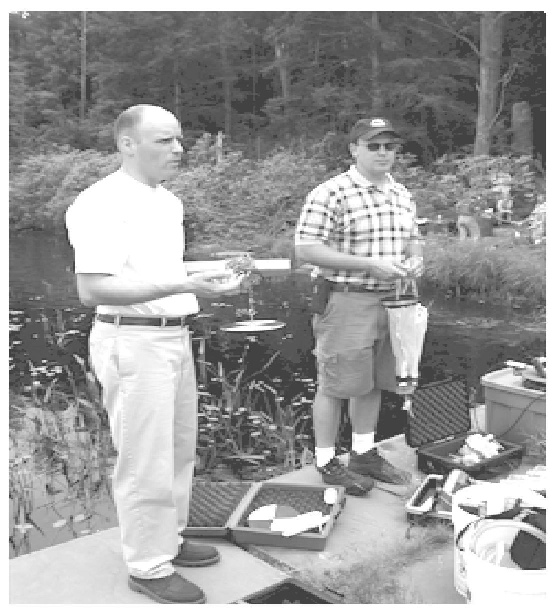
Physical

- Historical water uses and management including lake depth, area and volume;
- Location of structures such as rocks and tree stumps that make good fisheries habitat;
- Depth of bottom sediments in lake;
- Hydrological information such as precipitation amounts, inlet and outlet flows;
- Transparency (as measured using a Secchi disk); and
- Temperature profiles.

Using a SONAR gun to find the water depth, a volunteer works off the dock at Lake Lacawac.

Biological

- Location, type and abundance of aquatic plant species types (species) and amount of phytoplankton (free floating algae);
- Fisheries data (fish species and sizes);
- Types and amount of zooplankton;
- Fecal coliform bacteria; and
- Chlorophyll a (a measure of phytoplankton biomass).

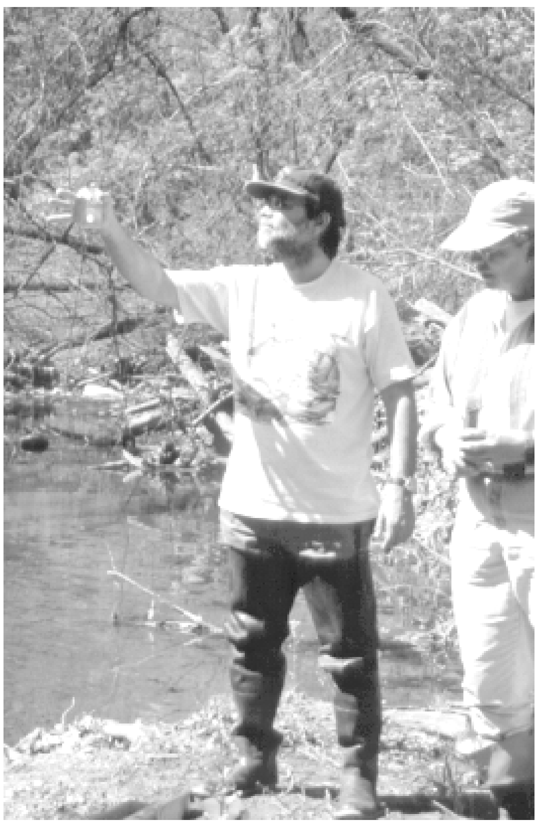


Jason Smith (left) from FX Browne Inc. shows Secchi disk, while Ed Molesky prepares to collect plankton with a tow net.

Chemical

Water chemistry plays a critical role in the ecological condition of a lake. While there are numerous tests that can be performed, some of the more important ones are:

- Nutrients that affect plant growth, particularly phosphorus and nitrogen;
- Lake acidity status, measured as pH and alkalinity;
- Total suspended solids; and
- Dissolved oxygen profiles.



Cheryl Snyder and Dan Nardis test dissolved oxygen using a Hach kit. They are working at Shutt Mill Park, Dauphin County

Where To Monitor: For many lakes, one lake monitoring station located at the deepest part of the lake is sufficient. For large lakes or lakes with complex shapes or many inlet streams, multiple stations should be monitored. In deep lakes that thermally stratify, water samples should be collected at different depths because the water quality is different in these stratified layers. Generally, samples should be collected at the surface, mid-depth and just above the lake bottom. At a minimum, samples should be collected at the surface, approximately two feet below the water surface. There are specific methods and equipment that should be used to collect water samples for chemical and biological analysis. If samples are collected incorrectly, the results could be misleading or incorrect.

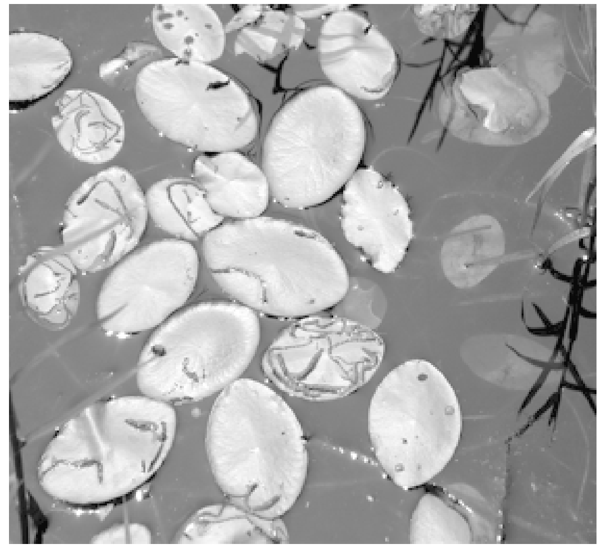
When to Monitor: The scheduling of your monitoring program will depend on the objectives of your monitoring program and your budget. The EPA Clean Lakes Program Guidance Manual recommends that sampling be performed twice per month from May through September and once per month from October through April. This is an excellent but very expensive monitoring program. A good, moderate monitoring program would be to monitor your lake once per month from April through September. If you are on a limited budget and just want to know the condition of your lake during the critical summer months, you could monitor your lake once per month in July and August.

Understanding Lake Monitoring

As we discussed earlier, lake monitoring includes the measurement of physical, biological and chemical data to determine the water quality and ecological condition of your lake. Measuring the vertical profiles of temperature is important because this information indicates whether your lake is thermally stratified. The chemistry and biology of a stratified lake is different than that of a completely mixed lake. The temperature and oxygen data also indicates the occurrence and extent of oxygen depletion in the lake's bottom waters. This affects the quality of the lake for fish and other aquatic organisms.

Like most aquatic plants, these rather rare *Little Floating Hearts* need protection, not elimination, so they can continue to function as part of healthy aquatic ecosystems.

Biological lake parameters indicate the biological condition of your lake. For example, chlorophyll *a*, a green pigment present in all algae, is a measure of the algal biomass. Algal (phytoplankton) cell counts and identification gives an indication of the algal diversity. The presence of blue-green algae, for instance, indicates that a lake may be eutrophic (containing excessively high amounts of nutrients), or becoming eutrophic. Eutrophic lakes (lakes that are aging – filling in – at an accelerated rate due to excessively high amounts of nutrients) are often dominated by one or a few algal species during the late summer. Conversely, lakes that contain very little nutrients (nitrogen and phosphorous) are said to be oligotrophic. They are typically very clear because they contain very little phytoplankton. Lakes that fall somewhere in the middle are called mesotrophic lakes.



Watershield leaves are 2" – 3" long with a jelly-like substance on the reddish underside and on the stem of the plant. Understanding the kinds and distribution of aquatic plants in their lakes helps lake monitors to value their lake community.

Macrophyte (aquatic plants) surveys, which are usually performed by visual observations, show the extent and variety of aquatic plants in the lake. Fecal coliform bacteria are indicator organisms. Most are harmless, but their presence indicates the possible presence of pathogenic (disease-causing) bacteria.

Berks County Watershed Specialist Pamela Spayd (seated) works with (L-R) Flynn Barnett, Neal Siegrist, Eugene Siegrist, Katie Jay and Stephanie Harmon to conduct chemical monitoring of Maiden Creek.

The chemical parameters are also very important. In most fresh water lakes, phosphorus and nitrogen are the key nutrients used by algae and aquatic plants to grow. The amounts and chemical forms of phosphorus and nitrogen are important in understanding the condition of your lake. Total suspended solids provide an indication of the amount of suspended sediments in the lake. These sediments could be from erosion and runoff from the watershed, or they could be from the algae and other biota in the lake. All of these parameters are evaluated together to determine the ecological condition of the lake.

Citizens' Volunteer Lake Monitoring Program

There are many excellent guides and workshops available for designing and performing lake monitoring programs. The Pennsylvania Department of Environmental Protection (DEP) has a Citizens' Volunteer Lake Monitoring Program. Most volunteer lake monitoring programs are best suited for monitoring basic lake aspects such as aquatic weed growth, water transparency (using the Secchi disk), and analyzing for simple chemical parameters such as pH, hardness and alkalinity. Chemical test kits cannot be used to reliably, accurately and precisely measure total phosphorus and nitrogen because they are not sensitive enough. A qualified laboratory should perform these tests and others, such as chlorophyll *a* and total suspended solids.

> The average price of a cup of water from a Pennsylvania public water supply, delivered to your kitchen sink is 1/160 of a cent; or 16,000 eight ounce glasses for a dollar!

Aquatic plants are an essential part of the natural community in this pristine Pennsylvania lake.

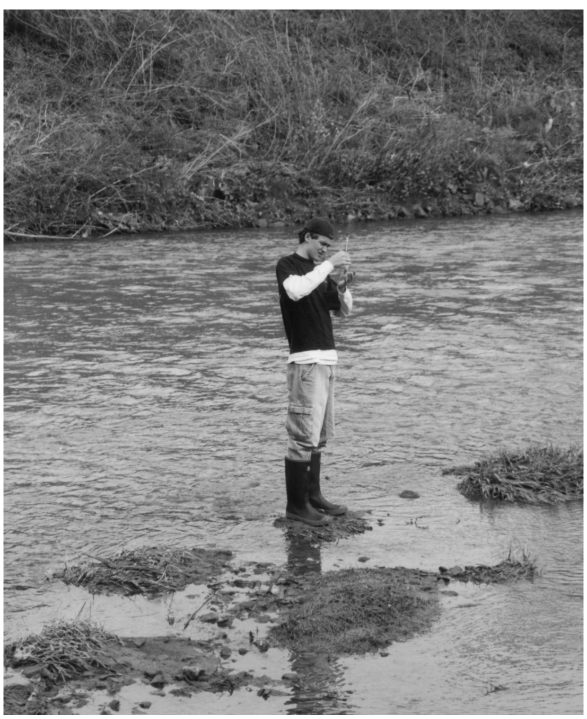
If you want to perform a detailed scientific study of your lake, you should contract with a qualified lake management consultant or university, or DEP's Lake Monitoring Program. Contact information is in the beginning of this booklet. Or, visit the Pennsylvania Lake Management Society's website: community.pennlive.com /cc/palakes.

Water Chemistry and Physical Factors Observed In WATERSHED SNAPSHOT 2001 & 2002

Temperature

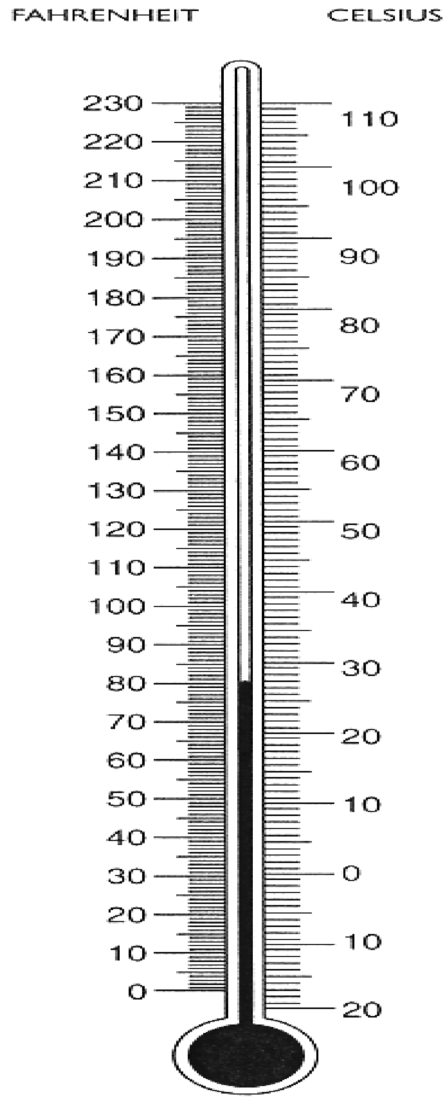
The summertime temperature of most freestone/soft-water streams gets cooler as you move upstream into the uplands and headwaters. Limestone streams are often fed by large springs, and the summertime temperatures are coolest as you get nearer the major springs. The water becomes gradually warmer in the lower reaches and in the waterways of higher stream order. The warm summer temperatures in large, warm rivers such as the Susquehanna or Ohio Rivers restrict the movement and dispersion of some organisms. For instance, brook trout populations in the major river valleys are essentially confined to their own home-streams as they cannot pass through the warm, oxygen-depleted rivers in the valley to begin a new life in the stream over on the next mountain. Some fairly level, shallow rocky streams, especially those with little shading, can have daily temperature variations of up to 15ºF (8ºC). Great daily temperature changes are stressful to stream life. Streamside vegetation is of tremendous value in stabilizing water temperature and, together with the tree root habitat, can cause dramatic improvements in aquatic life.

