STROUD™
WATER RESEARCH CENTER

2008 Annual Report

A YEAR IN REVIEW

For the millions of people who live in the Schuylkill River watershed of Pennsylvania, water quality is a complicated issue — impacted by 300 years of intensive land use, from mining and agriculture to urbanization and suburban sprawl.

The Stroud Water Research Center is tackling the problem by studying both the streams and rivers that supply the fresh water and the microbial communities that grow in the pipes that transport it throughout the City of Philadelphia.

Photo: Sarah Smith

2008 At a Glance

A. Twenty-four college interns worked side-by-side with Stroud scientists to move the basic research of stream ecology forward.

B. Stroud science demonstrated that healthy headwaters are the lifeblood of our streams and rivers — essential to the health of their ecosystems, and the well-being of the people who rely on these freshwater resources.

C. Planning began for a new green building to enable expansion of the scientific labs and create a more effective center for outreach and education programs.

D. Seventeen biologists, conservation workers and educators from Central and South America became Leaf Pack Ambassadors using our Spanish-language version product to teach others about water issues and how to monitor their own water sources.

E. Employees helped reach a milestone — planting the 100,000th tree in Pennsylvania — as part of a decades long effort to restore streamside forests to preserve water quality.

F. Stroud research demonstrated the value of streamside forests in providing a buffer from adjacent land use and reducing the amount of pollutants that enter a stream.

G. Stroud scientists collected data to determine whether salt marshes are a net producer or consumer of nutrients and whether nutrients from Kent County's wastewater treatment plant are significantly contributing to zero oxygen conditions in Delaware's Murderkill River estuary.

H. The arrival of Dr. William H. Eldridge signaled the launch of the fish molecular ecology department.

I. Our watershed education programs served 3,334 individuals — from children to adults.

Board of Directors

2008

Message
FROM THE DIRECTOR

Photo: Caitlin Bellucci

2008: WORKING OUR MAGIC

While a good magician appears to perform supernatural feats, in reality his magic reflects years of hard work, study and practice. Our efforts at the Stroud™ Water Research Center require a similar effort — intellectual curiosity, a systematic and rigorous approach to scientific research, and the drive to answer a series of challenging questions about freshwater ecosystems. The answers to these questions may take decades to fully understand, but it is critical that we persist, as they have the power to influence others in ways that positively affect the world's finite supply of fresh water. And that, to me, is pure magic, as well as the reason I continue to be excited by our work 35 years after I first arrived at this place.

That our work has helped lay the foundation for the basic scientific assumptions of stream research, and that we continue to be at the forefront of research that will benefit countless individuals, landowners, and businesses, as well as affect policy to protect this precious resource, is nothing short of magical. But it comes as no surprise to me, as the collective knowledge of our team and their ability to impart the meaning behind that science to create positive change is unparalleled.

Our goal is that our work will grow and its benefits multiply, just as the small streams we study join together to form larger river systems. And it has. In fact, many of the projects described in this report reflect decades of learning that began here and moved out across the globe. Our work on the Congo River, for example, builds on the organic chemistry work performed in White Clay Creek and other local streams. Our influential report on the water quality of the Schuylkill River system stems, in part, from refining the methods and approaches that were tested here years ago. And Stroud Water Research Center's efforts to understand the microbial communities in Philadelphia's drinking water and the efficacy of certain treatment options would not have been possible without forty years of knowledge acquired here.

Similarly, my appointment to lead the Freshwater Surveillance Group of the International Bar Code of Life project is a direct reflection of the expertise and success of this Center. Again, not magic — but a result of the knowledge and the credibility earned by a dedication to just one thing — acquiring and sharing the knowledge to ensure the protection, preservation and restoration of our freshwater ecosystems, a resource that has never been so challenged as it is right now.

"In a very real sense, biotic monitoring will move from the canaries that probed air quality in 19th century mines to barcode surveys that will register planetary health in the 21st" (iBOL Research Overview).

Photo: Terrence Roberts

Building a Library of Life

OUR ROLE IN THE ASSESSMENT OF PLANETARY HEALTH

Just as every item at a supermarket has a unique barcode assigned to it, so every animal species in the world has a unique sequence of DNA, located in the gene producing an enzyme called *cytochrome c oxidase I*. Scientists now have the ability to read that sequence like a barcode, which enables them to identify most animals to the species level based solely on a tiny sample of DNA. The possibilities this new capability presents are huge and far-reaching — not only for revolutionizing scientific research but also for shaping public policy, treating infectious diseases, controlling invasive pests, managing global trade and preserving biodiversity — and scientists from around the world have created a major collaborative effort to make the most of them. The International Barcode of Life — or simply iBOL — is a consortium of scientists from 25 countries on six continents whose goal is to create a comprehensive library of the world's species that is based on digital technology and DNA, rather than the physical appearance of a specimen.

