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Inside this edition: Water management

Volume XXIV Number 1 Spring 2009

UNIVERSITY of GUELPH

CHANGING LIVES
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Research magazine

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Water's bright future

PLUS

Graduate students Bailey Davis (left) and Patrick Soo are working with Prof. Steven Liss to keep municipal water safe and pure. See story on page 25.


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Volume XXIV Number 1 Spring 2009

Research

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magazine

Spring 2009
Focus: Water Management

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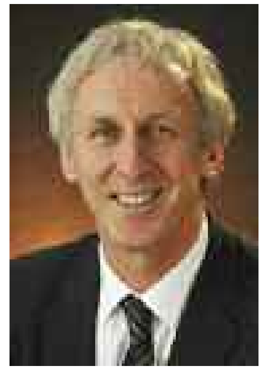
Cover Photo: Martin Schwalbe

A river runs through our research enterprise



Kevin Hall

If you're part of the research community — or if you follow the daily media — you probably know the University of Guelph's global reputation for leadership in agri-food research. You know how broadly that expertise reaches into areas such as food, health, the environment, sustainable rural communities and economic stability.

And it turns out that every one of those areas is touched by water.

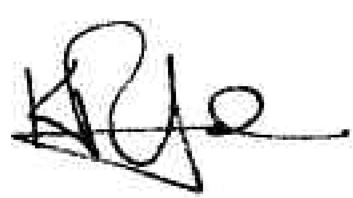
I think you'll be surprised at how much water research expertise you're about to see in the pages of this issue of *Research*, and how Guelph researchers are actively managing water at home and abroad.

Publicly, water has risen to a new place of prominence, particularly because of concerns about global warming, urbanization and food safety. Each of these either has an impact on water or is driven by its availability and cleanliness.

Water is one natural resource with no substitute. It's vital that the University of Guelph with its expertise in basic and applied science take a lead in helping better manage this asset. The alternative is unacceptable and unthinkable.

Improved water management is one of society's imperatives. We'll get there by following the four disciplines that also guide us through this publication — biological processes, security and source protection, conservation and health.

This edition of *Research* magazine, written and compiled by participants in our Students Promoting Awareness of Research Knowledge (SPARK) program, will bring further attention to the need for continuing water research to maintain our most valuable natural resource. As always, I welcome your comments and perhaps the opportunity to partner with you in these essential research endeavours.



Kevin Hall
Vice-President (Research)

The University of Guelph Research magazine is written and co-ordinated by students involved in the University's Students Promoting Awareness of Research Knowledge (SPARK) program.

Guelph temperatures dropped to -30 C this past winter, but SPARK writers were undeterred in their zeal for some quality pool time at the University's W.F. Mitchell Athletics Centre. It gave them a well-deserved break from their studies and their writing schedules, which they met with enthusiasm and commitment. There's no question: They jumped in with both feet!

Arthur Churchyard, who grew up in Guelph, has learned about varied solutions to environmental degradation throughout his four years of environmental studies at U of G. He was excited to learn more about recent leaps in water safety achieved by the Odanak First Nation communities in Quebec, and the training videos they produced to ensure safe drinking water for remote areas across Canada. See his story on **page 45.**

Having grown up on a dairy farm near Walkerton, Ont., **Lindsay Brown** knows the importance of choosing the best agricultural management practices for minimizing water loss. So she was especially interested in seeing tillage practices researchers have found to accomplish this goal. Lindsay, a fourth-year toxicology and marketing management student, reports on **page 13.**

Fourth-year biophysics PhD candidate **Robert Fieldhouse** grew up in Guelph familiar with the city's waste-water treatment facilities. Now, while doing his own studies in molecular and cell biology, he's able to understand how the facilities could benefit from the waste-water filtration technology Guelph researchers have developed to enhance water quality for industrial cooling, irrigation, recreation and even drinking. See **page 28** for his story.

Waterskiing and tubing are two of **Andrea Hruska's** favourite water sports when she visits Ontario's Mazinaw Lake in the summertime. While writing her article on page 10, Andrea, a third-year marketing management student, learned aquatic life that naturally keeps lakes clean is sustained through a process called mass transfer. See **page 10** for the Hamilton, Ont., native's story about zebra mussels' role in mass transfer in Lake Erie.

Every summer, fourth-year environmental biology student **Maria Dombrowsky** enjoys swimming and fishing near her hometown of Tweed, Ont. Although the tall water plants in Tweed's fishing ponds thrive with their roots in the lake bed, Maria has learned that some drought-tolerant plants can thrive just as well in water-scarce areas. Read more about these plants in her article on **page 12.**

Katharine Tuerke, a psychology and toxicology doctoral candidate from Oshawa, Ont., understands that contaminated water can be damaging. But even water that's subpar can serve a purpose for certain activities, such as irrigation practices, that might not necessarily require drinkable water. Read Katharine's article on **page 42** about reclaimed water and how it could be used to irrigate golf courses.

Photo By Frank Owens and Dave Peleschak |

Third-year biological engineering student **Matthew DiCicco** moved from his hometown of Guelph to acquire hands-on knowledge about water treatment plants for his co-op term in Collingwood, Ont. At the plant, Matthew was eager to apply what he learned about adaptive capacity and how understanding it can improve water systems. See his article on **page 48**.