Center In The Park members doing water chemistry.



Andy Villa uses a simple thermometer to read the stream temperature.

Most scientists and most of the world use the Celsius temperature scale. The thermometer shown below (Figure 14) will help you with converting from Fahrenheit to Celsius.



(Figure 14)

Temperature affects a lot of biological and chemical reactions. The amount of oxygen the water can hold goes hand in hand with the water temperature. Colder water can hold more oxygen than warmer water. The solubility of solids increases with increasing temperature, while gases tend to be more soluble in cold water. This is discussed more in the dissolved oxygen and conductivity sections.

All of us know that temperature affects things. For instance, it's pretty safe to say that cookies bake faster (or burn sooner) at higher temperatures. We have also observed that for some coldwater fish, the rates of protein consumption and growth of the fish increase as water gets warmer – at least to a maximum point - typically somewhere in the area of 10-14°C. Similarly, algae and other aquatic plants usually increase their growth rate as temperatures rise. Food supply, photosynthesis, metabolism and solubility of minerals and metals are all affected by temperature.

Stream temperatures in a heavily forested watershed will be more even and cooler on a daily basis than will the temperatures of a similar stream in a deforested area. Forests help maintain a constant, cool base-flow and offer protection from the direct rays of the sun. Usually, as forests are depleted they are at least partially replaced by blacktop and buildings. Heated water running off of parking lots, highways and roofs contribute to the heating problem while reducing groundwater recharge.

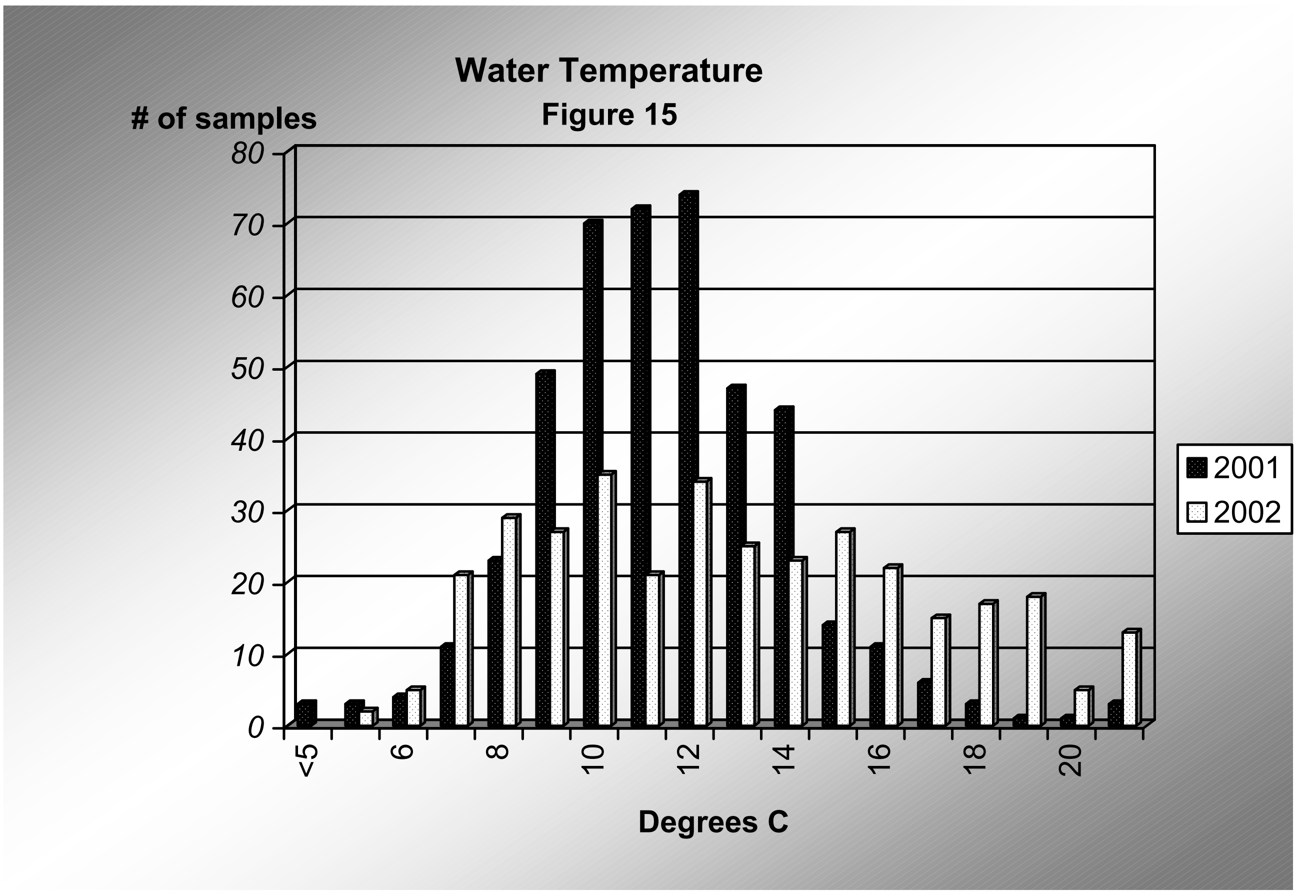
Stephanie Serrano of Sunbury Christian Academy measures stream width and water temperature.

Temperature measurements should be taken directly in the stream with a simple waterproof thermometer or other thermistor-containing meter. Use the same instruments, whenever possible, to collect all the data that you wish to compare. In order to make data comparisons from sampling event to sampling event, it is important to take the temperature at the same location in the stream each time and at the same time of day. It also is necessary to note weather conditions since water temperature is influenced by weather. Since temperature generally decreases with depth, it is a good idea to take the temperature at the same depth each time.

1,000 gallons of water going through a hydroelectric power plant can produce enough electricity to light a 250 watt bulb for an hour.

In Pennsylvania, water in streams, rivers and lakes seasonally ranges in temperature from near freezing or 32°F (0°C) to about 85°F (30°C). The graph (Figure 15) shows the water temperature of all the sites monitored during both ***Watershed Snapshot 2001 and Watershed Snapshot 2002***.

As you can see from this graph, ***(Figure 15)*** the range in temperatures among waterbodies is from 37°F (3.0°C) to 90°F (32°C), in 2001 and from 41°F (5.0°C) to 84°F (29°C), in 2002. Measurements for both years were taken through the latter half of April. The median (middle value from a ranked list) temperature for all 2001 data combined was 64 F (18.0°C). The median temperature for all 2002 data combined was 54°F (12°C). The average or mean (all numbers added together and divided by the number of entries) temperature of all sites monitored in ***Watershed Snapshot 2001*** was 56°F (13.5°C) and 2002 it was 55ºF (12.8°C).

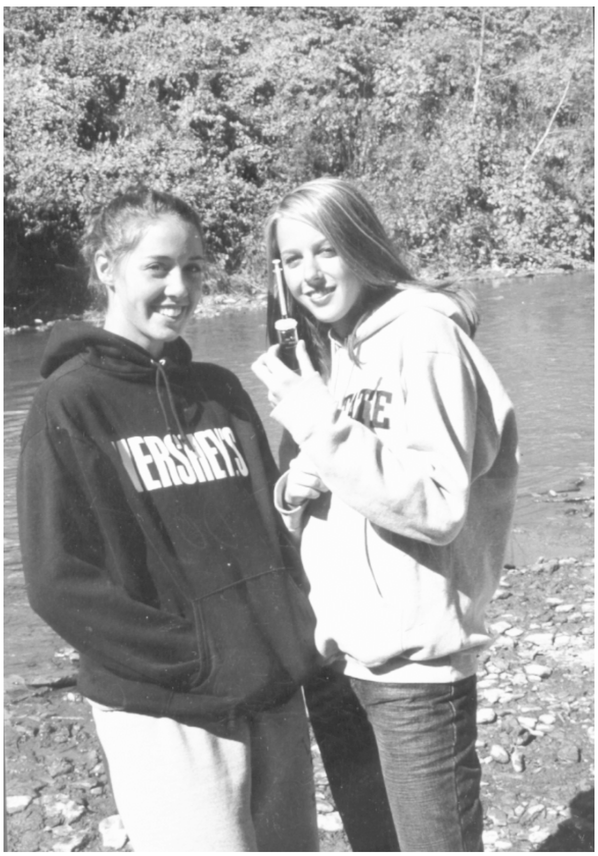


Dissolved Oxygen

Dissolved oxygen (D.O.) can be a good indicator of the water's health because in running water low oxygen levels usually mean that the water has a high biochemical oxygen demand (BOD). This is an indication that the water is polluted in some way, typically with a lot of organic material in the decay process.

Dissolved oxygen can range from 0-18 parts per million (ppm). Five - six parts per million will support diverse forms of aquatic life - more is better.

Glenwood Elementary - Kelli Thompson and Britteny Wentz, sixth graders at Glenwood Elementary, check the dissolved oxygen of Mill Creek in Erie.



Lisa Pascolli and Lindsay Basheda use a field filtration method to test dissolved oxygen.

Lots of oxygen is preferred by most life. Usually the organisms preferring cold water also require high levels of oxygen. Fortunately, in clean moving water, oxygen is usually near the saturation level, which is determined by the temperature. Cold streams should have 7 mg/l D.O. as a minimum, and lakes and ponds should have a minimum of 4 mg/l. Our waterbodies typically range from about 3 - 14 mg/l, but remember that high concentrations require cold conditions or oddities such as super saturation from extreme amounts of photosynthesis taking place in pools containing lots of algae.

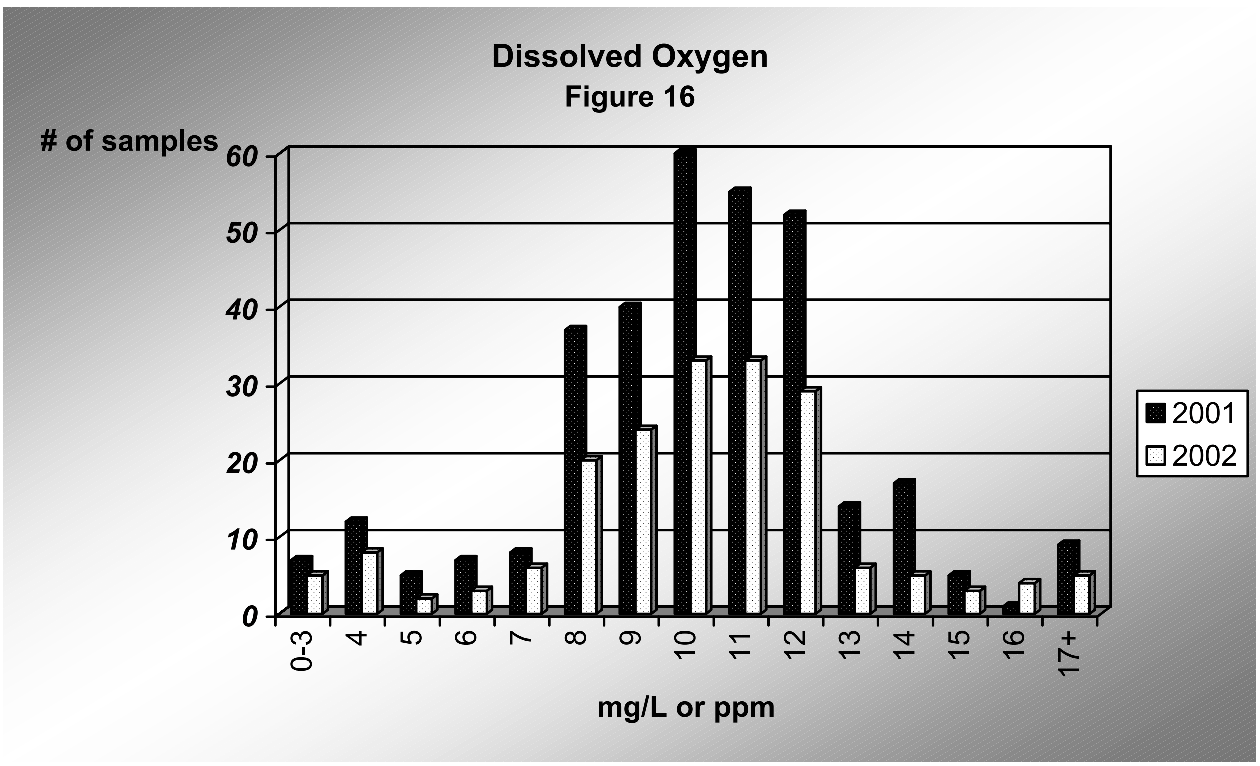
Oxygen enters the water mostly by direct absorption from the atmosphere and secondarily by algae and aquatic plant photosynthesis. Plants and animals use oxygen for respiration. Bacteria consume oxygen during the process of decomposition. Nutrients from fertilizer, sewage and runoff from urban areas can increase the demand for oxygen and cause oxygen depletion. When organic matter such as animal wastes or improperly treated wastewater enters a body of water, algae growth increases and the dissolved oxygen levels decrease as the plant material dies and decays.