Nowhere are the possibilities for using the new technology more far-reaching than in the realm of fresh water, where the construction of dams, the destruction of habitat and the

ravages of pollution have made organisms that live in streams and rivers the most endangered group of species on the planet. Researchers at the Stroud™ Water Research Center have been among the first to use barcode technology to assess the condition of freshwater macroinvertebrates and monitor the quality of the water they inhabit. In the wake of completing an initial project in White Clay Creek in 2008, Stroud scientists are now seeking to expand their efforts to a much larger undertaking that will take them from small Pennsylvania streams to the Peruvian Amazon, as well as to rivers in Costa Rica and the Canadian Arctic. And it will take Bern Sweeney to the heart of this international collaboration — for as a result of the Center's work, its ambitious plans to test its findings on a global scale and its established expertise in freshwater research, Sweeney was asked to lead the Freshwater Bio-Surveillance section, one of iBOL's 10 working groups.

The immediate objectives of the iBOL project are to:

- Catalogue the world's species — with a short-term target to expand current global barcoding records from 40,000 to 500,000 recognized species by 2014
- Identify new species
- Understand evolutionary relationships by tracing common ancestors and studying divergent histories
- Leverage the technology to enable inexpensive, rapid and regular biotic monitoring

From a scientific perspective, just building this library is an exciting undertaking. Dan Janzen, the University of Pennsylvania biologist who founded Costa Rica's Guanacaste Conservation Area in the 1970s and later urged the Stroud Water Research Center to help establish its Maritza Station nearby, likens the existing situation to a library filled with uncatalogued, randomly shelved books that are inaccessible to most readers. But Janzen understood from the outset that iBOL is much more than an academic exercise — that it can play a critical role in the effort to preserve the world's biodiversity, which is essential to protecting human life as we know it. And it was he who recommended Sweeney to head the freshwater group, calling him "focused, mission-oriented and VERY competent."

"The importance of this project is immense, particularly with regard to freshwater ecosystems" said Sweeney, who noted that fish and other aquatic animals are critical food sources for most of the world's people. "The macroinvertebrates, which are so vulnerable to human impact, not only sustain fish populations, but they also are used by scientists around the world to assess water quality and stream health. iBOL will revolutionize stream monitoring and give us extraordinary new tools to protect biodiversity."

"In scale and significance, this initiative is equivalent to the Human Genome Project of biodiversity," added fish ecologist Willy Eldridge. "Barcoding enables us to answer a whole new set of questions about evolution, community structure, and the impacts of humans on our environment."

Links

- For more information about the International Bar Code of Life (iBOL) project, go to: www.dnabarcoding.org/
- For more information on Bernard Sweeney, go to: www.stroudcenter.org/about/bernardsweeney.htm

Intern Travis Burt and Stroud entomologists Sally Peirson and Kyle Stem collect macroinvertebrate samples from an Exceptional Value reference stream in western Pennsylvania, to help interpret conditions in the Schuylkill River watershed.

Photo: Jan Battle

The Schuylkill River Watershed

A COMPREHENSIVE REVIEW OF THE WATER SUPPLY AND ITS DISTRIBUTION SYSTEM

The Schuylkill River: A Major Source of Philadelphia's Water

In the anthracite coal region of Schuylkill County, a small stream forms in an old mine pool beneath the Appalachian mountains. It flows out of a pipe at the Pine Knot Discharge and runs past the Cass Township School for Child Development, just below which it is joined by waters from another mine pool at the Oak Hill Boreholes. This still-small stream — the headwaters of the Schuylkill River — contains 30% of the heavy metals that will eventually arrive in Philadelphia, 130 miles away.

As its water travels downstream through a varied and changing landscape that has been the site of intensive settlement and use since the days of William Penn, the Schuylkill grows wider and deeper, fed by hundreds of tributaries — some clean and healthy, and many not — that drain its 2000-square-mile watershed. The unhealthy streams carry in their waters the residues of human development — metals, including toxic levels of aluminum, iron and manganese from old mining operations; fertilizers and soil from centuries of intensive agriculture; and pharmaceuticals, lawn chemicals and sediments from urban and suburban growth.

At the end of its journey in Philadelphia, a maze of underground pipes thousands of miles long — many well over a century old and lined with the effects of age and wear — distribute the river's treated water to the millions of people who live, work and visit in the city, as the Schuylkill River is a major source of drinking water for Philadelphia and other communities along its path.

Addressing The Clean Water Challenge

Providing clean water to millions of people is no simple task, particularly in Philadelphia's hot summer months when rising temperatures accelerate the growth of bacteria in the water that flows through the city's distribution system. To protect the public and control the growth of pathogens in its drinking water, the U.S. Environmental Protection Agency requires the Philadelphia Water Department (PWD) to maintain a prescribed level of disinfectant in a distribution system that must deliver 310 million gallons of treated water a day to homes and businesses across a 130-square-mile area. Its first step is to add chlorine to the water. That is the easy part…but the water chemistry quickly gets complicated.