Anupriya Dewan, a fourth-year nutrition and nutraceutical science student, knows it's important to isolate any harmful toxins from food before they spread elsewhere. For example, waste water produced on farms after milking cattle can't be disposed of without being treated to remove milk solids that could contain harmful bacteria. This native of Brampton, Ont., found that wetlands being custom-designed to properly filter water near farms are treating these contaminants and others to protect nearby streams and rivers. See story on **page 34**.

Natalie Osborne, a first-year biomedical sciences student, spent her childhood wishing she could live under the sea. Instead, she grew up on a farm near Guelph Lake, spending time maintaining her tropical fish aquariums. While writing her article on **page 11**, she learned how a process called meta-community dynamics is applied to help researchers understand and predict how aquatic organisms adapt to changes in their aquatic environments.

During the winter, **Kaitlyn Little**, hailing from St. George, Ont., likes to enjoy water in its frozen state while ice skating and curling. Kaitlyn learned that even the river and lake water she skates on goes through a heavy treatment process before it's safe to drink. Read the fourth-year public management student's story about improving current water treatment processes on **page 44**.

Ashley Morin spent summers fostering an appreciation for water while vacationing at Balsam Lake, Ont. As she became familiar with how harsh weather can affect water quality, Ashley – a fourth-year marketing management student from Waterdown, Ont. – became concerned that global warming may eventually threaten bodies of water just like those in the Kawarthas. See her story on **page 47**.

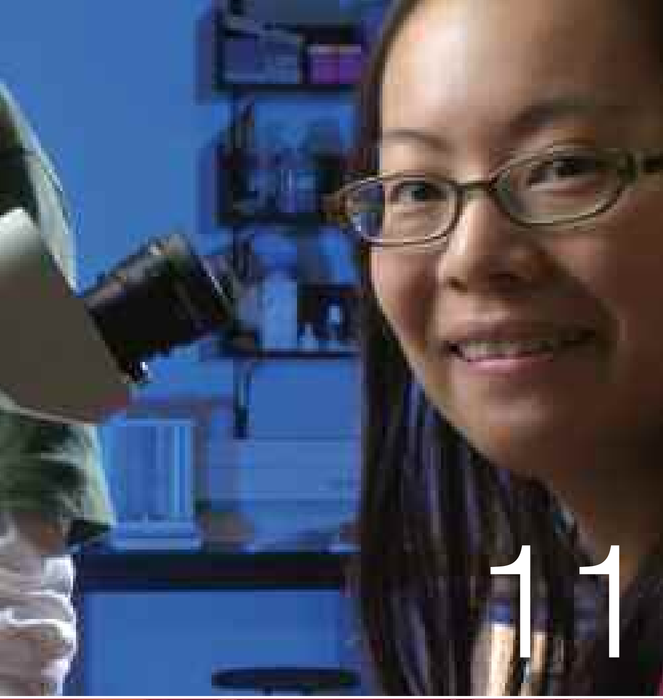
Hayley Millard, a bachelor of commerce graduate originally from Oakville, Ont., knows staying hydrated helps her to stay fit as a rower. It also gives her the ability to keep up with freelance writing jobs and co-ordinate this 56-page *Research* magazine. Hayley writes about the way many people in North America have become ill with cryptosporidiosis from their drinking water over the past decade. Read more about this water-borne illness on **page 46**.

Thank you, Athletics Centre pool staff, for helping to arrange these photos.

Growing their future together with practical applications in waste water management

A Proud Partnership

A unique membrane filter developed at the University of Guelph is being used to monitor the purity of the city's water. Here, researcher Hongde Zhou (left) and graduate student Amanda Farquharson (front) are pictured with City of Guelph manager, waste-water services, Cam Walsh and Guelph Mayor Karen Farbridge at the city's waste-water treatment facility.



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Jumping in w

Vice-president (Research) Kevin Hall (front), interim associate vice-president (Research) Rich Moccia and associate vice-president (Research services) Steven Liss.

Photo By Martin Schwalbe |

with six feet

Guelph's research administration leaders are also water-related research experts

BY ARTHUR CHURCHYARD AND ASHLEY MORIN

Underlining the University of Guelph's research expertise in water management are administrative leaders Prof. Kevin Hall, vice-president (research); Prof. Steven Liss, associate vice-president (research services); and Prof. Rich Moccia, interim associate vice-president (research) agri-food and partnerships. Together, they have more than 80 years of water management experience in water treatment microbiology, civil and humanitarian engineering and aquaculture sustainability. They've created new technologies, policies and procedures that are improving water quality and sustainability in Canada and around the world.

From surf to safety

Humanitarian water engineering is signature to **Prof. Kevin Hall**, who joined the University of Guelph as vice-president (research) Jan. 1.

Hall has 22 years of experience in applying science to water solutions in Canada and developing countries. He currently supervises more than a dozen graduate students, half of whom have moved with him to Guelph. They're involved in his diverse humanitarian projects – whether it's developing appropriate water-filtration units for urban slums in India or designing artificial coral reefs that create jobs for local artisans and fishers in post-tsunami Sri Lanka.

Three of his students are now in the South Pacific learning more about wave action, problems with garbage gyres and ways to use cameras to assess coral reef health instead of taking invasive samples.

"I'm thrilled to be working in a research community that embraces change," says Hall. "Working with innovative minds to help people around the world is what makes my job so enjoyable."

School of fish

Aquaculture is being touted lately as one way to save the world's wild fish stocks. But 30 years ago, when **Prof. Rich Moccia** became interested in it, it was mainly another way for farmers to diversify and make more money.