Mayfly nymphs, stonefly nymphs, caddisfly larvae and riffle beetle larvae need high concentrations of oxygen (over 6 ppm). As the dissolved oxygen levels decrease, worms, midge and fly larvae replace these sensitive indicator organisms. Also, in low oxygen conditions you will find the critters you would associate more with pond life such as damselfly naiads.

Erin Claycomb measures the dissolved oxygen in Shober's Run.

Dissolved oxygen levels change and vary according to the time of day, the weather and the temperature. When comparisons of dissolved oxygen levels are made they should be from measurements done at the same time of day, during the same season. The amount of sunlight, as well as temperature variation of more than 10ºC can make a lot of difference in the amount of dissolved oxygen in the water. When flowing water isn't nearly saturated with oxygen or if you find individual sites with readings below 4 mg/l, it should raise curiosity as to the cause of the depletion. A decrease in the dissolved oxygen from normal levels can be an indication of organic pollution.

The 2001 mean and median dissolved oxygen values were 11.3 mg/l and 10.1 mg/l respectively. In 2002, the mean and median dissolved oxygen values were 11.5 mg/l and 10.0 mg/l. These amounts exceed the requirement of any aquatic life. Out of more than 600 samples (334 samples in 2001 and 277 samples in 2002) only 12 sites were reported as having dissolved oxygen levels below 4 mg/l and only 49 were less than 7 mg/l - the generally accepted mark of good health for streams. The graph (Figure 16) shows the dissolved oxygen levels of all sites monitored during ***Watershed Snapshot 2001 and Watershed Snapshot 2002***.



As you can see from the graph, there is considerable range among waterbodies at the same time of year but for the two years of testing combined, ninety percent of the sites are in the healthy zone (7 mg/l or more). The extremes, disregarding outliers and data reported without units, included one report of near zero mg/l and one report of 29 mg/l.

pH

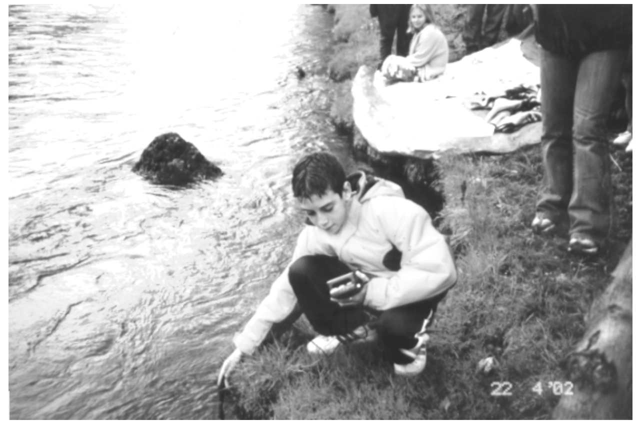
pH seems like a rather simple thing to understand at a "working knowledge" level. It's easy to read pH from a meter or litmus paper and to understand that low numbers (less than 7) mean acid, and high numbers (greater than 7) mean alkaline. Here is a somewhat simplified introduction to the chemistry: pH is the measurement of the hydrogen ions (H+) compared to hydroxide ions (OH-). If the

(H+)'s are winning, the water is acidic. If the (OH-)'s are winning, the water is alkaline. pH is recorded as a number between 0 and 14. Pure water has a pH of 7, which is in the middle of the scale, and therefore neutral. This means that the number of (+) and (-) ions in the water are equal.

The word "acid" comes from the Latin word for vinegar, acetum and, as you know, vinegar is acidic. If the level of hydrogen ions (H+) increases, the water is acidic and the pH number is less than seven. Acidic conditions (or acids themselves) can range from zero to any numerical value below seven. A pH of 6.9 would be an extremely weak acidic condition, even less acidic than urine, which is usually around pH six. A pH of 1.9 would be very acidic, about the same as stomach juices. Lemon juice is pH 3, and that's about as bad as you'll find any water in Pennsylvania. Tomato juice is pH 4.5 and that's about as bad as brook trout and frogs can tolerate.

A pH of 5.6 is still rather acidic but it is considered "natural" for normal rainwater, while rainwater less than this is referred to as "acid rain" (see Table 1).

The word "alkali" is an old Arabic word for ashes, and in fact, wood ashes are still used in some situations, such as amending garden soil, for their alkaline properties. If the (OH-) ions increase, the water is alkaline (or sometimes called "basic") and the pH number will be greater than seven. A basic (alkaline) solution has a range of any numerical value above 7 and up to 14. Your blood is probably pH 7.5. Blood is normally slightly alkaline. Antacid medicines like milk of magnesia are more alkaline – about 10, and that's about as alkaline as our most alkaline limestone streams. That's also about the most that a brown trout or sowbug can stand (see Table 1).



Sixth grader Jason Larioni of Mid Valley Secondary Center tests the pH of the Lackawanna River.

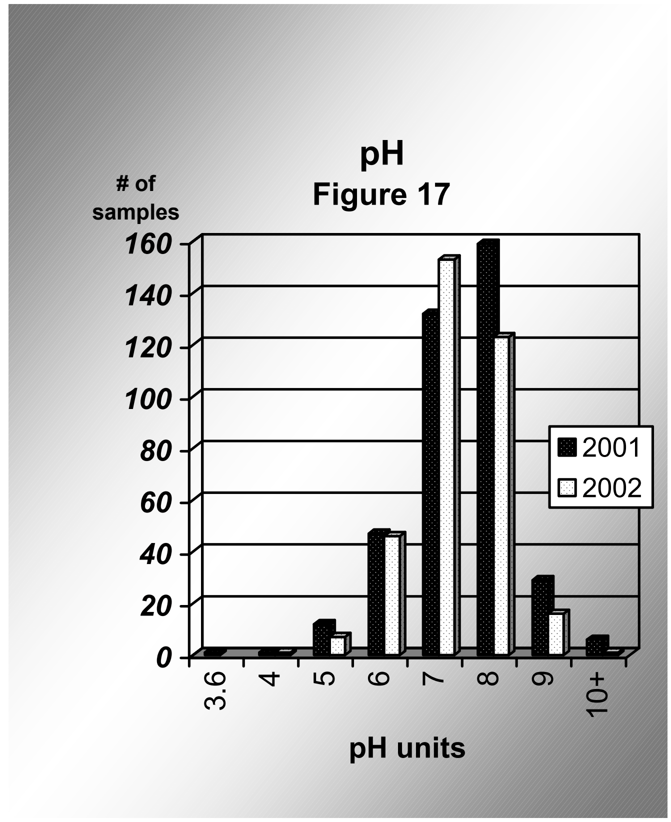
In Pennsylvania, the pH of most natural water systems range from 6 - 9, but wide variations can occur due to increases in the atmosphere of nitrogen oxides and sulfur dioxides from automobile and coal-fired power plant emissions. These oxides are converted to nitric and sulfuric acids in the atmosphere and fall to earth as acid rain or snow. Throughout the state, acid rain has impaired 135 miles of stream, but it influences an extensive portion of our waterways.

Testing for pH is done in nearly all aspects of water quality control and monitoring because pH affects the life within the stream and the chemistry of the stream. It can greatly influence the effects of aluminum, ammonia, carbon dioxide and alkalinity, and in turn, their impact upon water quality and aquatic life. pH values below 5 or above 9 will decrease the number of different kinds of organisms able to live, although some bacterial life forms can survive down to a pH of 1 and some up to a pH of 13. Most organisms are adapted to a relatively specific pH level. When pH increases or decreases, the composition of the community will be appreciably changed.

Table 1

pH	Effect on Aquatic Species
3.0-3.5	This is like lemon juice. It is unlikely that fish can survive for more than a few hours in this range although some plants and invertebrates can be found at pH levels this low. This is the lower limit for round worms.
3.5-4.0	Peat bog; severe acid rain; will kill trout and salmon in a few days.
4.0-4.5	Tomato juice; few or no fish, few frogs, few aquatic insects are present.
4.5-5.0	Typical acid rain; mayfly and many other insect species scarce or are not found. Most fish species will not successfully reproduce.
5.0-5.5	Black coffee; benthic decomposing bacteria begin to die off. Leaf litter and dead plant and animal materials begin to accumulate. Plankton is less plentiful than at higher pH.
5.5-6.5	Normal rain is in this range; freshwater shrimp (scuds) are not present, but okay for most fish, stoneflies and mayflies.
6.5-8.5	Milk, spit, human blood; most aquatic life (fish, bug, and plant life) is happy in this range.
8.5-9.0	Normal for ocean water; unlikely to be harmful to fish. Alkaline loving sowbugs and scuds are usually abundant as are several aquatic weeds, but some species disappear. Chemical changes in the water may occur.
9.0-10.5	Stomach antacids like milk-of-magnesia are in this range; upper limit for most perch and salmon. Scuds and sowbugs may be abundant, few other aquatic insects.
10.5-11.0	Prolonged exposure is lethal to most fish.
11.0-11.5	Lethal to all species of fish.

As shown on the graph below (Figure 17), only seven of the 633 pH readings taken during this study had a pH less than 5 – about the point which causes taxa richness to become compromised. The graph shows the pH levels of all sites monitored during both ***Watershed Snapshot 2001 and Watershed Snapshot 2002***.



Among waterbodies in Pennsylvania, the pH ranges from 3.6 to 12. In 2001, the median was 7.5 and the mode (the most frequently occurring) was 8. The mean pH of all 2001 sites combined was 7.3. In 2002, the median was 7.2 and mode was 7 and the mean was 7.2. Ninety-nine percent of the pH tests conducted during ***Watershed Snapshot 2001 and Watershed Snapshot 2002*** showed acceptable pH.

Conductivity

Conductivity is determined "in-stream" with a conductivity meter. You could find conductivity perhaps as low as 0.5 micromhos (umhos/cm) in distilled water or more than 10,000 micromhos in tidal areas. In the normal and natural conditions of Pennsylvanian waterbodies, conductivity typically ranges from about 20 - 600 micromhos.

Conductivity is a measure of the ability of water to conduct electric current. In electrical terms, it is the opposite of resistance. It does not measure any specific element in the water sample. Rather, it gives a good indication of the amount of dissolved metals, salts and minerals that allows electricity to pass through. These electrical conductors are salts, minerals, acids and metals, which are dissolved in the water.

