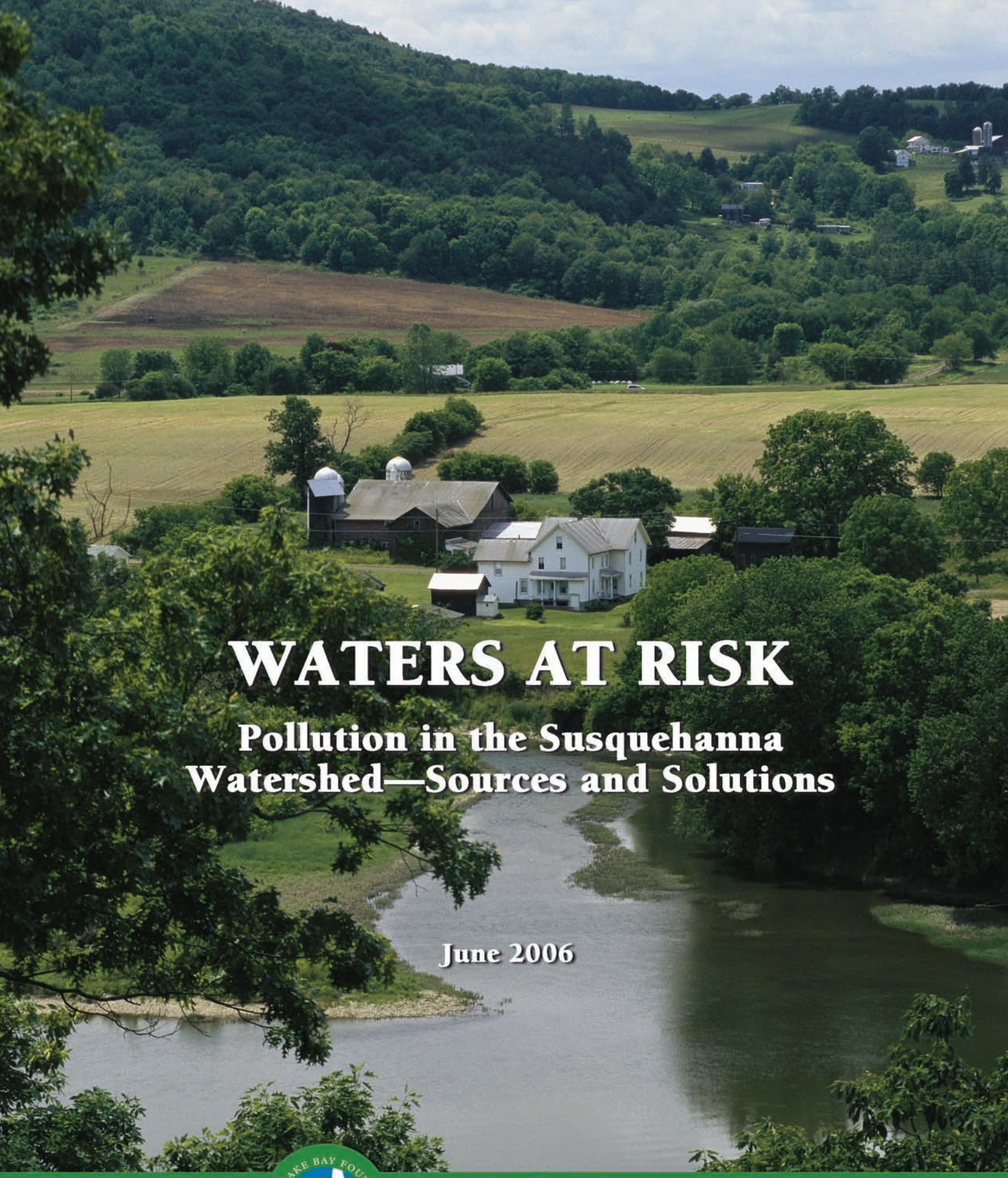

WATERS AT RISK

Pollution in the Susquehanna Watershed—Sources and Solutions

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CHESAPEAKE BAY FOUNDATION
Saving a National Treasure

Waters at Risk

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EXECUTIVE SUMMARY

Stand beside the Susquehanna at Blue Mountain water gap as it rolls through the Blue Ridge. It feels unstoppable. Physically, perhaps it is. It carved its path through the Appalachian Mountains 300 million years ago. Yet in just four hundred years of European settlement in this region, we have thrown off-kilter the natural forces that balanced the Susquehanna's eons-old ecosystem.