While chlorine is an effective disinfectant, it combines with natural organic matter in the water to form new compounds called disinfectant byproducts. Because these can be carcinogenic, they too are regulated by the EPA, and to counteract the threats they pose, the city adds ammonia to the water in its treatment plants. The ammonia reacts with the chlorine to form chloramine, a powerful new disinfectant, which is less likely than chlorine to produce carcinogenic compounds — but any excess ammonia also sets off a chemical and biological chain reaction that can ultimately spiral out of control and create significant challenges to the efforts of treatment plant operators who provide good, clean water to the people of Philadelphia.

Defining Treatment Options

To help the city determine the best water treatment options, the Philadelphia Water Department called on Lou Kaplan, head of the Stroud™ Water Research Center's biogeochemistry group, and funded a two-year research project that sought to

The first large city in the United States to regard the delivery of safe water as a municipal responsibility, Philadelphia's infrastructure dates back to the 1870's. Shown here, the inside of a failed pipe from South Philadelphia that PWD recently replaced. Stroud scientists are analyzing the old pipe for its microbial contents and insights into effective biofilm control strategies.

Shown here, Tulphehoken Creek, on the banks of which sit the historic buildings at Gring's Mill Recreation Area in Berks County, PA. This tributary of the Schuylkill River has lost 70% of its pollution-sensitive mayfly, stonefly and caddisfly families.

first identify the microbial communities living in the water supply and distribution pipes and then to understand the dynamics that enabled them to wreak such havoc — knowledge that is critical for the city to determine the optimal approach to treatment of its drinking water.

Kaplan's study produced the first comprehensive portrait of the microbial communities in Philadelphia's water distribution system — a critical step in the city's effort to address the hygienic, aesthetic and regulatory problems that have long affected its water supply — and a model for what other cities across the country may soon consider as part of their own treatment efforts.

The Link Between Land Use and Water Quality

While Kaplan was exploring the Schuylkill River's water in Philadelphia's distribution pipes, John Jackson and his staff of Stroud entomologists were completing the most comprehensive analysis ever made of water conditions in the entire Schuylkill River watershed. In their 11-year study funded by the William Penn and Wyomissing Foundations, Jackson's team sought to understand the impact of humans on the watershed and to suggest some things people can do to make a difference — for as Luna Leopold noted many years ago, "The health of our water is the principal measure of how we live on the land." Because the history of the Schuylkill mirrors that of many other watersheds across the country, the lessons from this study have broad applicability.

Jackson and his team discovered many clean streams, but the majority of streams and rivers in the watershed have undergone measurable degradation — and the cause of that degradation is people. From coal mining activities — many of them abandoned long ago — to agriculture, urban development and suburban sprawl, the single greatest threat to the quality of our fresh water is…us. The degradation

happens gradually, with incremental changes often imperceptible until a great deal of damage has been done. And it is damage that builds upon itself: declining water quality, and the loss of diversity it precipitates, makes streams and rivers less able to provide the services on which humans depend, which in turn causes people to intensify their interventions into the natural processes.

Most regions of the Schuylkill's watershed have a range of stream conditions, and most residents live near both a good stream and a polluted one. Good streams — which currently represent only 23% of the watershed's total — support the greatest biodiversity, but they too have suffered degradation associated with the intense settlement which began in the region more than three centuries ago.

Still, the actions that people take as citizens and homeowners — as well as the decisions their elected officials make on their behalf — directly affect the quality of the river's water and the biological integrity of its ecosystem. Every chemical that a landowner applies to a lawn and each square foot of impervious surface that a municipality approves within its boundaries — whether roadways, parking lots or rooftops — contribute to the degradation of the Schuylkill's water. On the other hand, each tree that a person plants in the watershed and each rain barrel that a homeowner installs to capture roof runoff help improve the river water for everyone.

Protecting Headwaters: The Key to Clean Water and Human Health

Jackson's study brings us back to Schuylkill County. "It all starts in the headwaters," he says. "We must protect the small upstream tributaries if we are to protect the river."

Kaplan — who with Jackson, Tom Bott, Denis Newbold and Bern Sweeney of the Stroud Water Research Center authored *"Protecting Headwaters: the Scientific Basis for Safeguarding Stream and River Ecosystems,"* which was published last fall and is now being used by environmental groups — agrees. Kaplan compares the role of small streams to that of capillaries in the human body. "We don't often focus on them," he says, "but how well would our bodies work if our capillaries were clogged?"

Imagine, then, Philadelphia as the heart of the Schuylkill system, and ask yourself how dependent it ultimately is on the state of the small and headwaters streams that make up 80 percent of the stream network that supplies its fresh water. Cumulatively, those streams have an enormous impact on the wellbeing of the entire watershed, and when they are healthy, they provide a host of important services, from flood mitigation to water-quality protection to critical habitat for plants and animals.