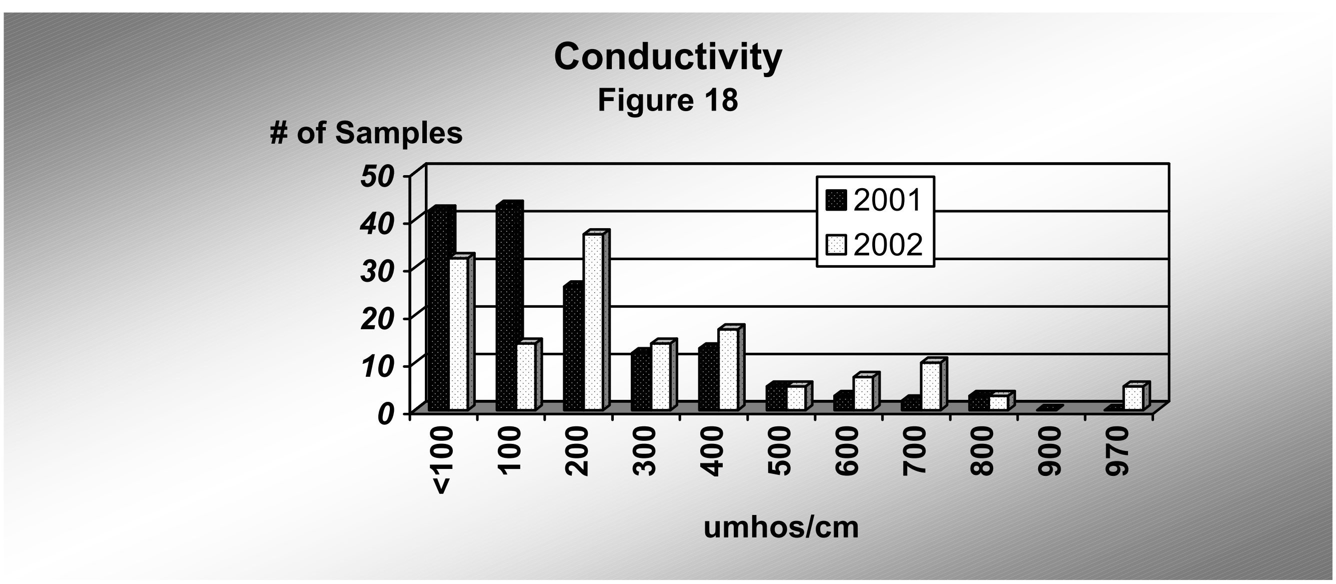
Lots of dissolved solids in drinking water can cause a "mineral or metallic taste." You may have noticed corrosion of your plumbing's metallic surfaces such as toilet flushing mechanisms, faucets, washing machines and dishwashers. This is caused partly by dissolved solids in the water.

While working in streams, you may notice fewer desirable food plants and habitat-forming plant species in those waterways with excessive dissolved solids (although this general rule depends on the kind of dissolved solids and does not apply well to limestone streams).

Water with high conductivity (usually over 600) can be of limited agricultural use, depending on which salts, metals or acids are present. For instance, water containing certain metals can be a problem for livestock watering. Presently, metals impair 2,500 miles of our streams. Water high in salts can degrade the soil when used for irrigation, especially if used over extended periods of time.

Conductivity is primarily related to the geologic composition of the streambed and the formations through which the groundwater seeped prior to entering the stream. Many inorganic pollutants (chlorine, sulfates, metals and fertilizers) will increase conductivity. Generally, the lower values are found in clean, freestone and sandy streams.

In 2001, conductivity results ranged from a low of 13.5 umhos/cm to a high of 1,460 umhos/cm and in 2002, they ranged from a low of 4 umhos/com to a high of 1,524 umhos/cm (Figure 18). In the two years combined, 86 percent of the conductivity reports were within the "common" range for Pennsylvania streams: 20 - 600 micromhos per centimeter. It is important to note that "normal" is specific to the stream and its geologic composition.



Exactly how conductivity directly affects aquatic organisms is not well understood. It seems as though the influence upon living organisms is more from the associated changes in osmotic pressure rather than from the water's ability to carry an electrical current. Most bivalves (clams) like living in relatively hard water, usually high in calcium and/or magnesium – and therefore high conductivity. The minerals are needed to form shells. Pennsylvania streams with high alkalinity (and almost always high pH) often produce a lot of algae, aquatic plants, as well as scuds and sow bugs. Water with very low conductance seems to be favored by very few creatures or plants with the possible exception of mosses.

Alkalinity

Some of Pennsylvania's streams flow through limestone rock and soils and the water is well buffered by calcium and magnesium carbonates and bicarbonates - the primary alkaline components of limestone. Dissolved alkaline minerals allow the water to keep a constant pH. In other words, alkalinity measures the water's ability to neutralize acids and keep the pH constant. This is not very different than chewing Tums for relief from excess stomach acid.

Jenna Cloud tests for alkalinity.

Measuring alkalinity (most frequently measured by titration tests) is one way to determine the sensitivity of an aquatic system to acid input. In order to meet the standards set by DEP, streams should have a minimum alkalinity of 20 mg/l. However, it is not all uncommon to find healthy streams with an alkalinity of only half this amount; in fact, natural geologic conditions are often the reason for such small amounts of calcium in the water. Low alkalinity occurs naturally in areas where the rocks and minerals lack calcium. At the high end of the scale, limestone streams commonly have around 200 mg/l calcium carbonate ($CaCO_3$). If your alkalinity reading is over 75 mg/l, you should be able to verify that the geologic formations in the area contain significant amounts of carbonate materials such as limestone.

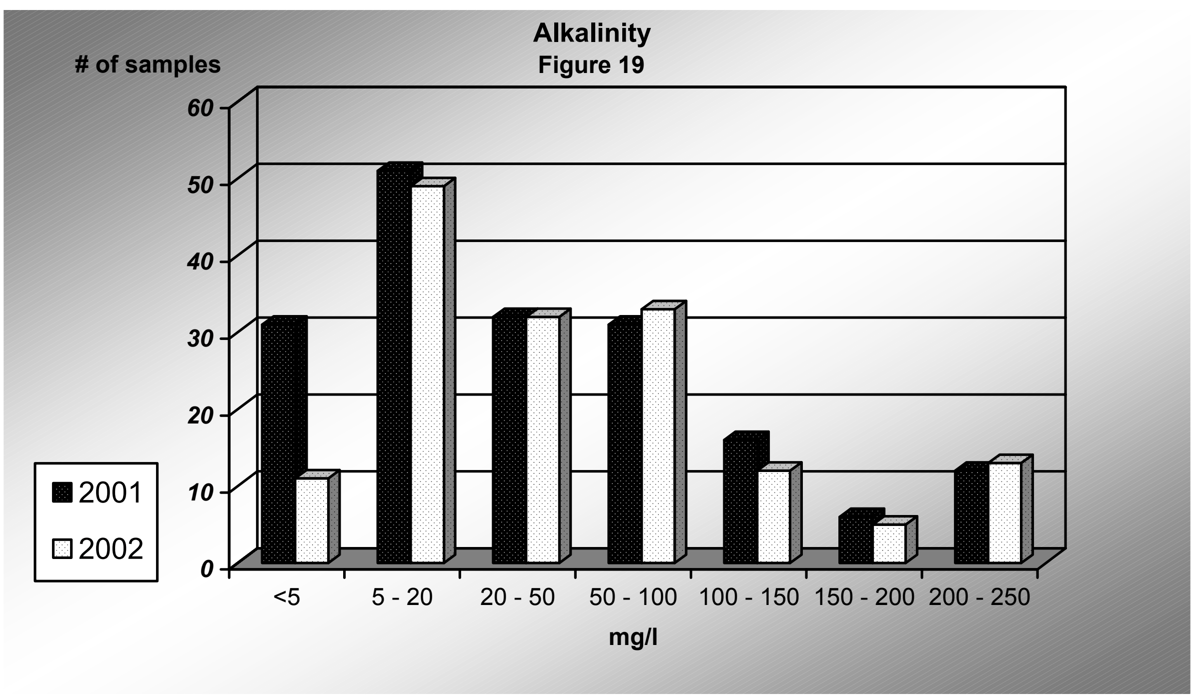
We know that at least 2,800 miles of Pennsylvania's streams are impaired due to mine drainage, acid rain and other sources of pH problems combined. These problems tend to be greatest in streams having little natural defense – less than 20 mg/l – of alkalinity. The bad news is that the miles of listed impaired streams have been increasing in recent years. This may be due to better reporting, but it still emphasizes the seriousness of the problem.

Six million gallons of water are used each day to produce a single day's supply of newsprint consumed in Pennsylvania.

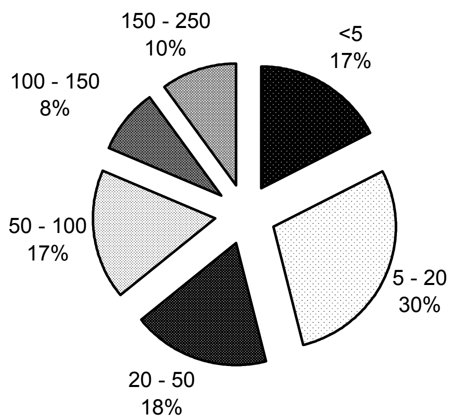
Barb Rupert and Lexa Taylor prepare to test the water quality of Raccoon Creek in Beaver County.

More than 330 alkalinity test results were submitted to ***Watershed Snapshot 2001 and Watershed Snapshot 2002***. They ranged from 0 mg/l to 320 mg/l (Figures 19, 20, 21). In 2001, 47 percent of the monitored sites had alkalinity less than our minimum target of 20 mg/l. In 2002, 38 percent fell short of the target, indicating that they are vulnerable to acidic influences.

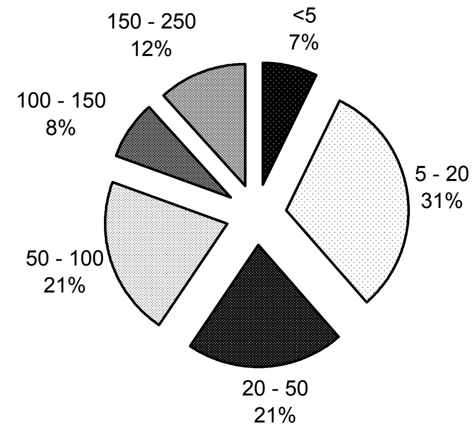
Water is the only substance on earth found naturally in three forms – solid, liquid, and gas.



(Figure 20)
Alkalinity (mg/l) and percentage of waterbodies within that range in 2001



(Figure 21)
Alkalinity (mg/l) and percentage of waterbodies within that range in 2002



Nutrients – Phosphorus, Nitrogen (Nitrate) and a look at Silicon and Potassium

Groundwater is less variable in nutrient content than surface water. Groundwater's nearly constant temperature and chemical composition provides important buffering effects to surface water systems. It is this consistency that endows certain springs with their economic importance. Food and beverage makers and bottled water industries are dependent upon such outstanding springs in order to provide the public with superior quality products. Precious water sources can be degraded when nitrate seeps down into the groundwater where it may exist for many years. Eventually the polluted groundwater will become part of the base flow of a stream. Even if no more excess nutrients were applied, it might take a whole generation for nutrients to be cleared from the groundwater.

Samantha Fisher and Tim Faust test the water chemistry to determine stream health.

Typically, low levels of nutrients are present in smaller streams and higher levels are found in rivers. This downstream increase is due to the influx, runoff and accumulation of nutrients from upstream sources: livestock, fertilizer and sewage discharges. However, as with all natural systems, this is not always the case.

Life in flowing water tends to be distributed more according to physical considerations (such as habitat and temperature) than by chemical properties. However, in lakes, algae and diatom cycles are closely correlated with certain nutrients. In surface water, nutrients such as nitrogen and silicon are present mostly in their soluble (dissolved) form: nitrate and silicate. In fact, it is not uncommon to have more than 90 percent of nitrogen in the form of nitrate and 75 percent of silicon in the form of silicate. Phosphates are associated with the particulate (solid) phase as well as dissolved phases. Usually, much less than half of the phosphate in a lake system is dissolved and directly available to plants.

Diatoms require a lot of silicon to make their glass-like shell. Otherwise, the major nutrients required by plants are phosphorus (P), nitrogen (N) and potassium (K). In freshwater, phosphorus is often the nutrient in shortest supply and when it is depleted, the plants must stop growing. As a rule of thumb, aquatic plants utilize about ten parts of nitrogen for each part of phosphorus.

Rebecca Gawronski determines how much plankton is present in the streams she monitors by using a plankton net.

The leading source of nutrients in our streams is from nonpoint source runoff carrying fertilizer. The problem is especially pronounced in areas of high concentrations of livestock and where excess fertilizer is used. Presently, more than 1,700 miles of our streams are degraded due to excess nutrients.

Nitrogen

Nutrient concentrations vary less throughout the year in streams than in lakes. The large volume of water retained in lakes dilutes the effect of inflows. Many factors in the watershed affect the amount of nutrients entering the water. Primary nitrate sources include sinks of nitrogen in the watershed (often as a result of fertilizer) and ammonia in rainfall, but freezing and thawing of soil, forest fires, erosion, recycling by vegetation and retention by the soil's humus layer all affect how much nitrogen will get to the stream.