Back then, fresh out of graduate school, he was a fish health specialist working at the Ontario Veterinary College for the Fish Pathology Laboratory. Now, aquaculture has evolved, and so has Moccia. He's a faculty member in the Department of Animal and Poultry Science, chair of the M.Sc. aquaculture program and interim associate vice-president (research) agri-food and partnerships, serving as the University's main day-to-day contact with the nearly $80-million annual agreement with the Ontario Ministry of Agriculture, Food and Rural Affairs.

Moccia continues to stay closely connected to the aquaculture sector. His research is based on various approaches to modelling and monitoring impacts on water quality — from quantifying the level at which ecosystems can assimilate and use nutrients to looking at social responsibility in decision-making and ecotoxicology. He's dedicated to building a better bridge between science and policy-makers to create the best approaches for smart regulation of the aquaculture industry in Ontario.

"It's great to be immersed in the breadth of expertise across all disciplines at the University, whether it's fish health management, aquaculture science, engineering, economics or food safety," says Moccia. "Guelph is a natural home for aquaculture research."

When microbes stick together

Microbes can be either helpful or harmful to engineered environmental systems such as waste-water treatment plants, and engineers need more information about how microbes interact to manage them biologically.

That's where **Prof. Steven Liss** comes in. Liss, who is associate vice-president (research services) and a faculty member in the Department of Environmental Biology, co-ordinates multiple research projects that examine how pathogens and other microbes behave.

One of his main interests is microbial flocculation, a process in which bacterial microbes clump together. This process is as important in biological waste-water treatment as it is in natural rivers and watersheds.

Liss is trying to create ways to reduce energy requirements to more efficiently manage the biological processes associated with bioflocculation and other microbial interfaces, and improve water quality from treatment systems.

His research extends to minimizing impacts from industrial emissions, as well as advancing new technologies such as membrane systems for waste-water applications.

Another major focus of his research is the fate and transport of pathogens in surface water and groundwater, a process that can be significantly affected by the way pathogens interact with microbes that tend to stick together in clumps and films.

"I am fortunate to work not only with outstanding facilities and analytical technologies but also with students from high school to graduate level," says Liss. "My goal is to increase these valuable partnerships to produce excellent research along with highly capable researchers."

See related story on **page 24**.

A human/nature partnership

Natural ecosystem in lakes and oceans helps keep water clean

BY ANDREA HRUSKA

The world's natural water ecosystem, including plant and aquatic life, works overtime to clean the lakes and oceans humans began polluting many years ago. Maintaining the ecosystem's natural function is possible only through a process called mass transfer, which explains how dissolved and particulate matter moves and interacts with aquatic ecosystems.

Researchers at the University of Guelph have used mass transfer to better understand low oxygen levels in lakes and the impact of zebra mussels on water clarity in Lake Erie. Integrative biology professor Joe Ackerman, associate dean of the Faculty of Environmental Sciences, and his research team found that as zebra mussels filtered the water for their own use, they made 40 per cent of Lake Erie

Prof. Joe Ackerman prepares an underwater instrument tripod for mass transfer research in Lake Erie.

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Nature Matters!

A Voice for the Environment

The Honourable David Anderson knows that the policy decisions we make about climate change will affect the saltwater marsh where this little fish thrives, and all of the ecosystems that protect Canada's water resources. As director of the Guelph Institute for the Environment, he draws on his past experience as a federal minister of both fisheries and the environment and as a president of the Governing Council of the United Nations Environment Program. Over the past two years he has connected innovative University researchers with policy-makers at all levels of government. Together, they are helping to address urgent issues affecting the environment and our food supply, water and health.

Nature speaks. David Anderson and the University of Guelph listen.

GIE Guelph Institute for the Environment

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— the lower portion — appreciably clearer.

This is a natural process for bottom-dwelling or "benthic" aquatic life, and it helps clean lakes and oceans. Ackerman calls it an "ecosystem service" that humanity couldn't do without.

"Problems occur when humans change natural patterns in our ecosystems," he says. "For example, introducing large amounts of pollutants can overwhelm the aquatic life's capacity to use them. It takes longer to clear the pollutants, and they accumulate and cause further problems."

As they go about their cleansing, benthic plants and animals manipulate the water currents that flow through their leaves or shells in unique ways. They do this to absorb dissolved nutrients or filter particulate matter they use as food.

That's what Ackerman and his team found was happening in Lake Erie. There, water is stratified 60 per cent of the time, meaning there's a separation between the sun-heated warm water on the surface and the colder water below. The zebra mussels on the bottom of the lake have cleared the colder water to such an extent that there's a noticeable difference between the upper and lower "layers."

"In the environmental sciences, we need to understand how the environment functions," says Ackerman. "If you understand the basic principles, then you can use that information to figure out how to fix problems after humans have made changes to the environment."