Headwater streams are not supposed to come out of pipes carrying heavy metals. They are the cradle of a river's biodiversity, the places that set the stage for what happens downstream, and the key both to the health of the river and to the human communities it serves. In their natural state, they provide their services free of charge so, if we protect them, we are not only protecting our own health, we are simultaneously saving ourselves millions of dollars in the remediation costs we will otherwise have to pay to filter and treat our water.

Links

- Details of the Schuylkill Project and summaries of the physical, chemical, and biological data can be found at: www.stroudcenter.org/schuylkill/
- For a downloadable, printer-ready copy of *Understanding Stream Conditions: Lessons From an 11-Year Study of Macroinvertebrates in Eastern Pennsylvania's Schuylkill River Watershed, with a Focus on Exceptional-Value and High-Quality Streams,* go to: www.stroudcenter.org/schuylkill/Schuylkill_Summary.pdf
- For a downloadable, printer-ready copy of *Protecting Headwaters: the Scientific Basis for Safeguarding Stream and River Ecosystems*, go to: www.stroudcenter.org/research/PDF/ProtectingHeadwaters.pdf
- For more information on Stroud Water Research Center's work with the Philadelphia Water Department, go to: www.stroudcenter.org/about/louiskaplan.htm

Stroud scientist Anthony Aufdenkampe is examining the biogeochemical properties of tributaries throughout the Congo watershed to understand the connection between large rivers and climate change. Shown here, the upper Ubangui River, the largest tributary of the Congo.

Photo: Anthony Aufdenkampe

The Congo

LARGE RIVERS AND THE LINK TO GLOBAL WARMING

Anthony Aufdenkampe is one of a handful of scientists who have worked extensively in the world's two largest rivers. The Stroud™ Water Research Center biogeochemist has authored several papers, including two in the prestigious journal *Nature*, on the Amazon and the role it plays in carbon sequestration and global warming. Now he is turning to the second largest river in the world in an effort to learn more about the connection between rivers and the global carbon cycle.

The Congo River in equatorial Africa is second only to the Amazon in the volume of its water and the size of its watershed. But unlike the intensively studied Amazon, almost nothing is known about the Congo. Aufdenkampe, with colleagues from across the world, intends to change that. Because of the river's size and because it flows through the vast rainforest of central Africa, which is even wetter than the Amazon basin, the scientists believe they can learn a great deal about the interaction between the river and its forest and the consequences of that interaction for climate change.

There are reasons why so little is known about the Congo. While the Amazon is navigable deep into its continent, the Congo is marked by impassable waterfalls, including Inga Falls, the world's largest, which lie fewer than 100 miles from the

ocean. So difficult is the river to penetrate that it took Henry Stanley 999 days of hell to trace its course, and when he finally reached its mouth in 1877, more than two-thirds of his original group were dead. Today, the 2,900-mile river flows through lands where war and genocide have been constant threats, and these heavily militarized regions have created a huge impediment to research. "But the basin is a big place and much of it is empty," said Aufdenkampe. "The conflicts tend to be localized, and you can avoid those areas."

For Aufdenkampe, the Congo project offers an opportunity to return to a place that had a formative influence on his career. Fresh out of college in 1992, he joined the Peace Corps and set off for the Central African Republic where he lived for two years on the banks of the Sangha River, one of the Congo's largest tributaries. There he taught subsistence farmers sustainable techniques to improve their yields, and spent hours in his canoe exploring the secrets of the river.

"I have always loved rivers," he said, "and before I went to graduate school to study the Amazon, I joined the Peace Corps to get a hands-on understanding of issues in the tropics — and particularly of the scientific, political and social factors that impact a tropical river."

Having taken what he learned in his Peace Corps years to the vast Amazon Basin, he is now bringing the combined experience back to Africa. "Although smaller than the Amazon," he said, "the Congo is similar in many ways. But there is one critical exception: the Andes Mountains and the huge amounts of sediment they discharge into the river, sediments that sequester a lot of carbon." Studying that difference, Aufdenkampe believes, will yield important clues to understanding how a large river affects global climate.

In 2008, two members of the Congo River research team (Robert Spencer, University of Reading, U.K. and Johan Six, University of California at Davis, U.S.A.) collected samples from six sites along the River and sent them back to Aufdenkampe and other team members around the world for detailed laboratory analyses. The team has submitted one article for publication, and two more are in preparation. This work is exciting and important, said Aufdenkampe. "There are few, if any, published studies that integrate so many different types of biological and chemical analyses on a single river.

"Our group is uniquely positioned to compare the two rivers," he noted. "The world's largest dataset on Amazon River biogeochemistry sits in my laptop computer, and I also have the largest existing set of Amazon sediment and water samples in my lab. I am now part of an exceptionally experienced team studying carbon dynamics in the Congo River with potential to increase our knowledge of those dynamics by a quantum leap."


Photo: Rob Spencer, University of Reading, U.K.


Photo: Bonnie Dickson

Left: The bridge over the Congo River at Matadi, near one of the six initial sampling sites selected by the research team for analysis. Right: Aufdenkampe during his two years as a Peace Corp volunteer in Africa, where he taught local farmers sustainable agricultural practices designed to preserve moisture, conserve water and reduce erosion — and where he gained a true understanding of the scientific, political and social factors that impact a tropical river.