From a great height, the enormous change may not be apparent. From this perspective, most of the 27,510 square miles of mountains, valleys, and plateaus that make up the river basin in Maryland, New York, and Pennsylvania look green and mostly undisturbed. But a closer look reveals the system's problems.

- Dams along the Susquehanna River and its tributaries obstruct spawning grounds for migratory fish and alter stream flow, habitat, and chemistry.
- Many farm field creeks accept a heavy load of nitrogen and phosphorus pollution from overwhelming amounts of animal manure.
- Throughout the river system, poorly treated sewage flows into the streams from the pipes of wastewater treatment plants.
- Streams run crystal clear but sterile over rocks stained yellow and orange with the acid, mineral-laden drainage of abandoned mines.
- In the south-central counties, woods and fields—the river's natural filters—give way at an alarming rate to bulldozers. Streets, parking lots, and roofs follow. They create impervious surfaces, efficient funnels that speed polluted runoff to streams and increase stream bank erosion.

According to regulators, sediment, metals, nitrogen and phosphorus pollution, acidity, or physically altered habitat and hydrology prevent more than 7,100 miles of the streams in the Susquehanna River Basin from providing a livable habitat for aquatic communities or being safe for human use. That is more than twenty percent of the watershed's 36,000 stream miles that cannot fulfill their vital functions. One of the best indicators of just how badly damaged this system has gotten is the health of its coldwater fisheries. Nearly every stream in Pennsylvania was once a natural coldwater trout stream, yet more than 70 percent of the state's present coldwater fishery is either gone or holds far fewer fish than it could.

The impact of pollution is not only evident in local waterways. All that the Susquehanna bears flows to the Chesapeake Bay. The Susquehanna River delivers half the fresh water in the Chesapeake Bay and about 40 percent of the nitrogen pollution, 20 percent of the phosphorus pollution[1], and a heavy load of the sediment pollution.

About the cover: A farm on the banks of the Susquehanna River. Photograph taken near the Endless Mountains.

As surely as we had the brawn to degrade the river's carefully balanced system, we have the brains to repair it. Through careful observation, scientists have developed an understanding of the problems and have identified solutions that will restore balance to the system. All that is required is the political will and leadership to fully fund and implement those solutions.

POLLUTION IN LOCAL WATERWAYS: DAMS

There are over 3,000 dams in Pennsylvania and many lie within the Susquehanna River Basin. The vast majority of these are small, often less than 15 feet in height, and are obsolete and in need of repair. Many of these dams present a safety hazard and impede recreational use of rivers and streams. Several, much larger dams are also found on the Susquehanna, such as the Conowingo and Safe Harbor Dams on the southern portion of the river.

Dams of any size can impact river systems by altering flow, sediment transport, critical habitats, water temperature, and chemistry. Dams capture and store sediment, fundamentally changing the habitat in their impoundment areas. Though dams temporarily prevent sediment pollution from moving downstream, within the next 20 years many dams will reach capacity and begin conveying increased sediment pollution loads to the Bay.

Dams can also degrade resident and migratory fish populations, such as the American shad. American shad spend most of their lives migrating along the Atlantic Coast, returning to their natal streams to spawn. Millions of shad historically swam hundreds of miles up the Susquehanna, which once boasted the largest shad spawning area on the East Coast. But as a result of dams, the shad's ability to reach spawning habitats has dropped 98 percent in the river basin.

Restoration efforts, such as fish passages on the large hydroelectric dams, have resulted in shad numbers growing from a few hundred fish annually during 1972-1984 to an average of 150,000 each year in 2000-2002.[2]

While numerous efforts to restore the ecological health of the river and its tributaries through dam removal have been growing, new dams are being proposed. One such effort is the Wilkes-Barre Inflatable Dam project which threatens to destroy valuable wetlands and bird habitat, and threaten human health from 16 Combined Sewer Overflows that pour untreated waste directly into the recreational pool behind the proposed dam.