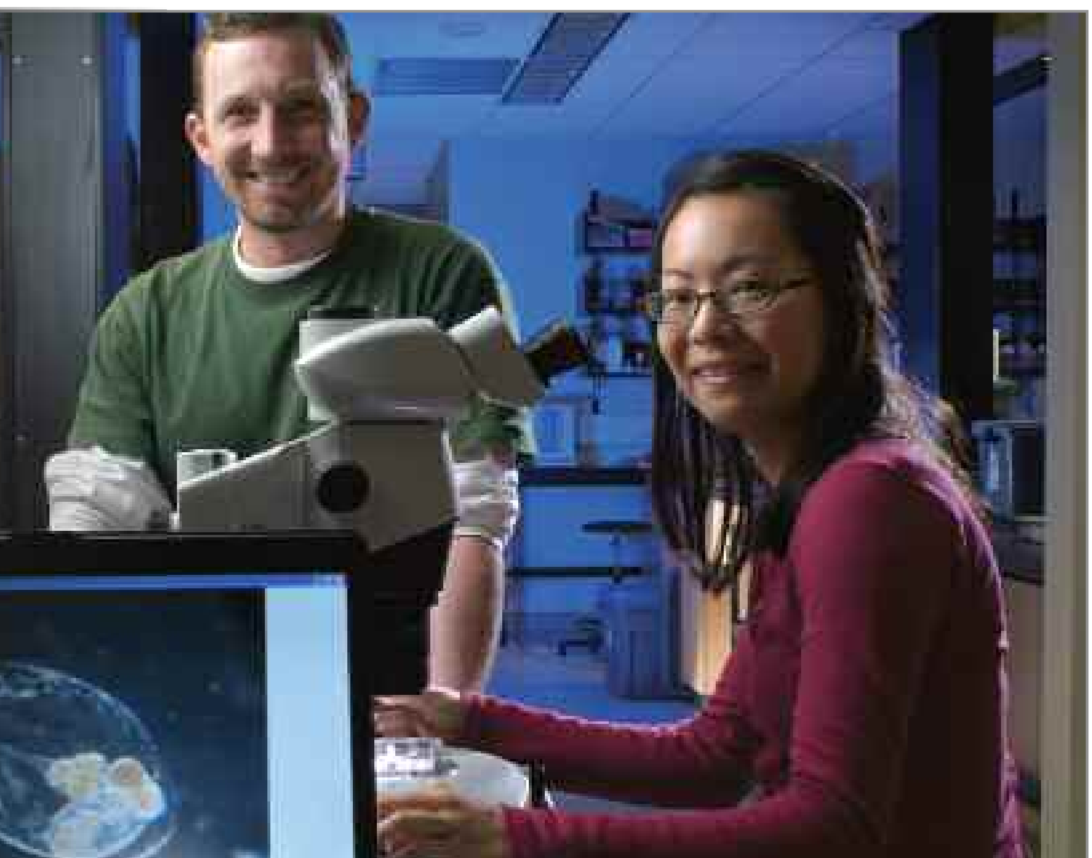
His collaborators include Profs. Leon Boegman of Queen's University, Mark Loewen of the University of Alberta, and Kevin Lamb and Ralph Smith of the University of Waterloo, as well as research scientist Ram Yerubandi of the National Water Research Institute.

Funding and support for Ackerman's research has been provided by the Natural Sciences and Engineering Research Council's discovery grant program, the Endangered Species Recovery Fund, Environment Canada, the World Wildlife Fund and the Department of Fisheries and Oceans. R

Logging and the life aquatic

BY NATALIE OSBORNE

Microscopic images of zooplankton shown on the monitor in front of Prof. Karl Cottenie and Ingrid Ng help the researchers monitor changes in the organisms' environment.



Studying aquatic life through a biological process called metacommunity dynamics — which looks at a species' ability to thrive in its natural surroundings and survive specific conditions — is helping ecologists understand how ecosystems respond to changes in the environment.

▲ *Continued on page 12*

| Photo By Martin Schwalbe

▲ Continued from page 11

Researchers at the University of Guelph are using this same principle to evaluate the effects of logging on neighbouring bodies of water. This work is intended to help design conservation practices that would more effectively address the needs of different ecosystems.

Integrative biology professor Karl Cottenie says metacommunity dynamics could determine the impact of foreign species on Ontario waters or the early effects of climate change on aquatic life.

"Metacommunity dynamics is similar to human cultural studies," says Cottenie. "It focuses on how the culture and society of isolated populations change and adapt when new people or ideas are introduced through communication technology or emigration."

A research project led by graduate student Ingrid Ng examined 21 headwater lakes in northeastern Ontario. The forests surrounding the lakes had been logged in 2005, leaving various unlogged buffer zones ranging from 60 to 200 metres around each lake. Water and zooplankton samples were taken from the lakes' zooplankton colonies to examine the relationships among buffer zones, water chemistry and the zooplankton communities.

The study found that logging had an effect on zooplankton communities, but the changes didn't appear to result from altered water chemistry, as previously thought. Instead, increased sediment runoff and changes in the larger predators of the ecosystem's food chain were the speculated causes. The researchers say further analysis is needed to identify the specific link between zooplankton and their environment.

Based on work with metacommunity dynamics, Cottenie hopes to develop ecological models for the potential effects of climate change on aquatic ecosystems in larger bodies of water. The ability to predict the progress and success of a species will help determine conservation practices that could put ecologists a step ahead of climate change.

Funding for this research was provided by the Natural Sciences and Engineering Research Council and the Canada Foundation for Innovation.

Friendly fungi fight drought

Arbuscular mycorrhizal fungi could be thirsty plants' conduit to life-giving water

BY MARIA DOMBROWSKY

When it comes to drought, fungi are like a cool drink on a hot day.

Most plants can't survive in water-scarce areas for long, but some are more drought-tolerant than others. Researchers are trying to determine characteristics that help plants cope without an abundance of water, and they're finding that naturally occurring soil fungi have a lot to do with it.