Research Projects

Nutrient balances in an estuarine salt marsh

Funded by: Kent County, Delaware

This two-year study is designed to determine whether salt marshes are a net producer or consumer of nutrients and whether nutrients from Kent County's wastewater treatment plant are significantly contributing to zero oxygen conditions in the Murderkill River estuary. Kent County will use this information to determine whether the treatment plant should be moved.

Principal Investigator: Anthony K. Aufdenkampe

Collaborator: William Ullman (University of Delaware)

Consequences of erosion and deposition in the Fly River, Papua New Guinea, on carbon cycling and climate change

Funded by: National Science Foundation OCE-0742478

This three-year research project on the Fly River in Papua New Guinea — one of the more dynamic sediment delivery systems in the world — aims to determine whether the combined effects of mountain erosion and deposition in flood plains and estuaries have important local or global consequences for carbon cycling and climate. In 2008 we began analyzing archived samples and are planning field expeditions for 2009.

Principal Investigator: Anthony K. Aufdenkampe

Collaborators: Miguel Goni (Oregon State University), Rolf Aalto (University of Exeter, United Kingdom), Wes Lauer (Seattle University), Bill Dietrich (University of California, Berkeley)

Earthworm invasion: Investigating changes in soil chemistry and carbon sequestration

Funded by: U.S. Department of Agriculture (USDA)

Human activities over the last 100 years have introduced exotic earthworms into many pristine northern forests. The fronts of these "earthworm invasions" are moving at 15-30 feet per year, bringing with them radical changes to forest ecology and soil chemistry. Our study is designed to examine whether earthworms increase or decrease carbon storage in forest soils, with consequences to greenhouse gases and climate change. In 2008 we began the process of analyzing samples that we had collected prior to receiving USDA funding.

Principal Investigator: Anthony K. Aufdenkampe

Collaborators: Kyungsoo Yoo (University of Delaware), Cindy Hale (University of Minnesota, Duluth)

The first assessment of Congo River organic matter chemistry and reactivity

Funded by: Stroud Water Research Center

The Congo River is the second largest river in the world, but warring neighbors have made its study logistically difficult, so little is known about it. In 2008, we conducted a pilot study to demonstrate our ability to collect water samples at multiple locations throughout the watershed and show the relevance of describing their biogeochemical properties. From our results we submitted one publication and a research proposal to the National Science Foundation to extend the project.

Principal Investigator: Anthony K. Aufdenkampe

Collaborators: Rob Spencer (University of Reading, U.K.), Peter Hernes and Johan Six (University of California, Davis), Aron Stubbins (Old Dominion University)

Abandoned mine drainage remediation and stream function

Funded by: Pennsylvania Department of Environmental Protection (Growing Greener)

Abandoned mine drainage (AMD) impacts thousands of stream miles in PA. This project expands earlier studies of the effects of AMD on stream ecosystems in PA's bituminous mining region to three new streams in the anthracite mining region. Research includes effects on macroinvertebrate community composition, nutrient utilization, ecosystem metabolism, leaf litter degradation and microbial enzymatic functions. The study also evaluates how well remediation of AMD restores stream biological communities and functions by comparing polluted to unpolluted reference streams.

Principal Investigator: Thomas L. Bott

Collaborators: John K. Jackson, J. Denis Newbold and Bernard W. Sweeney (Stroud Water Research Center), Matthew McTammany (Bucknell University), and Steven Rier (Bloomsburg University)

Long-term research in environmental biology (LTREB): How stream ecosystems respond to reforestation and climate in a tropical dry forest

Funded by: National Science Foundation DEB 0516516

Twenty years of research on tropical streams near the Maritza Biological Station in northwest Costa Rica provide the framework for this study. We expanded our efforts to include sites near Santa Rosa and Rincón de la Vieja in an effort to include a wider range of environmental conditions. This study examines stream responses to large-scale, passive re-establishment of tropical dry forests, as well as to the natural moisture gradients (wet versus dry seasons, rain versus dry forest sites) that define much of the character of the Guanacaste Conservation Area.

Principal Investigator: John K. Jackson

Collaborators: Louis A. Kaplan, J. Denis Newbold, Thomas L. Bott, Anthony K. Aufdenkampe (Stroud Water Research Center), Julio Calvo (Instituto Tecnológico de Costa Rica Escuela de Ingeniería Forestal, Costa Rica)

Spatial and temporal variation in water quality among Exceptional Value streams in Pennsylvania

Funded by: William Penn Foundation

This research and education/outreach project continues our efforts with local watershed groups to monitor macroinvertebrates in streams throughout the Schuylkill River basin. In 2008 our work expanded to include Exceptional Value streams outside the Schuylkill River basin to better understand the fauna in southeastern Pennsylvania.