POLLUTION IN LOCAL WATERWAYS: NITROGEN AND PHOSPHORUS

Nitrogen and phosphorus pollution, which enter the river primarily from manure and sewage, have been the main focus of more than twenty years of intensive environmental clean up. The two, particularly nitrogen, damage the Chesapeake Bay more than any other pollutant. Efforts to reduce these pollutions have paid off. Water quality monitoring on the Susquehanna shows the flow-adjusted concentrations of nitrogen and phosphorus have declined since the 1980s when monitoring began. However, the scientists who develop this data find disturbing news in their latest samples. Across some river monitoring stations, the long-term trend in the reduction of concentrations has slowed and, in some cases, reversed.

According to scientists, declines in flow-adjusted concentrations are due to long-term efforts to improve sewage treatment plants, ban phosphates in laundry detergents, and improve agricultural practices. However, many factors influence the health of our waters. As these factors individually change—for example, as the human population grows, as more land is developed, and as agriculture shifts toward more intense animal production—they

compete with the hard-won progress achieved by new policies and best management practices. The competing effects of these changes are embedded in the monitoring data, but are not easily singled out. Scientists suspect that the recent increases they see in the concentrations of nitrogen and phosphorus are a reflection of these changes.

Phosphorus pollution, from sources such as manure, runoff, and sewage treatment plants, has a significant effect in the ecosystem of the Susquehanna's small, freshwater streams and ponds. The algae that live in fresh waters thrive on phosphorus. In slow moving streams, mill ponds, and lakes, excess phosphorus pollution fuels the algae growth that leads to oxygen starvation and cloudy water.

While nitrogen pollution does not seem to impact the waters of the Susquehanna River, it is a major problem for the Chesapeake Bay downstream. Because of nitrogen pollution, the Bay suffers every summer from massive algae blooms that rob hundreds of square miles of adequate oxygen for healthy fish. Large sections of the Bay become dead zones, where even the hardiest of bottom-living worms cannot thrive. In summer 2005, the Bay's dead zone was among the worst on record. The

SOURCE: Manure
ONE SOLUTION: Precision feeding

Fine-tuning the feed that cows eat can help dairy farmers make a major difference in reducing nitrogen and phosphorus pollution in the Susquehanna watershed—and increase profits, too.

Scott Kreider is participating in a CBF-sponsored precision feeding program to reduce excess nitrogen and phosphorus in cattle feed.

Studies have shown that feeding adjustments can lead to nitrogen reductions of 30–50 percent and phosphorus reductions of 40–60 percent in cow manure. Accordingly, CBF has embarked on a project with the University of Pennsylvania School of Veterinary Medicine, Penn State University, and the Pennsylvania Department of Agriculture to help Pennsylvania dairy producers adjust feed rations. In a precision feeding program, cows are given feed containing nitrogen and phosphorus in precise amounts according to their needs, and as a result, far fewer nutrients end up in the manure.

"Precision feeding is one of the most cost-effective strategies to reduce pollution loads to local streams and the Chesapeake Bay," said Kelly O'Neill, Pennsylvania Agricultural Policy Specialist for CBF.

When cows can utilize the nutrients they ingest more efficiently, they excrete fewer nutrients. Because Pennsylvania farmers must adhere to limits in the amount of nitrogen and phosphorus that they apply to their lands in the form of manure, manure with fewer nutrients relieves them of problems disposing of it. Precision feeding also ensures that the animals' nutritional needs are met, maximizing productivity and profitability.

Precision feeding is already widespread in swine and poultry production. CBF foresees the precision feeding initiative leading to adoption by about 4,000 Pennsylvania dairy farms, with reductions of approximately 24 million pounds of nitrogen pollution and 9.5 million pounds of phosphorus pollution.

Scott Kreider, of Kreider Farms in Lancaster County, has been participating in the project. He says that this project helps him proactively prevent accumulations of phosphorus pollution in the soil that could prevent future manure application. The main benefits, he says, are that the improved rations are "saving us money and the cows are doing better. Butterfat and protein levels have improved, and that's where the money's at."