Prof. Hafiz Maherali of the Department of Integrative Biology is examining wild plants in assorted environments to learn how some can survive water scarcity and still complete photosynthesis successfully. He wants to know the genetic makeup of plants native to drought areas versus plants living in water-abundant areas, to figure out how drought tolerance has evolved and, potentially, how to transfer drought-tolerant genes to plants that are less tolerant.

Arbuscular mycorrhizal fungi form symbiotic relationships with more than half of all plant families. They grow on plants' roots for their entire lifespan, and being much thinner than plant roots, they can go into the smallest soil pores in search of water. The exact mechanism of transfer has yet to be discovered, but researchers are on it.

Here's what they do know: The fungi allow water to be transferred from the soil to the plant when conditions are dry. In return, the fungi thrive on the plant's sugars.

Maherali's research is focused on why some plants have this relationship with fungi and others do not. He's looking at the roles of ecology, evolution and genetics.

"There's a lot of potential for this research in the agricultural industry," he says. "If we can find a way to make field crops more drought-tolerant, we will reduce the need to irrigate and will conserve water."

He is currently examining a Mediterranean annual grass called *Avena barbata*. The plant is common in California and is a close relative of cultivated oats. The results from genetic and evolutionary studies with *Avena barbata* will help him develop approaches to breeding drought-tolerant crops.

Fields of *Avena barbata* grass in the arid foothills of California's Sierra Mountains survive thanks to water-absorbing fungi on their roots.

Maherali is collaborating with Prof. John Klironomos, Integrative Biology, doctoral student Mark Sherrard and undergraduate student Noah Sokol.

Funding for this research is provided by the Natural Sciences and Engineering Research Council, the Ontario Ministry of Research and Innovation, the Ontario Innovation Trust and the Canada Foundation for Innovation. R

Water-friendly farming

Which tillage practices limit transpiration and evaporation?

BY LINDSAY BROWN

Water lost through a combination of plant transpiration — the evaporation of water from plants — and evaporation from the land's surface is called evapotranspiration. A certain amount occurs naturally, but it's exacerbated by such things as land use — especially tillage, which disturbs the soil — and a plant's normal growth. Excessive evapotranspiration can cause significant water loss, and researchers at the University of Guelph are trying to determine how to mitigate its effects.

Since 2001, Prof. Jon Warland, Land Resource Science, and a team of researchers have been looking at how different agricultural management techniques affect

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| Photo By Mark Sherrard

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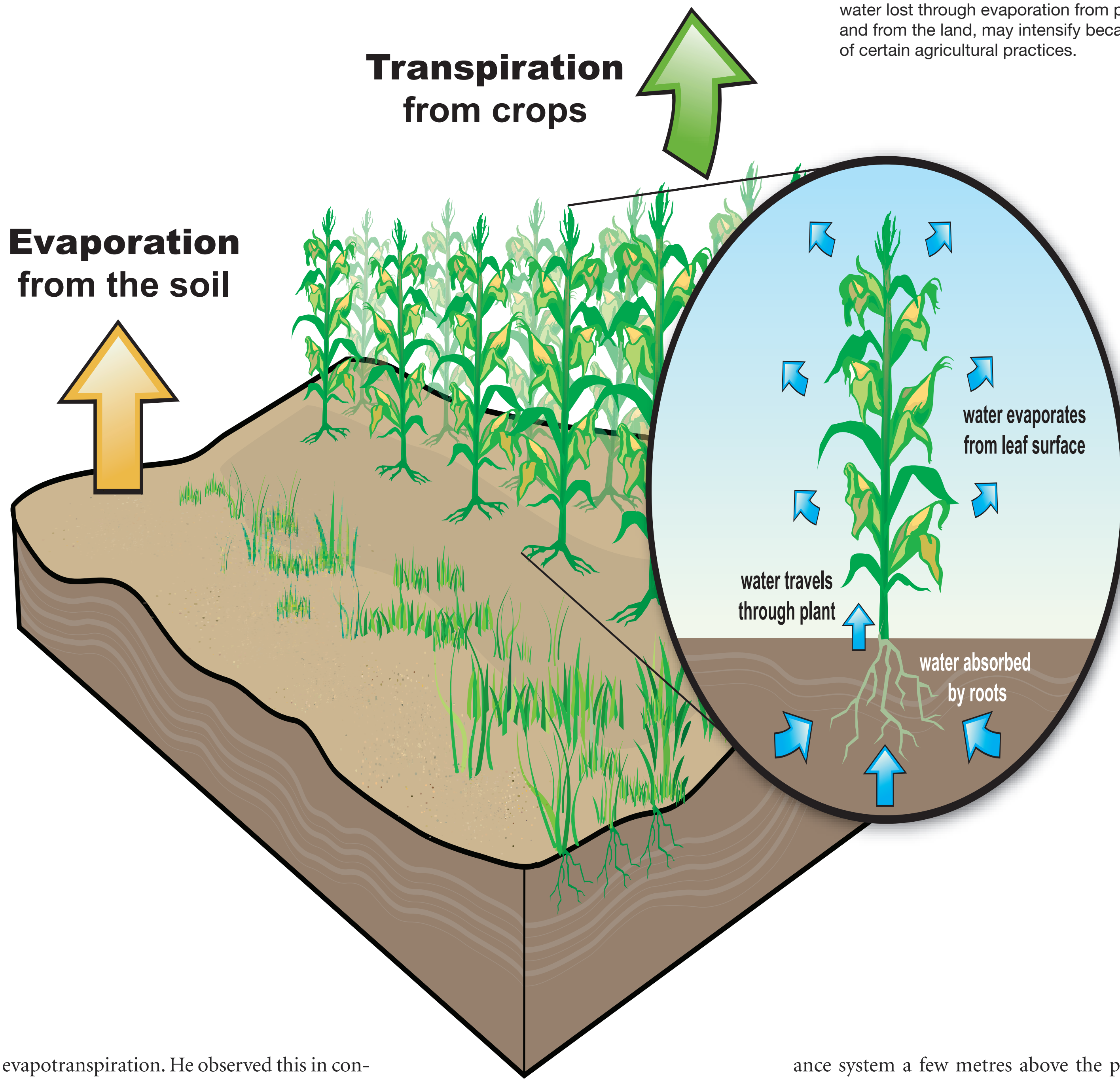