Principal Investigator: John K. Jackson

Collaborator: Bernard W. Sweeney

Implications of parthenogenesis and hybridization for stream insect communities

Funded by: Pennswood No. 2 Research Endowment and the Stroud Endowment for Environmental Research

Our multi-year focus on the virgin reproduction and hybridization of *Centroptilum triangulife* and *Centroptilum alamance* has been expanded to include a number of related and unrelated mayfly species in White Clay Creek as well as in streams throughout eastern North America. Our most recent work has concentrated on hybridization between two heptageniid mayfly species that are genetically distinct but which are

given the same name, *Macaffertium modestum*, in morphological keys.

Principal Investigator: David H. Funk

Collaborators: Bernard W. Sweeney, John K. Jackson

Macroinvertebrate monitoring of water quality

Funded by: Various public and private sources

These macroinvertebrate monitoring projects use aquatic insects, such as mayflies, stoneflies, and caddisflies, to assess current water quality at sites in the following rivers and streams: Flint River, GA; Mississippi River, MO; White Clay Creek, PA and Susquehanna River, PA. Where long-term data are available, we compare current conditions with conditions observed 5, 10, 20 and 30 years ago.

Principal Investigator: John K. Jackson

Collaborator: Bernard W. Sweeney

Using a bioassy to measure the potential of polymer solutions to support bacterial growth

Funded by: Rohm and Haas

We inoculated test solutions of 15 different polymers used in water treatment with two species of bacteria known to grow on a wide variety of molecules. We then measured the growth of the bacterial inoculum to determine if the carbon in these polymers can support bacterial growth and to determine their biological stability.

Principal Investigator: Louis A. Kaplan

How organic molecules from the watershed influence energy flow in stream ecoystems

Funded by: National Science Foundation DEB 0516516

We grew young deciduous trees in chambers enriched with the stable isotope of carbon, harvested and composted the trees, and extracted the compost to prepare a "tea" of complex, microbially modified molecules. We are now following the fate of those organic molecules in artificial laboratory streams and through releases of the molecules into 1st through 5th order natural streams to learn how the organic molecules are used for energy in a river network.

Principal Investigator: Louis A. Kaplan

Collaborators: J. Denis Newbold and Anthony K. Aufdenkampe (Stroud Water Research Center), Robert H. Findlay (University of Alabama), and Peggy H. Ostrom (Michigan State University)

Biofilm ecology in Philadelphia's East Park Reservoir distribution system and the efficacy of control strategies

Funded by: Philadelphia Water Department

Most microorganisms in nature grow attached to surfaces, encased in a protective matrix or biofilm. Our research focuses on the growth and control of microbial biofilms in the East Park Reservoir distribution system. Ultimately, we will test different disinfectant agents for their ability to inactivate distribution system biofilms.

Principal Investigator: Louis A. Kaplan

Collaborators: David A. Stahl (University of Washington) and Anne K. Camper (Montana State University)

Connecting the hydrologic cycle from hillslopes

Funded by: National Science Foundation EAR 0450331

This collaborative research will generate the first model that links the water and carbon cycles of river catchments by focusing on the interactions of water movement and organic carbon in hillslope soils, individual stream reaches, and over the entire river network.

Principal Investigator: Louis A. Kaplan

Collaborators: J. Denis Newbold and Anthony K. Aufdenkampe (Stroud Water Research Center), and George M. Hornberger (Vanderbilt University)

Long-term research in environmental biology (LTREB): Changes in stream ecosystems in response to a maturing streamside forest

Funded by: National Science Foundation DEB 0424681

This project addresses long-term changes in a stream ecosystem in southeastern Pennsylvania to evaluate best management practices for streamside lands and provide a time frame for ecosystem recovery during reforestation. Educational and outreach programs will transmit these findings to farmers and landowners for implementation, to public officials and community groups for policy considerations, and to teachers and students.

Principal Investigator: Louis A. Kaplan

Collaborators: J. Denis Newbold, Anthony K. Aufdenkampe, Thomas L. Bott, John K. Jackson, Bernard W. Sweeney, Charles L. Dow

Dynamics of organic particles in river ecosystems

Funded by: National Science Foundation (NSF) DEB 0543526

To understand and quantify how small streams influence downstream rivers, we are using innovative methods such as tracing with fluorescent dyes, respirometry, flow cytometry, stable isotope analysis, and simulation modeling to study the movement of microscopic organic particles. We are also developing special educational resources under NSF's Research Experience for Teachers (RET) program.

Principle Investigator: J. Denis Newbold

Collaborators: Anthony K. Aufdenkampe and Louis A. Kaplan (Stroud Water Research Center), Aaron I. Packman (Northwestern University), and James N. McNair (Academy of Natural Sciences of Philadelphia)

The importance of streamside reforestation for reducing nonpoint-source pollution in small streams

Funded by: Pennsylvania Department of Environmental Protection, U.S. Environmental Protection Agency, U.S. Forest Service, and Pennsylvania Department of Natural Resources

This ongoing project to track water-quality improvements provided by a riparian forest buffer in the Stroud Preserve, Chester County, PA, indicates that, 15 years after planting, the buffer reduced the nitrate export from the agricultural watershed by 30% and the suspended sediment export by 55%.