Susquehanna delivers about 40 percent of the nitrogen pollution the Bay receives and more than half of the nitrogen pollution in the Susquehanna's water comes from manure.[3]

Manure

Across Pennsylvania, the cows, chickens, hogs, and other livestock produce approximately 30 million tons of manure per year, containing approximately 171,000 tons of nitrogen and 81,000 tons of phosphorus. Pollution from agricultural operations is the source of one-third of the streams listed as unable to support healthy communities of aquatic life and represents the second largest source of pollution to the Susquehanna system.

The excess manure has its effect. Nitrate levels reach into the danger zone of more than 10 milligrams per liter in 36 to 45 percent of groundwater samples in the lower Susquehanna region.[4] Nitrate in drinking water at levels above 10 milligrams can harm adults and livestock and can result in blue-baby syndrome, a condition in which a baby's blood cannot carry enough oxygen.

The manure "hotspot" in Pennsylvania is Lancaster County, the second largest producer of agricultural products east of the Mississippi, fifth in livestock production nationally, and the largest producer of manure in the Chesapeake Bay drainage basin.

Lancaster County, which contains only 1.5 percent of the area in the entire Chesapeake watershed, produces more nitrogen from manure than any other county—72 million pounds a year, about 12 percent of the total nitrogen from all manure sources in the watershed.

Not that long ago, Lancaster represented a balanced system. The grain fed to the livestock grew in the county. The manure generated by the county's farm animals fed the grain. More fallow land was available to productively absorb any excess manure. Much of the nitrogen and phosphorus pollution stayed within the boundaries of the agricultural system.

In the past few decades, agriculture in the county has shifted. Now large numbers of animals—twenty-two million cattle, dairy cows, pigs, chickens, and turkeys—are fed on small lots. The number of animals outstrips the local grain supply, so they are fed with grain from other regions. With the nutrients from this imported grain, the animals generate tons of nitrogen and phosphorus rich manure. Meanwhile, Lancaster lost fields that could once absorb manure to fast-paced development. The result is tons more manure than Lancaster can handle. The excess nitrogen and phosphorus spills out of the agricultural system and pollutes the local ecosystem, from the air to the groundwater.

Sewage

Many of the sewage treatment plants that empty into the Susquehanna are old and no longer up to the task of protecting the river, the people along the river, or the Bay. Heavy rains can overwhelm some of these plants with runoff from city streets. Yet even when the plants are not stretched by rainfall, their level of treatment fails to remove enough pollution to protect the river and the Bay.

Pennsylvania has more than 190 "significant" sewage treatment plants that empty into the Susquehanna's streams and rivers. (Significant plants are defined as those with the capacity to discharge 400,000 gallons per day or more.) Sewage treatment plants add approximately 13 million pounds of nitrogen pollution annually to the Susquehanna, and about 1.5 million pounds of phosphorus pollution annually.[5] Under the Chesapeake 2000 Agreement, Pennsylvania's Department of Environmental Protection (PADEP) has committed to cap nitrogen and phosphorus pollution from sewage treatment plants in the Susquehanna basin to 7.9 million pounds and 477,000 pounds, respectively, by 2010.

In order to meet these caps, PADEP has begun to issue draft discharge permits that specify limits on the annual amounts of nitrogen and phosphorus pollution that can be released. These limits are based on an annual concentration average of 8 mg/L and estimated flows in 2010. According to 2004 data, only 46 of the 133 plants in the database are discharging at concentrations of 8 mg/L total nitrogen or less. The state has introduced a "nutrient trading" program to help in achieving and maintaining pollution caps.

Combined Sewer Overflows (CSOs) also continue to be a significant problem in older communities adjacent to the river or its tributaries.

CSOs are underground pipe systems that carry both sewage and stormwater. Most of Pennsylvania's older communities have such systems. During many rain events, these systems are simply overwhelmed, resulting in the dumping of raw, untreated sewage laden with disease-causing pathogens, toxins, hygiene products, and pharmaceuticals into nearby rivers and streams.

There are over 400 CSOs that can dump untreated sewage into streams or directly into the Susquehanna. The viruses and bacteria associated with CSOs raise significant

SOURCE: Outdated Sewage Treatment Plants
ONE SOLUTION: High-Quality Wastewater Systems

State and federal officials are targeting the nearly 200 mid-sized sewage plants in the Susquehanna River watershed for improvements in order to reduce the outflow of nitrogen and other pollutants into streams that flow into the Bay. But the University Area Joint Authority wastewater treatment plant (UAJA) near State College has already achieved that goal.