Evapotranspiration, a combination of water lost through evaporation from plants and from the land, may intensify because of certain agricultural practices.

evapotranspiration. He observed this in conventional tillage, which involves turning over the soil with a plow, and in no-till, where the roots and lower portion of plant stalks are left in the ground.

"When developing agricultural management practices, producers should consider the type of tillage used as it may increase or decrease the loss of water through evapotranspiration from the watershed," says Warland.

The water lost from plants during the growing season naturally affects their growth and productivity. To absorb the atmospheric CO_2 that is also required for growth, a plant must open up the pores on the underside of its leaves. Once the pores open up, water is lost through transpiration. The faster a plant grows, the more water it needs as an increasing amount is lost through the pores.

Warland and his research team measured evaporation and transpiration year-round at 30-minute intervals. They positioned measurement instruments called an eddy covariance system a few metres above the plants or crops. Overall, a no-till environment improved water conservation because of the improved soil structure, and there was no significant reduction in yield.

Research collaborators include Profs. Claudia Wagner-Riddle and Gary Parkin, Land Resource Science; Prof. Aaron Berg, Geography; and PhD candidate Nasim Alavi.

Funding for this research is provided by the Canada Foundation for Innovation; the Ontario Ministry of Agriculture, Food and Rural Affairs; and the Natural Sciences and Engineering Research Council.

Illustration By Brandon Denard |

Helping farmers out of a deep problem

Groundwater recharge must be balanced with proper irrigation for crops to survive

BY KATHARINE TUERKE

Deep drainage, or groundwater recharge, occurs when water moves downwards from the surface and past a crop's root zone to become groundwater. This happens naturally when it rains, but it's vital that any excess water lost through deep drainage be balanced with proper field irrigation so that plants have the water they need to grow.

One U of G researcher has found that certain irrigation strategies most effectively minimize the effects of deep drainage to ensure farmers' crops will thrive. Prof. Gary Parkin of the Department of Land Resource Science is using the simultaneous heat and water (SHAW) computer model to estimate the amount of irrigation needed to balance out deep drainage in two different climatic regions in British Columbia — Abbotsford and Osoyoos.

This model accounts for seasonal changes in water, such as freezing in the winter, thawing in the spring and potentially dry summers. These are all important for Canadian producers to consider when evaluating how much water to use to irrigate their crops.

"Best irrigation management practices decrease the negative impacts of deep drainage on the environment and crop yield," says Parkin. "They should be profitable for farmers."

Producers can benefit from proper irrigation strategies by measuring their fields' water content to determine when to irrigate without wasting water, he says. These strategies can be applied across many different farms and require only minor adjustments on the producer's part to account for differences in climate and crop needs.

Parkin compared the effects of different irrigation strategies on deep drainage when the water in the crop's root zone fell below a certain capacity. Raspberries and apples were irrigated using two different strategies — one added 40 millimetres of water and the other added 60. In both Abbotsford and Osoyoos, he found that the 40-mm strategy resulted in less deep drainage.

Deep drainage, or groundwater recharge, forces water downwards below a growing crop's root zone, so proper irrigation is required to balance this natural effect for crops to flourish.

Many agricultural soils also have high salt levels, which dehydrate the soil to an extent and reduce the amount of water plants can take up, leading to poor growth and yield. Minimizing deep drainage could cause further buildup of salt in the crop root zone. Next, Parkin will investigate different irrigation strategies that could minimize the effects of soil salt content on crop yield.

Other contributors to this project include research assistant Robin Wang, research scientist David Fallow, technician Peter von Bertoldi and University of Waterloo professor David Rudolph.

This research was funded by the Canadian Water Network and the Natural Sciences and Engineering Research Council.

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Digging in

Researchers drill down on groundwater contaminants

BY MATTHEW DICICCO

Groundwater represents more than 96 per cent of all fresh water on the planet, not including the water tied up in ice caps and glaciers. Aquifers are highly permeable layers of sand, gravel or fractured bedrock that provide drinking water to more than eight million Canadians and most of the world's population.

Much of this groundwater is exposed to contamination, and as industrialization and intensive agriculture expand, contamination becomes more common.

U of G engineering professor Beth Parker, who holds the Natural Sciences and Engineering Research Council (NSERC) Chair in Groundwater Contamination in Fractured Geologic Media, is studying how groundwater movement transports contaminants and how to remediate groundwater that's already contaminated.

"With population growth, the demand for fresh water is increasing in many communities, including Guelph," says Parker. "We need to provide solutions to existing problems and develop better plans to protect groundwater and reduce the likelihood of impacts on human and ecosystem health."