Principle Investigator: J. Denis Newbold

Collaborator: Bernard W. Sweeney

Evaluating the seasonal effects of short-term temperature change on macroinvertebrates and fish in streams and rivers

Funded by: PPL Corporation

We are conducting laboratory studies to test the effects of different levels of temperature changes to fish and macroinvertebrates during a 24-hour period in both winter and summer to better understand thermal discharges.

Principal Investigator: Bernard W. Sweeney

Collaborators: William H. Eldridge, John K. Jackson

Education Projects

The science of water through the world of art

Funded by: Point Lookout Farmlife and Water Preserve Foundations

This program at Point Lookout Preserve seeks to expose students and teachers to new ways of thinking about stream ecosystems and stewardship through the creative process of art and science. Fifty-eight high school students from Delaware and Pennsylvania participated in the program that combined watershed science, artistic exercises, canoeing, and introductions to the art of the Brandywine Valley through guided tours of the Brandywine River Museum and Jamie Wyeth's home and farm. In addition, 14 teachers from three states took part in a weeklong, 30-credit-hour, continuing education summer institute, *The Science of Water Through the World of Art,* and Stroud staff presented a workshop, *Dream Scene: Gardening for Stormwater*, at the American Horticultural Society's 16th annual National Children and Youth Garden Symposium.

Water quality and stream health in eastern Pennsylvania

Funded by: NASA

Center educators, along with the Central Bucks School District, the Heritage Conservancy and the Peace Valley Nature Center, provided programming to 250 people to show the impact of almost four decades of suburban expansion, rural development, dam construction and environmental regulations on the region's freshwater sources.

Consortium for scientific assistance to watersheds (CSAW)

Funded by: Pennsylvania Department of Environmental Protection, Growing Greener Stewardship Funds

As part of the CSAW program, a partnership of nine organizations across Pennsylvania whose goal is to teach conservation groups how to conduct effective watershed assessments and restoration efforts, Center educators provided technical assistance to a variety of organizations, ranging from county conservation districts to municipal environmental advisory committees, and from watershed associations to citizen action groups.

Leaf pack as a water quality monitoring tool

Funded by: E. Kneale Dockstaeder Foundation

Stroud educators and entomologists joined together to test the effectiveness of leaf packs as easy-to-use monitoring devices for citizen groups. Comparing the results with those from widely accepted monitoring techniques on six sites along White Clay Creek, the Center found strong preliminary evidence that leaf packs can accurately differentiate between polluted and clean streams.

Mountaintop to Tap photography and journal exhibit

Funded by: Catskill Watershed Corporation, New York City Department of Environmental Protection, New York State Department of Environmental Conservation, Virginia Wellington Cabot Foundation

The Mountaintop to Tap exhibit, which records the three-week trek of a diverse group of high school students who traced New York City's drinking water supply from its headwaters in the Catskill Mountains to Central Park, was on display at the Catskill Center for Conservation and Development's Erpf Gallery, the Queens Museum of Art and the Sidney Public Library. Through their photographs and journal entries, as well as in a documentary film, the teenagers tell the compelling tale of their journey and the story of what it takes to deliver and protect the drinking water for 9 million New Yorkers.

Streamkeepers

Funded by: New York State Department of Environmental Conservation

In partnership with Hudson Basin River Watch and Riverkeeper, Stroud educators trained teachers in the New York City watershed in stream ecology and the Leaf Pack through a series of two-day workshops. The workshops focused on how streams function and on helping teachers integrate Leaf Pack into their classroom curricula.

Schuylkill buffer strategies

Funded by: William Penn Foundation

This project brought together several organizations with different expertise to help municipalities in Pennsylvania's Schuylkill River watershed create and adopt streamside tree-planting ordinances to protect their freshwater resources. Stroud educators conceived and led the project, provided the scientific rationale for the ordinances, and gave presentations to educate the public, while other groups brought ordinance-writing, community organizing and public dialogue skills to the table. Four townships reviewed new ordinances, one of which was adopted in 2008. The Center staff provided the townships with posters demonstrating the benefits of riparian buffers, led public meetings in Berks and Montgomery counties, developed the template for a web site, and helped prepare a comprehensive article on streamside forests.

Schuylkill learning community

Funded by: William Penn Foundation

Members of the education department participated in the Schuylkill Learning Community, an association of William Penn Foundation grantees working on projects in Pennsylvania's Schuylkill River watershed, which met throughout the year to discuss both various problems in the watershed and collaborative solutions to address them.