State College's University Area Joint Authority Advanced Water Treatment facility, shown here before its completion last year, far exceeds all current standards for wastewater treatment.

As UAJA officials planned an upgrade for their 35-year old facility, they designed far ahead of the curve. Their new $52 million plant, completed last year, so exceeds existing standards for wastewater that it's in a class by itself. "We knew we were going to spend a lot of money, so we wanted to do it well," explains Cory Miller, executive director of UAJA. Through micro-filtration and reverse osmosis, a portion of the wastewater treated at UAJA now becomes ultra-high purity H_2O—a category comparable to high-quality drinking water. Rather than being put back into Spring Creek, it's pumped back to an industrial park for reuse.

Optimum water cleanliness is only part of UAJA's success story. Temperature is another vital factor. "We're trying to drive the temperature (of the filtered product) down to counter the effects of the urban stormwater that enters the system," says Miller. This is an ongoing concern due to UAJA's location in the Spring Creek watershed, a high-quality coldwater fishery. Warming of local streams can stress the trout population; new data show that brook trout are now imperiled in more than 70 percent of Pennsylvania.

Now, Miller relates, the plant should take care of the area's clean water needs until the end of the century. "As the community grows, it will actually improve the quality of our streams."

SOURCE: Stormwater Runoff
ONE SOLUTION: Low Impact Development Techniques

The Village at Springbrook Farms, a new, 259-unit residential development in Campbelltown, Lebanon County, proves that it's possible to create new housing that is protective of water quality. The 59-acre development incorporates an innovative stormwater management system which uses 127 separate but interconnected elements to prevent runoff from the site from degrading local streams.

Porous paving, shown here on sidewalks in The Village at Springbrook, returns stormwater runoff to the ground below. Inset: Wesley R. Horner, Principal Planner.

Most developments cause an increase in stormwater runoff, which can trigger flooding, erosion, stream channel alteration, and other ecological damage. The runoff carries with it nitrogen, phosphorus, and sediment pollution, hydrocarbons, metals, toxic herbicides and pesticides, and bacteria—often deposited in the nearest creek. Reducing the amount of stormwater generated and treating it—rather than the traditional solution, sending contaminated runoff to the stream with little or no treatment—is a big boost for water quality.

"Our approach at Springbrook was to keep the stormwater as close to the source as possible, cleansing and recycling it with many different 'best practices,'" says Wes Horner of T.H. Cahill Associates, the engineering firm responsible for the system. Extensive geological and hydrologic testing was the first step. To replace the "huge and ugly" stormwater detention basin called for in the original development plan, the Cahill design proposed mitigating water runoff in several ways. A primary one was porous asphalt paving—for sidewalks, paths, and parking areas—with stone-filled recharge beds built underneath. The beds purify water from the surface before it seeps back into the ground. Infiltration beds installed beneath non-porous driveways also return water directly to the site. In addition, the Cahill plan established rain gardens and vegetated swales through the development as extra water quality mechanisms.

With all elements working together, Springbrook's stormwater management plan treats pollutants, re-charges the groundwater, and maintains the water table, while preventing flooding and destructive effects downstream.

human health concerns, particularly in recreational areas, and especially when located behind dams where the untreated discharge can stagnate.

POLLUTION IN LOCAL WATERWAYS: IMPERVIOUS SURFACES

Two kinds of development threaten the Susquehanna River system. In south central Pennsylvania, vast areas of development have converted woods and fields at a dramatic pace. Smaller, diffuse areas of development are scattered throughout the watershed. Both large-scale development and diffuse sprawl significantly increase pollution and threaten the health of the Commonwealth's streams and rivers.

Land converted from nature's absorbent buffers—forests and fields—to impervious roofs, parking lots, and roads creates more pollution and speeds its path to water. Without filters and buffers to slow and absorb rainwater, the volume of runoff entering local waterways increases. Further, loss of shade provided by streamside forests causes an increase in water temperature that can be devastating to aquatic life. Research has shown that as total imperviousness in small watersheds approaches 10 percent,

water quality begins to decline. As that percentage grows, so does stream degradation.