In order to meet the standards set by DEP, water used for drinking should not exceed 10 mg/l nitrite + nitrate. Many aquatic biologists would also agree that the health of the aquatic system is better when nitrite + nitrate amounts do not exceed this amount. "Nitrate (N03)" by itself is considered elevated if above 1 mg/l. The unpolluted, (naturally occurring) maximum concentration is probably about 3.0 mg liter for N03. In cases where amounts are greater than this, you would be wise to suspect and look for an unnatural source of nutrients. From the biological perspective, no "total nitrogen" limit is established. In a general sense, less is better.

Tiffany Kardos, Catherine Campbell and Maliorie Goguen, sixth graders at St. Joseph Sharon test the waters of Seven Mile Creek as a part of their environmental education week.

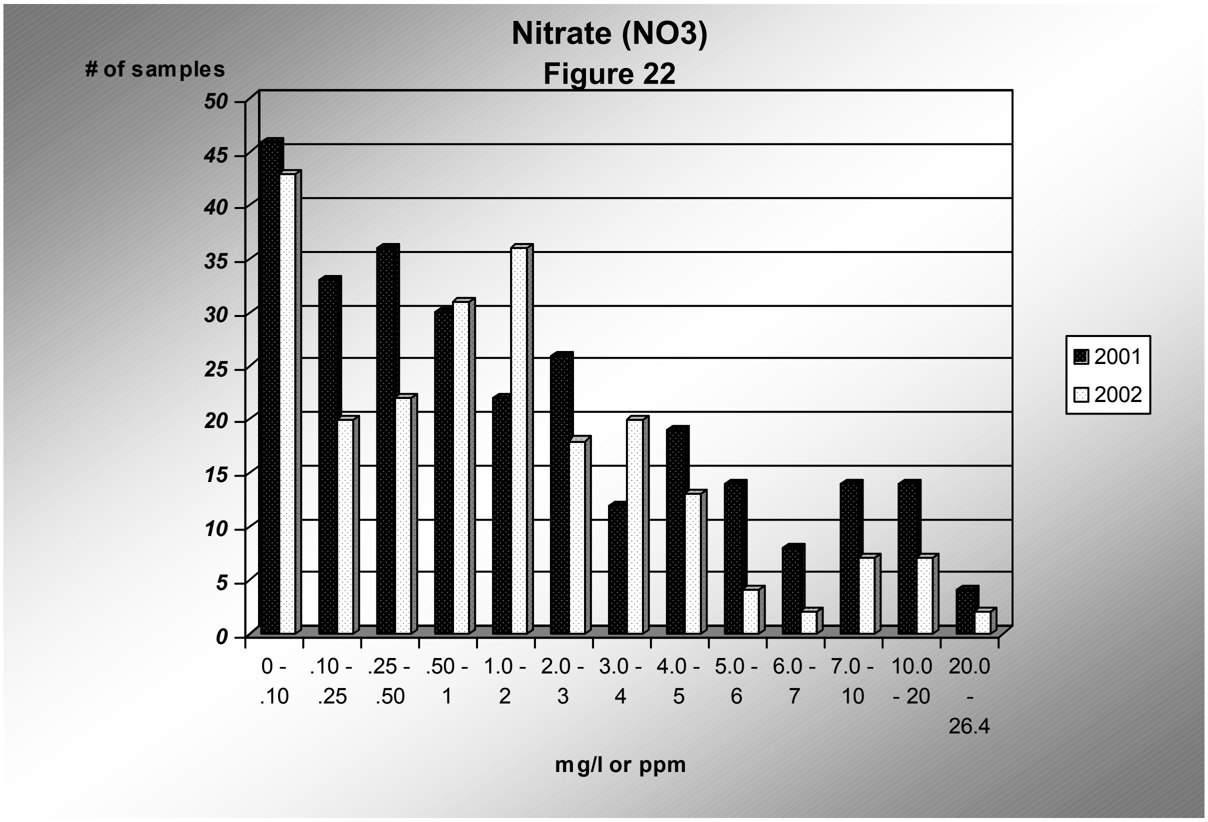
If the concentration of nitrate is greater than 20 mg/l, it may pose a health hazard to baby mammals by preventing hemoglobin from transporting oxygen. In humans, this is known as blue-baby syndrome. DEP has stated that nitrate levels should not exceed 10 mg/l in potable water supplies in order to avoid this potential health risk.

Nitrogen, like phosphorus, is a plant nutrient. The problems it causes are often similar to those we will discuss next in the section on phosphorus, but foremost, it can lead to excessive algae and plant growth that in turn degrades water quality, recreational opportunities, and can accelerate the aging of lakes. While nitrogen commonly limits plant growth in marine and terrestrial systems, it seldom does so in freshwater. However, since most of the state's water eventually flows to the marine environment of either the Chesapeake Bay or Delaware Bay, we need to be concerned about nitrogen. We must reduce the amount of nitrogen getting into our water supplies.

In ***Watershed Snapshot 2001 & 2002***, nitrate levels of zero (or below detection levels for the particular instrumentation in use) were commonly reported. Several tests were as low as .02 mg/l and ranged to several extremely high values (over 40 mg/l) being reported.

Figure 22 shows that 53 percent, or 154 of the 288 reports, indicated that nitrate was less than 1 mg/l and 95 percent of the samples showed nitrates of less than 10 mg/l. We could reduce the amount of nitrogen in our waters by working harder to correct acid rain, avoid excess fertilizer usage, prevent nutrient runoff and by routinely removing nitrogen as part of the wastewater treatment process.

An ordinary five-minute shower takes 22 gallons of water; a reduced-flow showerhead cuts that to about 15 gallons; and low-flow showerheads further reduce that to as little as 10 gallons.



You can help prevent pollution by making sure that the sewage system in your yard or community is properly functioning. Minimize the use of fertilizers on your lawn, make sure septic systems are working properly, and prevent runoff from yards and fields. Strategies that limit nitrogen loss to the water should be developed and employed throughout entire watersheds. Everyone is affected when water resources are degraded and everyone can contribute to correcting and preventing environmental problems.

Phosphate (PO_4)

Phosphorus, like nitrogen, is modified by the activities taking place in the watershed and by the geologic makeup of the watershed. But, due to the adsorption of phosphate onto soils, erosion is by far the greatest source of phosphate to waterbodies.

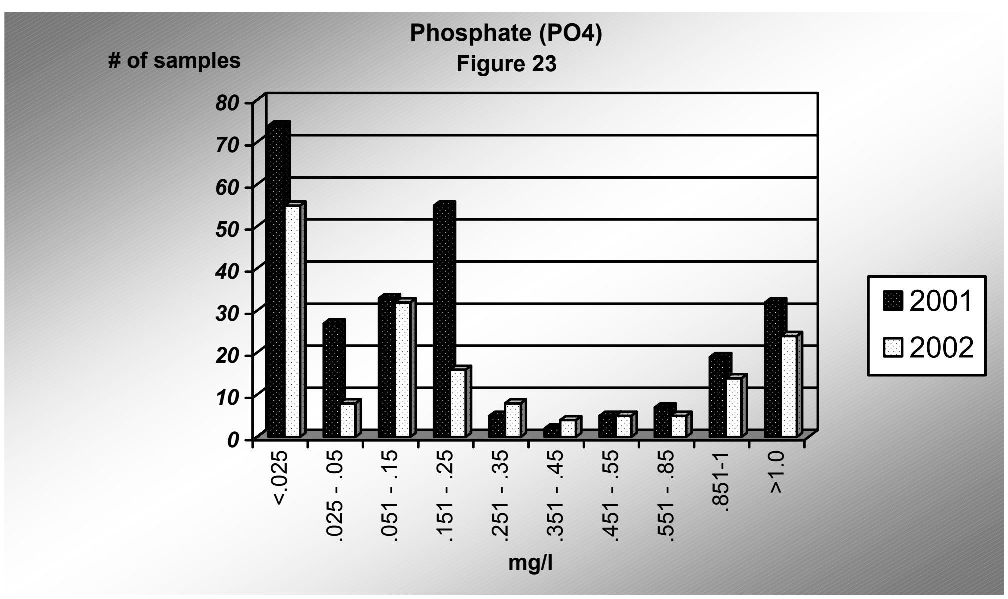
In order to test for total phosphate, the water sample must undergo an acid heat digestion process. This process converts all the phosphate to dissolved orthophosphate. The prepared solution is analyzed using a colorimetric test. A standard is set for some Pennsylvania lakes at 0.1 mg/l. The U.S. Environmental Protection Agency (EPA) recommends that sewage effluent should contain less than 1 mg/l phosphorus. Total phosphorus levels greater than 1 mg/l are seldom due to natural causes. Soluble phosphate **(PO_4)** concentration in unpolluted rivers is usually less than 0.01 mg/l, and often only 0.001 mg/l. This is below the detection limit of most field test kits.

Excess phosphorus leads to extensive algal and aquatic weed growth. Enrichment of lake-water with nutrients, usually phosphorus, affects several water quality issues, one being accelerated eutrophication – the aging and filling-in process of all lakes. In waters where accelerated eutrophication is taking place, the number of pollution sensitive species declines. Species that can tolerate lower dissolved oxygen levels replace the many different species that would exist in oligotrophic (nutrient poor) water. “Nutrient poor” sounds like a bad thing, but it is generally considered a good thing when it come to the health of a lake or stream. In areas with extra phosphates, less desirable blue green algae (bacterioplankton) will sometimes flourish and compete with the green algae and other phytoplankton. Some blue-green algae cause illness in livestock and humans. All this can lead to loss of recreational opportunities, fisheries and drinking water resources.

John Domsic and Steve Wasiesky, of Explorer Post 808, test the water of Elk Creek at the Ashbury Woods Nature Center for nutrients.

Two primary concerns are correcting runoff problems and using the proper amounts of fertilizer. Test your soil before adding fertilizer. Most modern farmers, gardeners and ecologists suspect that a phosphorus threshold value, for crops or for environmental concerns, between 35 and 100 ppm (parts-per-million) is an acceptable range. Crops will benefit little, if at all, from higher concentrations of phosphorus in the soil and the potential to pollute a stream increases. You will save money by not applying more fertilizer than is needed and you will prevent the potential threat to the environment. Management systems that balance phosphorus applications (input) with the amount removed by harvests (output) are good practices to keep your nutrients out of the water. Remember, a little bit of phosphorus goes a long way!

Phosphate ranged from zero (or below detection levels for the particular instrumentation in use) in many cases, to a high report of 100 mg/l (Figure 23). Twenty-eight percent of the readings were less than 0.025 mg/l. In the last several years, 50 percent of the tests indicated that phosphate was 0.1 mg/l or less – the desired maximum, but this year only 45 percent made that goal. Thirteen percent are still above the 1 mg/l goal set for sewage effluent! For better stream health, we would like to see the amount of phosphate reduced at half of the sample sites. Due to natural conditions, reaching the goal of 0.1 mg/l or less at all sites is probably not realistic, but making significant improvements is always realistic.



Mine Drainage, Iron and Sulfate

Recently, citizens have become very interested in monitoring mine drainage sites, particularly for iron and sulfate. A tremendous amount of information about mine drainage is available at www.dep.state.pa.us/info.htm. Here we present the basics of the topic.

One of the biggest sources of water pollution facing Pennsylvania is polluted water draining from abandoned coal mining operations. One third of the streams that don't meet water quality standards - more than 2,700 miles – do not meet standards because of mine drainage. Within 45 of our 67 counties, Pennsylvania has more than 250,000 acres of abandoned mine lands, refuse banks, old mine shafts and mining relics. That is more than any other state in the nation. Though not a record to be proud of, efforts are underway to reclaim much of this land.

Scrubgrass mitigated wetlands

Acid mine drainage (AMD) is a devasting form of coal mine drainage formed by a series of reactions occurring when water meets pyrite (iron disulfide minerals) in coal, refuse or the overburden of a mine operation. Through chemical reactions, the water usually becomes highly acidic and loaded full of dissolved metals. The metals stay dissolved under certain pH conditions but precipitate out (fall out as solid material) under others. Typically it is in low pH water where this falling out of solid particles occurs. Most of us are familiar with the bright orange iron precipitate in these streams. It's sometimes called "yellowboy", which is oxidized iron, or basically, rust. You may have seen mine drainage streams with slippery whitish bottoms. In this case the precipitate is likely aluminum. Yellowboy and aluminum precipitates coat the substrate and can smother the eggs and larvae of aquatic life. The coating reduces or eliminates much of the habitat needed by aquatic macroinvertebrates and fish.