Leaf Pack ambassadors

Funded by: Private donations

Stroud Water Research Center translated into Spanish the manuals for its popular Leaf Pack Experiment and Watershed Tour® and in October, hosted the "Leaf Pack Ambassadors," a weeklong workshop in Spanish and English, in which Center staff taught effective and affordable methods for understanding and protecting fresh water. Eighteen educators, conservation workers and government officials from Costa Rica, Guatemala, Peru, Mexico and Texas were introduced to Leaf Pack and Watershed Tour® and agreed to present a similar workshop within six months of their return home.

Watershed curriculum development for middle schools

Funded by: Applestone Foundation

Stroud educators worked with faculty at the Upland Country Day School in Pennsylvania to develop, implement and evaluate educational materials to increase quantitative, data collection and analytical skills through the study of watersheds.

University of Pennsylvania graduate studies program

Funded by: University of Pennsylvania

Stroud scientists taught *Introduction to Freshwater Ecology* and educators taught the following three courses in the graduate program of Environmental Studies at the University of Pennsylvania:

- *Science, Policy and Management of Rivers and their Watersheds*
- *Environmental Science for Teachers*
- *Contemporary Issues in Environmental Studies*

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2008

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Annual Fund Contributions

It is only by knowing how healthy streams and rivers work, and what happens when they become polluted, that we can determine how to protect this vital resource now and for generations to come. Your gift to the 2008 Annual Fund enabled us to continue the freshwater research and watershed education programs that are helping to protect, preserve and restore fresh water everywhere. With loyal support from you, the Friends of the Stroud Water Research Center, our work will continue for many years to come.

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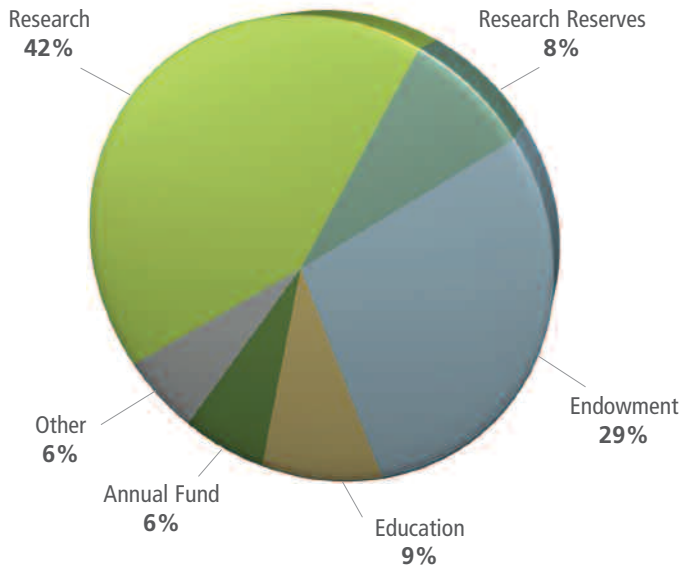
2008

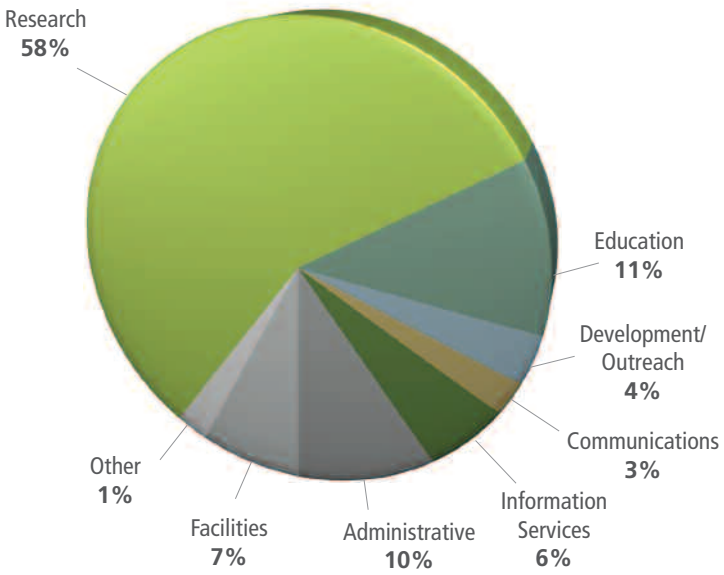
Operating Statement
for the year ended December 31, 2008

Revenues & Support	
Research Programs (Grants & Contracts)	$1,903,300
Endowment	1,306,992
Education/Public Programs	413,853
Research Reserves	345,543
Annual Fund	286,382
Other Contributions & Income	268,766
Total Revenues & Support	**4,524,836**
Expenditures	
Research	2,557,952
Education	507,140
Administration	462,180
Facilities	338,799
Information Services	271,388
Development/Outreach	162,297
Communications	115,554
Other	109,526
Total Expenditures	**4,524,836**

2008 Operating Revenues & Support



2008 Operating Expenditures



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2008

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Ph.D. Candidate, University of Pennsylvania

David C. Richardson
Ph.D. Candidate, University of Maryland

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Director, Communications & Marketing

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