Groundwater contamination occurs in many ways, including migration down through natural fractures (small fissures or cracks) in clay deposits spread across the top of freshwater aquifers. These contaminant pathways exist in many regions, including parts of southern Ontario.

Industrial organic chemicals such as chlorinated solvents like tetrachloroethene, trichloroethene and chloroform are denser-than-water oil-like liquids. Commonly used in many industries, they are exceptionally prone to sinking through fractured clay deposits and entering aquifers used for community water supplies. Many cases of this type of contamination have been found in Guelph and most towns and cities.

▲ *Continued on page 18*

Prof. Beth Parker (left), along with California university researchers Vicki Padone (right) and Ross Wagner, is dwarfed by this natural display of sandstone rock near Los Angeles, where they are studying the migration and fate of chlorinated solvents through the fractured bedrock.

| Photo By Mike Perkins

▲ *Continued from page 17*

Once in the aquifer, these oily liquids slowly dissolve, producing plumes of chemicals that can eventually cause nearby community wells to be shut down.

Parker and her collaborators have been using new approaches to investigate clay deposits at many locations across North America to determine fracture origins and influences. This research is needed to better understand how contaminants enter aquifers in different geological situations.

Another focus of her research is groundwater contamination in bedrock, which also involves fractures serving as pathways for groundwater flow and contaminant migration. Fractured sedimentary bedrock aquifers provide water for communities in Guelph and Cambridge, not to mention thousands of others around the globe. Parker's research currently involves intensive studies of representative contaminated bedrock industrial sites — two in the Guelph-Cambridge area, one in California and one in Wisconsin.

She says the groundwater system's behaviour and its interactions with rivers, wetlands and lakes need to be understood and represented realistically in mathematical models. This will help government and industry make science-based decisions about sustainable options for increasing water supplies.

Contaminants Parker is studying include oily liquids, dissolved molecules and small particles such as viruses and bacteria.

Her research receives funding from NSERC, the Boeing Company, Schlumberger Water Services, Syngenta Crop Protection, Guelph Tool, the Canada Foundation for Innovation, the City of Guelph, the Ontario Research Foundation and the Ontario Geological Survey. She also receives support from many private-sector companies, including AquaResource Inc., Ardvaark Drilling, Gerrits Drilling, R.J. Burnside and Associates, Geosyntec Consultants, Golder Associates, FLUTe Ltd. and Solinst Canada.

Since 2006, the Ontario Clean Water Act has required that all communities produce a source-water protection plan for water quantity and quality, which must be updated every five years. But existing knowledge is inadequate to create such a plan for bedrock groundwater communities such as Guelph. So a multi-institutional project using Guelph as the model community has recently been initiated to advance the science, with the University of Guelph as the lead.

Engineering professor Beth Parker and her collaborators have begun the first phase of a major groundwater field research and education facility, located on U of G's main campus. One focus of the project is to establish intensive and innovative monitoring systems for all aspects of Guelph's hydrological cycle.

Parker is also collaborating on a project in Wisconsin, where viruses have been found in municipal wells pumping water from fractured bedrock. She's using this experience to guide further studies in Guelph.

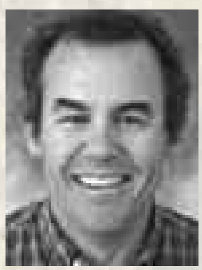
The dirt on septic bacteria

Nearly a metre of soil is needed to properly filter harmful contaminants

BY KATHARINE TUERKE

A thick layer of soil located below a septic system filters waste water by removing harmful bacteria and chemicals before this water becomes groundwater. But little is known about how changes in septic soil depths alter how many bacteria the soil can filter.

U of G engineering professor Doug Joy could change that. He's found that proper soil depths can reduce the number of bacteria present to acceptable levels.



Prof. Doug Joy

"The Walkerton tragedy demonstrates how source-water protection is essential to human health," says Joy. "Without correct waste-water filtration, contamination of groundwater, surface water and nearby wells is possible."

He studied septic systems in new rural home and subdivision areas and found that some bacterial reduction occurred within two shallow soil measures taken at 0.375 and 0.75 metres. But a soil depth of at least 0.9 metres is needed to consistently decrease the bacteria concentration to a safe level.

Joy also found that large daily changes in bacterial levels depend on how regularly homeowners use their septic system. Less use means less contaminated water needing to be filtered and fewer bacteria building up. A soil depth of 0.9 metres minimizes the impact of these changes, too, and protects groundwater.

"Deeper soil levels provide greater decreases in bacteria concentrations," he says.

He will continue to measure waste-water quality in rural septic systems over the coming year and will examine the impact of adding a treatment unit between the septic tank and soil layer.

Other contributors to this research are Weber Septic Services, engineering master's student Peyman Tehrani, project co-ordinator Katherine Rentsch of the Ontario Rural Wastewater Centre and individual homeowners.

Funding for this project was provided by the Ontario Ministry of the Environment and the Natural Sciences and Engineering Research Council. R

| Photo By iStock

Bringing arsenic to a halt

Researchers are developing system to immobilize arsenic in water

BY LINDSAY BROWN

Arsenic, a notoriously poisonous compound, can either bind to other elements or not. It's extremely adaptable, which means it can make its way into groundwater with relative ease. Arsenic interacts with plant roots and soil, which further changes its chemical properties, allowing it to be mobilized in the groundwater.