Low pH also is detrimental to life in the stream. Mayflies are one of the most sensitive groups to this problem and they are among the first to disappear. Frequently, mine drainage is below pH 4.5, eliminating most aquatic life from the stream. Usually then the water is unfit for drinking, swimming, irrigation, livestock and many other uses.

Iron

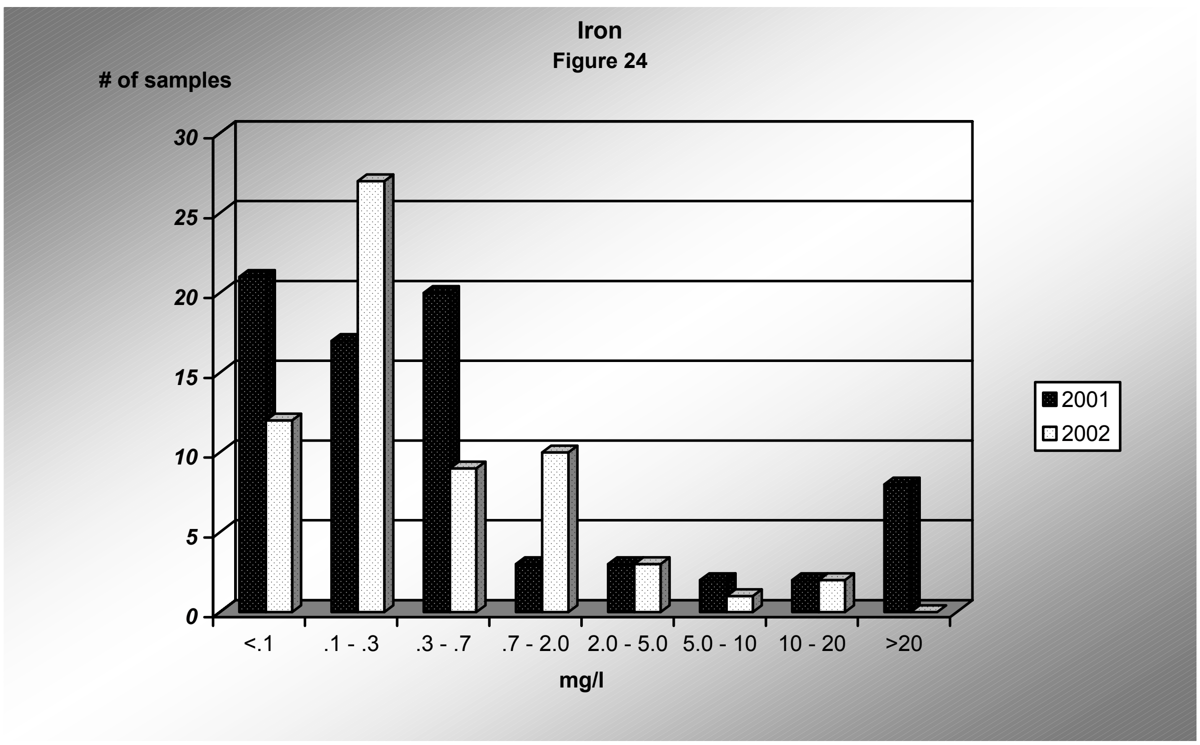
The scientific abbreviation for iron is Fe. This comes from the Latin word for iron - ferrum – and compounds that contain iron are commonly called ferrous or ferric. Iron is the fourth most abundant mineral in the earth's crust. Iron ore is very common in rocks and soil. When water flows through soils rich with iron, some of the iron will dissolve into the water and be carried away. Sometimes water that is rich in iron will cause a yellow, orange, red or black stain in a sink or wherever the water flows. A little bit of iron in the water is not harmful. In fact, our bodies use iron to help our blood carry oxygen.

Pennsylvania DEP and the U.S. Environmental Protection Agency list the maximum dissolved iron level as 0.3 mg/L. Fifty percent of streams sampled in 2001 were below this standard. In 2002, 61percent of samples were found to have iron levels below 0.3 mg/l. Iron is frequently found as a naturally occurring element in well water and surface water. Iron in a water supply usually does not cause any adverse health effects to healthy individuals. However, clothes washed in water that contains elevated levels of iron will often come out dingy looking, rusty colored, or have rust colored spots on them. The inside of dishwashers, toilet bowls and sinks will become rust-colored with stains that are difficult to remove.

Taking a tall, clear glass, filling it with water, then placing it on a white piece of paper can be a quick test for iron. After about 30 minutes, look down through the water for a rusty color. If any rusty color is apparent, most likely the sample will fail the iron test.

The amounts of iron found in water samples tested by the Snapshot Volunteers for ***Watershed Snapshot 2001 and Watershed Snapshot 2002*** are shown below (Figure 24).

2,072 gallons of water are used to make four new car tires.

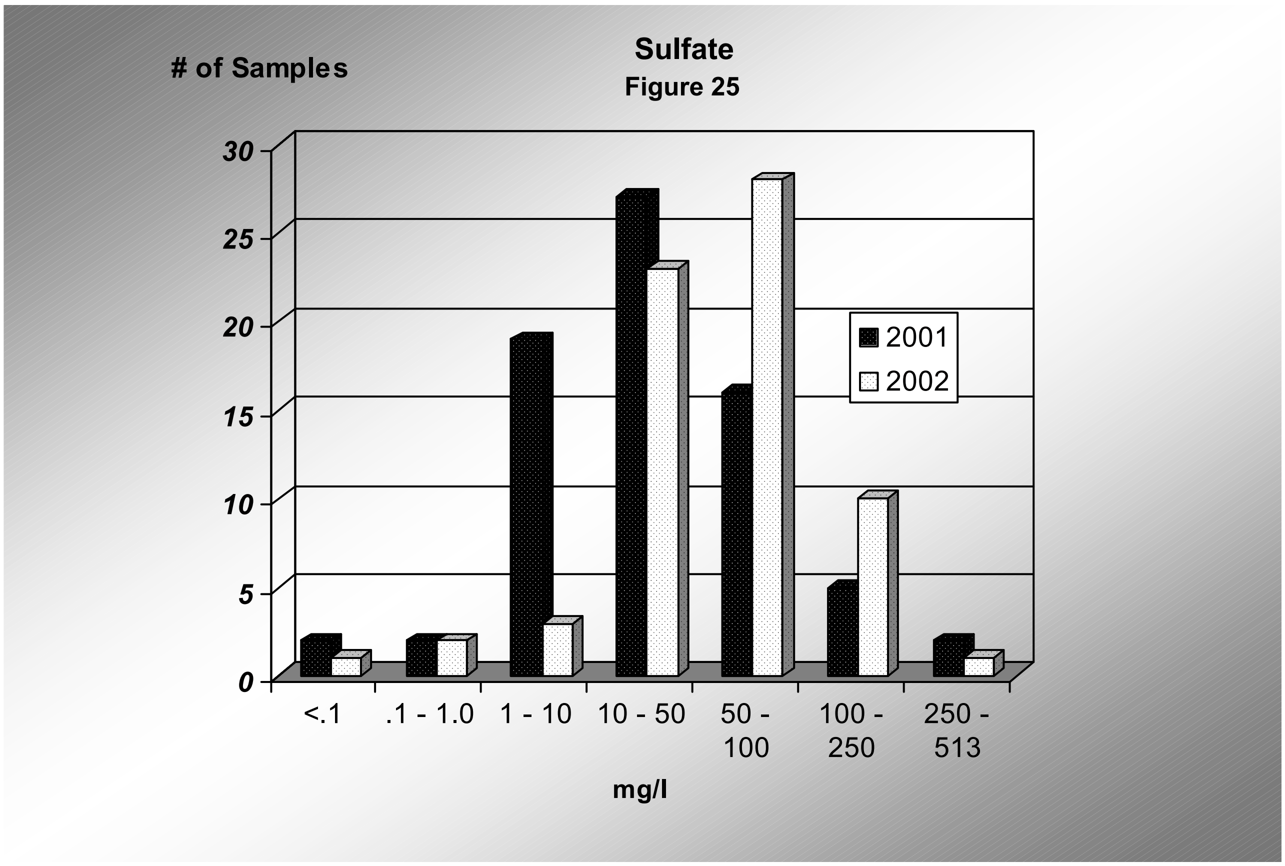


Sulfate

Sulfate is derived from the weathering process of various common sulfur-containing sedimentary rocks and is a very common anion in water. Sulfate is a form of sulfur and is required by plants and animals in trace amounts. Sulfate enters aquatic ecosystems primarily in three ways: acid precipitation, acid mine drainage and detritus breaking down and releasing hydrogen sulfide (H_2S). Upon entering an aquatic ecosystem, the sulfuric acid may have a detrimental impact on the ecosystem.

Sulfate concentrations should normally range from 5 to 50 mg/l in natural waters. Sulfate should not exceed 250 mg/l in water used for drinking, mostly because it smells and tastes bad, and in sensitive individuals it can have laxative effects. Sulfuric acid is a major component of acid precipitation and mine drainage. Serious biological impacts from sulfuric acid are possible, especially in poorly buffered streams. High levels of sulfate do indicate a system that is 'sick.' However, this is a bit complicated because representatives of all the major orders of aquatic insects have been found where sulfates were greater than 400 mg/l. Sulfates do not become toxic to fish until they measure well over 1000 mg/l. The water's buffering capacity may be the key to whether or not the biological community is seriously impacted when sulfate levels are elevated.

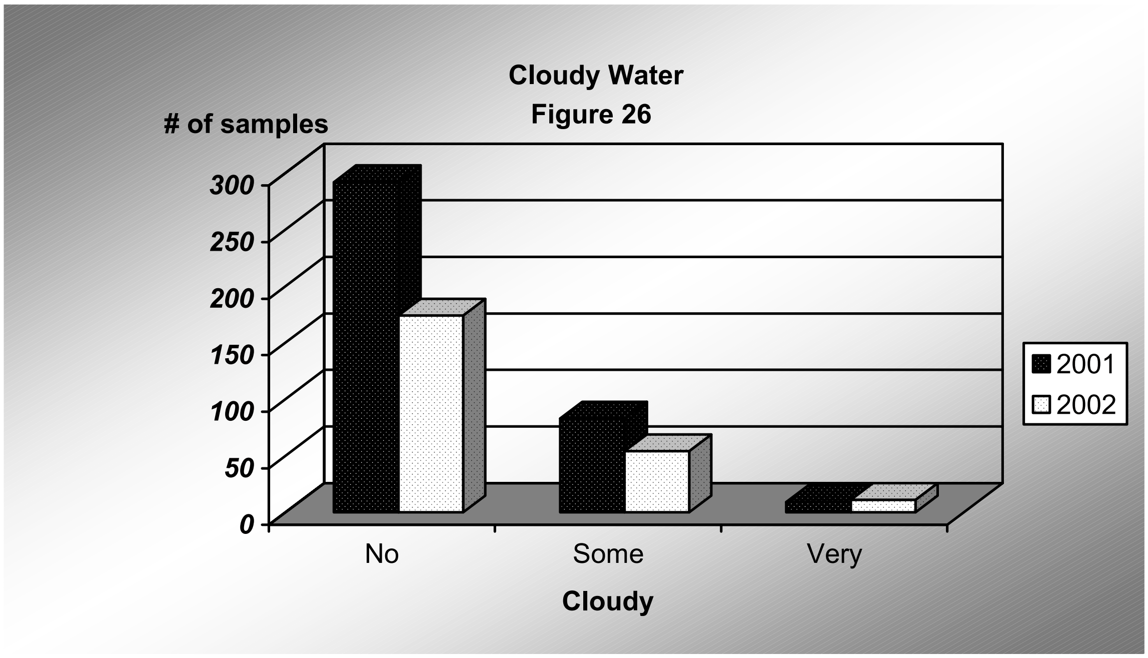
One hundred fifty-four test results for sulfate were submitted for this report. Seventy-six to ***Watershed Snapshot 2001*** and 78 to ***Watershed Snapshot 2002***. They ranged from 0 mg/l (or not detectable) to 625 mg/l (Figure 25).



Frequently sulfate is simply reported as "less than 50 mg/l" which is the detection limit for some tests and a "rule of thumb" number accepted by many biologists as a mark of good quality. About two out of five results were elevated above the "normal" mark of 50 mg/l, but only three results were above the 250 mg/l mark set as an upper limit goal for drinking water and only one site was in the range that may be detrimental to aquatic life. Note that these results do not show any sort of statewide average because the interest in testing for sulfate is greatest in areas having acid mine drainage.