Little watersheds all over the Susquehanna's basin suffer as sprawl spreads. However, the concentrated blow from the past decade's development falls on six of the watershed's 35 counties: York, Lancaster, Blair, Dauphin, Lebanon, and Cumberland. Of those, York and Lancaster have lost the greatest percentage of farm and forest land.[6]

The construction activities that accompany development create erosion and, even with the best efforts of builders, erosion often leads to sediment pollution entering streams. Sediment blocks sunlight needed by aquatic plants, smothers fish spawning habitat, and delivers phosphorus pollution to the stream. Impervious surfaces speed the flow of polluted runoff. Toxic chemicals, such as copper from automobile brake rotors and oil from leaking motors, settle on streets. Nitrogen oxides from automobile tail pipes land on roofs. Rains wash these hard surfaces and the water flushes from city streets and country roads in greater volumes into streams. In water, toxic compounds attach to suspended particles and drop to the bottom, then re-suspend during storms. Toxics also lower reproductive success in fish and stress the health of aquatic animals. Nitrogen pollution leads to algae blooms and dead zones.

POLLUTION IN LOCAL WATERWAYS: ABANDONED MINE DRAINAGE

Across the historic coal fields of Pennsylvania a quiet reaction simmers, a legacy of the nation's early industrial age. Pyrite, a molecule made of iron and sulfur and commonly found in coal, and discarded materials from abandoned mines combine with oxygen and water and produces sulfuric acid and yellowboy, the telltale yellow-orange precipitate that colors many miles of streams. The result: statewide, more than 4,000 miles of streams polluted by acid and heavy metals.

A quarter of a million acres of abandoned refuse banks, mine shafts, and mine lands litter 45 of Pennsylvania's 67 counties; more acres of old sites than any other state in the nation.

Mine drainage discharges range from alkaline water containing iron to heavily polluted acid discharges containing iron, aluminum, manganese, and sulfates.[7] This brew kills off the aquatic insect communities essential to fish life and kills young fish and any adult fish that cannot escape it.

While historic abandoned mines continue to pollute our waterways, mining technology and pollution prevention efforts have improved for active mines. Regulations require that acidic water produced at active mines must be neutralized or treated before discharged.

Pennsylvania has modified its laws to encourage mining companies and community organizations to re-mine and reclaim abandoned sites. The new laws limit the liability companies face for re-opening already polluted mines or citizen groups face if they tackle difficult reclamation projects. Still, the clean-up is expected to cost $15 billion and take 50 years or more to cleanup the legacy of abandoned coal mines.

COLDWATER FISHERIES

Pennsylvania's streams are not only beautiful; they are also a significant economic engine. In 2001, anglers spent over $800 million on fishing-related activities in the Commonwealth and created over $1.6 billion in economic output.[8]

SOURCE: Abandoned mine drainage
ONE SOLUTION: Natural Treatment Systems

Pennsylvania was the nation's leading coal producer through the early 1900s, and still ranks fourth in U.S. production. Many once-active coal mines in the central part of the state—the Susquehanna watershed—are now deserted, but continue to damage the environment in the form of pollutants that seep into waterways and creeks. Runoff and drainage from abandoned mines in Pennsylvania affect over 4,000 miles of streams statewide.

Suzanne Ward, a USGS hydrologic technician, measures the flow rate in Mahanoy Creek, a stream in the Swatara watershed affected by abandoned mine drainage.

Coal mine drainage usually contains elevated concentrations of acidity and toxic metals. Restoration projects can neutralize acidity and remove toxic metals from the water through one or more methods: alkalizing chemicals, constructed wetlands, or passive systems that channel the drainage through a streambed lined with limestone.

In the Northern Swatara Creek Basin, which empties into the Susquehanna, a variety of successful passive treatment systems have been constructed since 1995 to cleanse approximately 25 miles of streams. The results have been dramatic. Today, aquatic communities that have been absent for decades have re-established themselves—proof that the systems have had a significant impact. "It's a success story by any standard," says Dr. Charles A. Cravotta III of the U.S. Geological Survey, who supervised the scientific and engineering aspects of the system. "Streams have come back from lifeless in 1990 to a very productive ecology."