Runoff and Sediment

Half of the problems we find in the aquatic environment are runoff related. We could greatly lessen this problem though better land use practices. Agricultural and urban runoff, along with silt and sedimentation from all other causes, are presently reducing the quality of 7,000 miles of Pennsylvania's rivers and streams. A quick and easy way to determine if a pollutant may be present is by sniffing the sediment for odors. Ninety-six percent, or 457 of our volunteer "sniffers" said the sediment smelled normal to them at their test sight. Four percent could smell sewage, and less than one percent smelled chemicals or metal. Runoff problems frequently are made evident by the cloudiness of the water. Cloudiness, or turbidity, is a measurement of visibility through the water and it is measured with a turbidity meter, Secchi disk or simply by observing the water and using descriptive terms to categorize it. Twenty-four respondents used a Secchi disk to measure turbidity, 82 used other instruments, and 719 respondents used descriptive terms to report turbidity with results as shown in the graph (Figure 26).



In some cases, such as the lower Susquehanna River, topsoil carried away from some of the most fertile agricultural land in the world has nearly filled in the reservoirs behind dams. In many other rivers and streams, investigators notice mud and silt surrounds the rocks in the substrate. By affecting either the water or the aquatic habitat quality, runoff from agricultural lands, suburban development and urban streets is degrading the health of rivers, lakes and estuaries.

Cloudy water and sedimentation are caused by the wind and water carrying soil particles from the land to the streams and rivers. The soil clouds the water and severely limits the sunlight reaching aquatic plants. As sediment accumulates, the rock and cobble substrate is covered with mud, and habitat for fish and lower forms of river life is lost. Reproduction rates of desirable species are reduced when spawning areas and eggs themselves are covered with soil particles. Furthermore, those sediment particles may have metals, phosphorus and other pollutants attached to them. Simply applying better management practices will reduce soil erosion.

Runoff from urban areas contributes a variety of pollutants to our waters including: oils, antifreeze, road-salt and nutrients washing from pavement into the storm sewers and ultimately into the river. Working at this problem is primarily a matter of making better choices and utilizing environmentally friendly practices to reduce runoff volumes and velocity.

Forestry practices also play a small role in runoff pollution. To minimize the impact of forestry practices, it is imperative that streamside vegetation be protected and improved. Logging in sensitive landscapes should be avoided altogether. Properly constructed logging roads can help reduce rutting and loss of soil. Planning forestry activities for dryer times of the year also helps avoid runoff, as does carefully replanting the area after harvesting of timber.

The table to the right (Table 2) shows some of the leading causes of degradation to our streams and some of the symptoms that might be observed.

Stephanie Serrano and Samantha Fisher measure the velocity of the stream by measuring how long it takes a tennis ball to travel 30 meters.

> To produce a gallon of milk, a dairy cow drinks just four gallons of water. In contrast, standard irrigation practices use about eight gallons of water to produce one tomato!

Table 2

Impairment	Effects
Agriculture impairs 2,700 miles of Pa. streams	Algal blooms are often caused by overuse of fertilizers and manure runoff from pastures or feedlots. Bacteria counts are often elevated. Slumping and livestock worn stream banks increase sediment.
Mine Drainage impairs 2,700 miles of Pa. streams	Orange (iron) or white (aluminum) sediments on substrate, low pH, high sulfates, crystal clear water or a decrease in sensitive macroinvertebrate numbers and taxa may indicate mine drainage.
Urban/road runoff impairs 1,300 miles of Pa. streams	Surface sheen, low pH levels, high conductivity or few sensitive macroinvertebrate organisms may be the result of metals, salts, chemicals and oils.
Construction and land development impair 250 miles of Pa. streams	Cloudy or muddy water may be a sign of sedimentation, which may occur around construction sites if proper barrier structures are not in place.
Sewage Treatment Plants and Septic Systems impair 200 miles of Pa. streams	Excessive algal or aquatic plant growth and increase in tolerant organisms are indications of nutrients; odor or a decrease in sensitive macroinvertebrate numbers may indicate high levels of chlorine in the water. Bacteria counts are often elevated.
Industrial discharges impair 180 miles of Pa. streams	Stream discoloration, odors, low pH levels, warmer water, excess algae, few sensitive macroinvertebrate organisms, few fish may result from the discharges of industry.
Forestry impairs three miles of Pa. streams	Cloudy or muddy water may be a sign of sedimentation from any earth disturbance including logging, road building or clear cutting trees and other vegetation.

Building a Better Future

What can each of us do to assure that we will pass a clean environment on to the future generations from whom we are now borrowing it? Individuals can reduce using chlorine and phosphate detergents, keep all engines in good tune and leak free, and use extra care to avoid spills when refueling. Where possible, replace small engine equipment with electrical versions or use hand powered tools and implements. Wooden decks, grass, gravel, brick or mulch are possible alternatives to covering the surface with impervious concrete and asphalt.

Better controls and small changes in the way we do things can prevent a lot of sediment and other pollutants from reaching the rivers and streams of our watersheds. Do we want to do things in a better way? If so, help to make local decisions. Join your local watershed organization and be an active member.

How good is our stewardship and how good do we want it to be? Recently, citizens have become more interested and more involved in working with their communities and government to control runoff (nonpoint source) pollution. More state grants have become available and citizens are making use of funding to take a more active role in monitoring the environment, restoring streambank vegetation, enhancing wetlands, organizing educational activities and promoting conservation of water resources. The hope of a brighter future, and the goal of cleaner water and higher quality of life depend on you and your stewardship of your watershed. For many years, ecologists warned us that the environment was getting sicker. Now we have many success stories to tell, especially about improvements to surface water quality. But the biggest success story is in you – the number of volunteers who have an interest and desire to monitor their environment. Never before has the discipline of ecology been so blessed with such a force of fresh, fun, upbeat volunteers! Your interest and participation in activities like ***Watershed Snapshot*** and your dedication to the environment indicates that achieving a brighter future and high quality of life is possible.

Thank you for participating.

Mindy Ruggiero, Stephanie Baker, and Tara Anderson test Walnut Creek.

Appendix A
Watershed Snapshot 2001 Participants

A C Palmer
A. Lezark, N. Lezark, R. Patsiga
Alfred & Betty Maser
Alice M. Lang, Nathan Walker
ALLARM
Allen Hoppes
Andy McClay
Andy Saul, Marge Firn
Angela Check and Beth Langham
Anne W. Gale
AP Envir Science Class
Arthur Popp & Ed Michaelski
Arthur Youse
Bellwood-Antis H.S. Energy & Environment Class
Beverly DeBarros, Bob Hawk
Bill & Lorie Reichert, Desiree Vernicky
Bob & Dolores Kohnken
Bob Bisigmani
Bob Bruce, Cal Alston
Bob Ferry
Bob Grane
Brian Pilarcik, Braden Hoffman, Lisa Flinn
Bruce Sandstrom
Bryon A. Killian
Cal Alston, Bob Bruce
Carl Rohr
Carl Trout, Harry Charles, Carol Cummins
Carla Huffman & 4th and 6th grade students
Carolyn Koch
Carrie, Stephanie, Camila
Carroll R. Williams
Cathy Lighty
Central PA Institute
Chad Fox, David Mearham
Charles J. Kopcho
Charles Takita
Charlotte Sprenkle
Cheryl A. Petrakovich
Chester J. Sewalk and Calvin Gindlesperger
Claudette Bedard, Dave, Jes Sunder, John Lundquist, Bill Ray, Mike Swatzler
Connie F. White
Connie, Mimi, Bobbi, Jim, Phil, Linda
Coudersport Ag Science Class
Craig Weinstein
Cussewago Boy Scouts Den 4 Pack 222
Dan Townsend
Darryl Sitlinger
Dave & Sheila Does
David Churchill
David Mearham, Chad Fox
Deb Serenno, Geoff Ragolsky
Debby Meyer, Clyde Ayers
Deputate Muskrats
DeSales University
Desiree Vernicky, Jeff Hertzog
Devin Lehr, Nate David, Kyle Ladd, Nick
Diane & Darwin Hollinger
Diane Harris
Diane Motel
Don Chamberlain, Dave Johnson, Caleb Johnson, Kress Simpson, Steve Smith, Jim Weaver, Jason Weigle
Don Eckhart and Outdoor Club
Donna Remick
Doreen Jacoby, Steve Grim, Ron Detterline
Dr. Fatimata Pale
Dr. Mac F Given's Class
Earl Derstine
Earle Robbins, Craig Williams, Jim Weaver, Jason Weigle, Changra Weigle
Ed Shoener
Emil House
Environmental Geology Class, Suzanne E. Brown
Eric Garner
Eugene Marks, Jim Pitcherella
Eunice Alexander
Explorer Post 808
Faith Zerbe, Diane Harris
Fred Gusz
Fred Mavrer
Fred Neely
Frederick Lewis, Susan McLaughlin, Robert Meyer
George Bernard
George Walthour
Gina Ellis & Christopher Coat
Glenwood Elementary

Greg Hertz
Greg Leinweber, Deb Sevenno, Geoff Rogalsky
Greg Marshall, Boyscouts
H.S. Long, Jacqueline Long
Hailey Calhoun
Hams Environmental Club (Frederic R. Wilson)
Hazleton High School - Marie Ernst
Heather, Mandy, Breanne
Herbert A. Volker
Herman Hittner
Hilary, Caitlin, Thol
Hot Mamas
Ivan Pettit
Jack Neary, Warren Schmidt
Jackie, Kim, Jean, Dorothy, Eric
Jacobs Creek Watershed Association
James A. Klass
Jane H. Evans
Jason and Chandra Weigle
Jason E. Smith
Jason Weigle, Jim Weaver, Lynn Wigglesworth
Jason, Hillary, Mike, Steve
Jeff & Desiree Vernicky
Jeff Sherry
Jeff Story
Jill Shankel, Shawn Hedglin
Jim Mendok
Jim Weaver
John Bitman
John C. Kearney
John Ferraro, Carl Trout
John Gallo & Gabriela Musat
John Jefferson - DEP
John Layman
John Linkes
John R Schirk
John Tremba
John William Clune
Joseph Zemes (Pocono Joe's Guide Service)
Judi Hartzler, Erin Pekurny
Karen Wilson
Karyn McGee & Steve Bent
Katie Jay, Gene Siegrist, Jo Litz, Flynn Barnet, Steph Harmon, Pam Spayd
Katie Ombalski, Kirk Vodopals
Kelly, Spencer, Jennifer
Ken Cook, John Fichthorn
Ken Frye, Amber Messer, Josh Farley, Mike Busher
Kevin Cary
Kevin Kelly, Cathy Putt, Carol Keller, Dan Devlin, Jon Miller, Ralph Scanlan
Kim Forsythe, etc.
Kress Simpson - KTS Farms
Kristin Carter
Larry Barrett
Lauren, Dan, Ryan, Justin
Lauren, Dan, Steven
Learning Enrichment Activities Program
Lee R. Harper
Len Gorney
Len Schall
Leonard Nawrocki
Leroy E. Skinner
Les Martin, Gretchin Martin
Linda Brook, Charlene Briggs
Lisa Armstrong, Fred Kaulback
Lisa Bennett & Samantha White
Little Neshannock Watershed Project
Lois& Adam Oleksa
Lower Dauphin Ecology Club
Luther Lengel, S. R. Jeng
Lynn Roccograndi Middle School
Maggie & Andrew Parsons
Margaret Rempe & Gary Kwiecinski
Marge Leach, Bob Leach, Bea States, Ray Gillen
Mark Miller
Mark Sincavage, Dominic Vangarelli
Mary Beth Hegeman
Matt Kichline, Forrest Jacobs, Jeff Ni, Cory Fenstemaker
Maurice W. Hutelmyer
Max, JO, Tim, Jarred, Shawn
Michael Rhodes
Michael S Bernarsky
Mick & Fay Messner
Mike Boyer
Mike Matso
Mike Swatzler, Jes Sunder, Claudette Berdand, Dave, John Lunquist, Bill Ray
Moniteau High School Ecology Classes
Mrs. Snavely's Freshwater Bio Class
Mrs. Burkhardt's 4th Grade Class
Ms. Cantone's 4th Grade Class
Myra Amodie
Nick Brink, Toni Brink, Jacqai Wagner, Tom Doman, Osud Long