In treatment areas throughout the Swatara basin, the acid drainage flows through open channels filled with sand-sized fragments of limestone, which add alkalinity (decreasing acidity and raising pH) to the water as they dissolve. Limestone drains and limestone-based wetlands also help to restore the aquatic system to a normal level. All together, the Bureau of Abandoned Mine Reclamation at Pennsylvania's Department of Environmental Protection has completed 12 projects in the area, and numerous other projects initiated by local watershed groups have been employed to improve water quality.

The Susquehanna River basin contains some of the best fishing in the world. Even so, it should contain a whole lot more. Coldwater species, such as the brook trout, once thrived in all of the Susquehanna basin's streams and brooks. Only the bigger rivers did not hold trout year-round.

Today healthy, intact brook trout habitat and populations exist in only one percent of the fish's historical sub-watersheds, and relatively healthy populations and habitat exist in only nine percent.[9] Greatly diminished, remnant populations remain in the headwaters of 39 percent of its historical range and are gone entirely from at least 34 percent.

Brook trout, Pennsylvania's state fish, are not the only coldwater species, but they are arguably one of the best indicators of a watershed's health. Very sensitive to habitat degradation, brook trout need cool water and intact stream structure (a gravelly bed, pools and riffles, and moving, but not swift, waters).

De-forestation eliminated the tree cover that kept streams cool. Associated sedimentation covered the gravel stream bottoms and made them unsuitable for spawning and accelerated runoff changed stream hydrology and destroyed the riffle and pool structure coldwater stream fish thrive in.

Today agriculture, development, and road construction pose the greatest threat to coldwater streams. Poor agricultural practices may be linked with a loss of about 50 percent of the brook trout habitat.[10] In the south-central part of the watershed, land development has the same effect. Both, if poorly managed, create high water temperatures by removing trees, increasing nutrient runoff, and increasing sediment pollution. Compounding the problem, acidity and the heavy metals from abandoned mine drainage kill fish and destroy the healthy insect community fish need for food.

CONCLUSION

The Susquehanna River is perhaps one of the most ancient river systems in the world. Along with the thousands of miles of streams that feed it, it is the lifeblood of central Pennsylvania and the Chesapeake Bay, to which it drains. The impacts of human actions along the river over a mere 400 years in the Susquehanna's long history have been severe. There is hope, however, for Pennsylvania's waterways, for the coldwater fish that inhabit them, and for residents of the watershed. Numerous success stories illustrate that many concerned Pennsylvanians are actively committed to saving this important and historical natural resource. Once habitat is restored, hatchery-raised brook trout can thrive and rebuild populations. The waterways that people value for recreation and beauty can be protected for future generations. Scientists have studied the problems facing water quality in Pennsylvania's streams and in the Susquehanna River. They have identified solutions. What is needed now is the persistent leadership to fully fund and implement those solutions. Only then can Pennsylvania restore and protect this critical system from further degradation, ensuring a thriving agricultural industry and vibrant communities with clean water and healthy fisheries for the benefit of all.

[1] *Chesapeake Bay Program*
[2] *U.S. Fish and Wildlife Service*
[3] *U.S. Geological Survey*
[4] *U.S. Geological Survey*
[5] *Chesapeake Bay Program 2004*
[6] *Woods Hole Research Center*
[7] *Joseph Pizarchik, Director of the Bureau of Mining and Reclamation, Pennsylvania Department of Environmental Protection*
[8] *Pennsylvania Fish and Boat Commission*
[9] *Eastern Brook Trout Joint Venture*
[10] *Eastern Brook Trout Joint Venture*

Saving a National Treasure

Chesapeake Bay Foundation
Maryland
Philip Merrill Environmental Center
6 Herndon Avenue
Annapolis, MD 21403
410/268-8816
410/269-0481 (from Baltimore metro)
301/261-2350 (from D.C. metro)

Pennsylvania
The Old Water Works Building
614 North Front Street, Suite G
Harrisburg, PA 17101
717/234-5550

Virginia
Capitol Place
1108 East Main Street, Suite 1600
Richmond, VA 23219
804/780-1392

Web site: cbf.org
E-mail: chesapeake@cbf.org
Membership information: 888/SAVEBAY


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