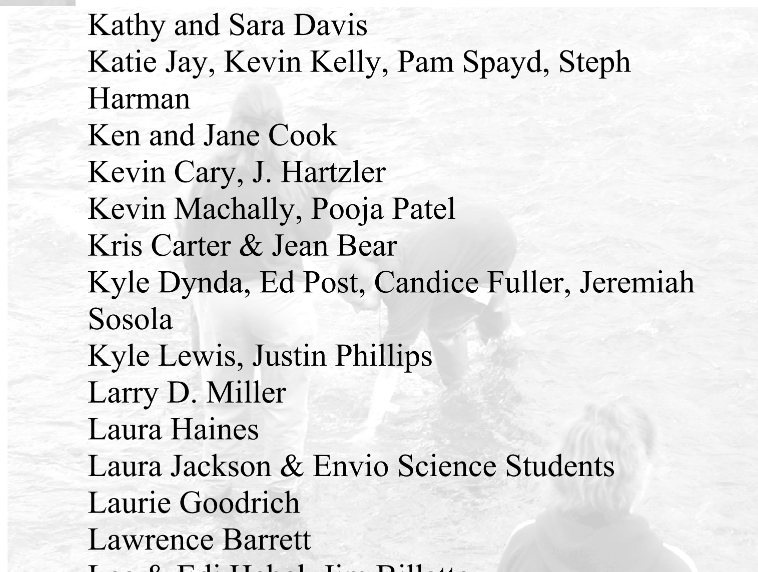
Nicole Foremsky, Mike Barrick & Craig Barras
Norah Goldfine
Norma Weinstein
Pat Bixler's Enviro Science I Class
Pat Lupo OSB, 6th Graders @ St. Joseph
Patrick L. Naugle & Alice Savage
Paul Smith, Lois Smith
Paul Snyder
Pauline Risser-Clemens, Glenda Ferrer, Alissa Myers, Becky Mione
Phil Stillerman
Phil, Nick, Andrew
Phleane Kissling
Phyllis Chambers, Frank Botto
Rachel DeMarzio
Rae L. Durnin
Ralph Heister, Michelle Norman, Robert Nordall, Rich Feldenzer, Marcella Shriber
Randy Novakovich, Darlene Madarish, Pat Hook, Julie Rey
Ray Bechtel, Jean Bechtel, Clare Bechtel
Ray, Matt, Aylssa, TJ
Rich Kolka
Rich Widmannt, Deb Carr
Rich Zimmerman and Grade 5 Students
Richard Ader
Richard S. Hesse, Christopher Hesse
Richard Swomley, Vernetta Wallander, Alan Bruns
Rick & Jennifer Barborak
Robby Fromuth
Robert Eddy
Robert Hosko, Robert Stevens
Robert J. Baronak
Robert W. Streeter
Ron Schmalzle
Russell Menz, Carol Ellis
Ruth Koss, Roy Tolly
Salt Springs Homeschool Group
Samantha White, Lisa Bennett
Scott A. Shainler
Scott, Lauren, Gina, Amanda
Sean C, Tamlor B, Danny N
Sharon Cornwall
Sharon Yates,Teri Dautcher
Shawn Hedglin, Jill Shankel
Shawyn Haynes, Mike Ford, Kevin Misiewicz, Jeff Skalizan
Shelley, Alycia, George
SPHS Watershed Warriors
Stan Kotala
Stan, Alice & Helena Kotala
Stephanie Harmon, Pamela Spayd, Furnace Creek Vol Monitors
Stephen A. Kosiak
Steve Hodgson
Steve Kosiak
Steven P. Benz
Steven, Kristi, Andrew
Stream Ecology Class
Susan Braun
Susan Hoekstra
Suzanne Marinel and students
Tammy Shreffler, Jitu Parekh
Team 7B Sheddens
Ted Suttmeier, Hans VanHeyst
Thomas Embich
Tim Smith
Tinicum Conservancy
UST Team
Victor E. Fiori
Victoria Michaels/John Davidson
Virginia Fitzpatrick
Virginia Fizpatrick
WAAC/EASI - Pat Naugle
Walt Cressler
Warwick HS Students
Wendy, Mary, Pat, Ed
William Robb
Wintz-Prokopian

Appendix B
Watershed Snapshot 2002 Participants

Academic Envirnmental Science
Adam Linetty, Amy Slicker, Lera Tsayukova
Alan Stauffer, Stephen Lum
Albert Decker
Alexis Hoover, Jackie Hoover, Doug Hoover
Alice M. Lang
Amy Zakorchemny
Andrew Saul
Andy Blascovich, Heather Eggleston, Mel Zimmerman
Andy McAllister, Jeremy Trexel
Andy McAllister, Jeremy Trexel
Andy Peiffer, Diana Robinson
Angela Check, Emily Thomas,
Ann Harmon
April Newell, Mike Weigand
Aquatic Biology Class
Arthur Popp and Steve Kazmierczak
Arthur Vouse
Autumn Long, Katie Long, Beth Langham
Autumn Mohney, Mr. Kocher
B Scott Fiegel, Penny Rickenbach, Carolyn Reider
Barbara Rupert & Vicky Michael
Bea States
Ben Kikta
Beth Yingst, Preston Mason, John Manzd
Bill Frezel
Bill Robb, John Palic, Bill Ebel
Bob and Dolores Kohnken
Bob and Marge Leach
Bob Bruce, Cal Alston
Bob Eddy
Bob Ferry
Bob Gebhardt, Dick Margerum, Herman Hithner
Bob Reese, Lynn Reese, Anne Cambpell
Bob Yachera, Jineen Boyle, Pam Spayd
Brent Bakur, Wayne Wagaman
Brian Beskitt
Brian Dhunke, Carla Ortz
Brian McGee, Beth Riley
Bruce Sandstrom
Bruce, Andrew, and Chris Grasberger
Carl Rohr
Carroll Williams
Cassandra Shaffer
Chad Kuny
Charles Kanetsky
Charles Schaefer, Jr.
Chelsea Merkel
Chris Barth, Krystal Shannon, Kendra Smeal
CIP-SEC
Claire Orner
Clare Bechtel, Ray Bechtel, Jean Bechtel
Coleen Deloney, James Stuhltrager
Colleen Coffey, Betul Korale,
Corrine Stobbe
Coudersport Ag Science Dept
Courtney Lockhart, Paul Gera, Renee Young
CVHS Freshwater Biology Class
D. Churchill, J. Zenes
Daevan Rodgers
Dale Hollerbach
Dan Hendey's 7/8th grade class
Dan McCollugh,Cory Check
Dani-Ella Betz
Daphne Webb
Dave and Sheila Does
Dave Churchill,Willie & Nicole Zenes
Dave Irco, Claudette Bedard
Dennis Beck, Matt Pisarski, Tom White, Josh Shoff
DEP - Central Office
DEP Finders
Diane Wilson,Bob Dillman
Dick Lehman
Dick Montfort, Rick DeVene
Don and Diane Stump, Peter Bol
Donna Reish
Doran Shade
Dorne White
Doug Thompson & Heather Quick
Dr. Hank Webster & Biol 220 Class
Earl Derstine
Earthright Coalition
Eastern Area High School SAVE
Ecology & Earth Science Class
Ed Schoener
Edward Klavon

Elizabeth Burns, Chris Alley
Emil House
Emily Pickett
Eugene E. Wroblewski
Eugene J. Bocan Jr.
Eugene J. Dougherty
Eugene Marks
Fran Bires, Lee McCoy
Frank Dux, Ed Michalski, Don Holibaugh
Fred Gusz
Fred Wilson, Margo Wilson
Gail Johnston
George E. Farley
George Haab and Waly Stange
George Kuhn, Mike Cunningham
George Walthour
Greg Daley
Greg Leinweber
Gretchen Schatschneider, Brian Dusault, John Rawluk
H.S. Long, Jacqueline Long
Hal Royer, Mary Royer, Carl Bashore
Hannah Koller
Harry J Weber
Harry Maner
Heidi Wirtner,Valerie Tarkowski, Jes Sunder
Herb Volker
Herman Hittner and John Linkes
Hilary Lewis
Hilary Shutt, Becky Hornberger
Howard H. Giles
Indian Creek Twp
James Klass

Jane H. Evans
Jason Keil, Brian Dusel
Jay Hernley, Justin Hoover, Frank Hoover
Jeremy Ketter, Brian Zeckmeister, John Alukonis, Michael Meteney
Jerry Baxter
Jerry Lawrey, Barry Wasfriewig
Jess SundersEAN Voorhees
Jessica Hopper, Claire Fooks, Matthew Berthinet
Jessica Tanis
Jim Broughton
Jim Rutkowski's Biology Class
Jim Stuhltrager
Jineen Boyle, Dan Helm, Nicole Caruso, Ariel Allen
Joan Jessen, Carrilee Hemington
Joe Phillips, Danny Khale, Josh Kline, Mrs. Bunch
Joe, Margie, Willie, and Nickie Zenes
Joel Alex, Jenn Dunkle, Sara Hester, Ray Mckee
Joel Kosmal
John and Marilyn Robb
John Cottrill, Anthony Kuppel
John Dudash
John Ferraro, Carl Trout, Don Cipollini
John Gallo and Gaul Puente
John Hernandez
John Kearney
John McHale
John Wozniak
Kathleen Belmonte



Kathy and Sara Davis
Katie Jay, Kevin Kelly, Pam Spayd, Steph Harman
Ken and Jane Cook
Kevin Cary, J. Hartzler
Kevin Machally, Pooja Patel
Kris Carter & Jean Bear
Kyle Dynda, Ed Post, Candice Fuller, Jeremiah Sosola
Kyle Lewis, Justin Phillips
Larry D. Miller
Laura Haines
Laura Jackson & Envio Science Students
Laurie Goodrich
Lawrence Barrett
Lee & Edi Hebel, Jim Billatte
Lee Harper, Bill Gothier
Len Gorney
LeRoy Skinner
Les Martin, Gretchen Martin, Reed Grosvenor
Linda Deluca
Lisa Armstrong, Fred Kaulbach
Lisa Facciponti, Linda Christensen
Lois Oleksa
Lori Sander, Bill Ray
Lorie and William Reichert
Lower Dauphin HS Env Science
Lower Merion Conservancy
Luke and Christina Thawley
Maddi Raleign

Margaret Rempe and Gray Kwieciasky
Maria White
Marisa L Hopp
Mark Sincavage and Dominic Vangarelli
Mary Jane Stell
Mary Poste, Norman Ritterson
Matt Kofroth
Matt Kofroth, Alison Trexel, Ron Laughlin
Matt Welch, Andy McAllister, Cindy Iberg
Maurice Hutelmyer
Md Khalequzzaman & other members of Geology Club
Melanie Holowaty, Mike Plachta
Melisha Miller & Frank Kerch's 7th Grade
Melissa Black
Melissa Hipps
Michael Andrews
Michelle Moyer
Mick & Fay Messner
Mikayla Herbert
Mike & Laura Jackson
Mike Gillen and Fred Berg
Mike Matso
Mr. Walsh
Mr. Hoppel's Bio II Class
Mrs. Alexander, Mrs. Schott, Mrs. Box
Myra Amodie
Nancy & John Potts
Nancy and Alex Lezark
Nancy Kachniase, Linda Kreiser
Neal Wychock, Linda McKinne, Mike McKinne
Ned Fetcher and Dan Townsend
Neil Harner
Norah Goldfine
Olive Plubel, Eunice Marvel, Melinda Hughes
Pat Bixler
Patrick Naugle, Alice Savage
Patti O'Keefe & students
Paula Wynn
Paula Wynn, Craig Newberger
Peggy Shandish, Bill Unrath
Peter McGurkin, Kristine Dzurison
Pignuts Envirothon Team
Pleasant Mount FCS
Rachel DeMarzio
Rae Durnin
Randy Straub
Raymond Gillen
Rebecca Shirer
Richard Hackenberger
Rob Noerr, Phil Sarachine
Robert Hosko & Robert Stevens
Robert J. Baronak
Robert McKinney
Robert Osborn
Roman Zaharchuk
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Sally Demmler
Sara Seiberling, Kaleigh Felisbert
Sarah Gorecki, Peter Steele
SEWER
Sharon Clune
Stepen Baier
Stephanie Emery, Marybeth Markiewicz
Stephanie Harmon, Matt Kofroth
Steve Wasiesky-Explorer Post 808
Stream Study Explore
Sugar Valley Rual Charter School & WS Assoc
Susan A. Murad
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Suzanne Brown
Suzanne Marinella
Sybil Nicho & Vincent Calabrese
Tad Radzinski
Ted Suttmeir and George Bernardin
Tina Lewis, Scott Lewis, Larry Cottrill
Tom Embich, Stephanie Harmon
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Tracey Crawford & Brian Pilarcik
Troy Magnelli
Victor Fiori
Vince Trinckes
Virginia D. Weber
Walt Cressler
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Zac Heyman, Dan Cooperman
Zack Jud, Ed Mich

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