Either way, it's a problem. The World Health Organization says more than 50 million people worldwide are drinking groundwater with arsenic concentrations above a safe standard.

Prof. Susan Glasauer, Land Resource Science, is studying how arsenic converts into the mobilized form that causes soil and water contamination.

"Through understanding arsenic's properties at the molecular level, we hope to find a way to immobilize arsenic in both water and soil," she says.

Glasauer is working with the Kinross Gold Corporation — the third largest primary gold producer in North America by reserves — to learn how arsenic is affecting water near the Kinross gold mine in Paracatu, Brazil.

There, arsenic is found in association with excavated ore rocks. After gold is extracted from the rocks, arsenic becomes part of the waste rock in tailings piles, which are the left-over materials from mining ore.

Glasauer and her Brazilian collaborators will study the chemical forms of arsenic in soils around the mine. The mobility of arsenic is strongly affected by reduction and oxidation reactions that are typically controlled by micro-organisms in the soil. The zones around plant roots are target areas to look for oxygen-controlled arsenic cycling because the rich chemistry in those areas facilitates electron transfer reactions. Through these chemical interactions among the plants, soil and arsenic, the physical properties of arsenic can be altered, mobilizing or immobilizing the arsenic in the soil, depending on the conditions.

After Glasauer studies the oxidation and reduction reactions that affect arsenic chemistry, she hopes to develop a series of wetland treatment cells that depend on micro-organisms, wetland plants and mineral precipitation to immobilize the arsenic for safe removal. A doctoral student in her group, Al Mattes, has developed a similar treatment system for arsenic-contaminated water in Trail, B.C.

Funding for this research has been provided by the Kinross Gold Corporation of Paracatu, Brazil. Research collaborators include Jamie Mellio of Kinross and Guelph land resource science professors Beverley Hale and Les Evans. R

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Environmental Sciences Research Initiative

The Environmental Sciences Research Initiative (ESRI) is a fund designed to develop new and existing environmental research at the University of Guelph. Approved projects are provided with funding to assess the university's research capacity, to hold a workshop involving faculty and external stakeholders (university, industry, and government), and to generate a research proposal. An annual call for funding involves a three-page online form, which is evaluated for quality, interdisciplinary scope, innovativeness, societal relevance, internationalism, and likely research outcomes. Past projects have involved the Community Energy Plan, Corporate Social Responsibility, and the Guelph Pollinator Park (pictured at right).

Faculty of Environmental Sciences

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In parts of Paracatu, Brazil, arsenic from excavated ore can become mobilized in the groundwater.

| Photo By Beverley Hale

Keep it deep if it comes from sheep

Research prevents sheep manure contamination from hitting home

BY ANUPRIYA DEWAN AND KAITLYN LITTLE

Photo By Pam MacKenzie

Sheep manure bacteria have been linked to multiple groundwater contamination outbreaks in several European countries. Canada hasn't seen a similar problem yet, but sheep populations are growing as Canadian tastes diversify.

As a precaution, researchers at the University of Guelph's affiliate campuses in Kemptville, Ridgetown and Alfred are collaborating to develop a risk assessment program that will help farms identify possible sources of contamination from manure. Ultimately, it would allow farmers to take preventive measures to keep water clean.

Kemptville Campus director Prof. Michael Goss is spearheading one study that will determine how sheep manure contaminates groundwater, so preventive measures can be designed for Ontario farmers. His research will lead the agricultural industry towards a better understanding of waste management and possibly new regulations for waste control.

"We want to prevent an outbreak from happening here," says Goss.

Sheep manure is commonly used as fertilizer, but even this simple action can result in contaminants being transferred to surface water during heavy rainfall, he says.

Conditions near the soil surface can encourage bacteria to multiply. But incorporating the manure fertilizer deeper in the ground delivers the manure bacteria to soil microbes, which can eliminate the pathogens. That makes it a safer fertilizing method.

A study by PhD student Aala Ali monitored changes in the number of bacteria during sheep manure storage. The results showed that high pH levels in manure bedding may also kill any pathogenic bacteria present in storage.

Although these findings are significant for the prevention of groundwater contamination, other risks from sheep manure bacteria might not be so easy to uncover. That's why Goss and his team developed FarmRas, a risk assessment program that will help farmers reduce the likelihood that their agricultural practices will contribute to pathogenic bacteria harming ground or surface water.

FarmRas is a stand-alone computer program that uses information from farmers about their acreage and practices to develop a risk assessment for their farm's ground and surface water based on microbial contaminants that could be present. Farmers can use that assessment to prevent water contamination by considering whether their manure storage facilities should be improved or if their septic system needs repair.

This project is a collaborative effort involving numerous researchers. They include Profs. Susan Glasauer, Richard Heck, Gary Parkin, John Lauzon and Kari Dunfield of Guelph's Department of Land Resource Science; Prof. Paula Menzies, Population Medicine; Profs. Ramesh Rudra, Doug Joy and Bill Van Heyst, Engineering; Shu Chen of Laboratory Services; Jim Fisher and Paul Sharpe of Kemptville Campus; and Prof. Chris Kinsley of Alfred Campus.

Funding for the project has been provided by the Ontario Ministry of Agriculture, Food and Rural Affairs; the Natural Sciences and Engineering Research Council; Health Canada; Agriculture and Agri-Food Canada; Dairy Farmers of Ontario; and Ontario Pork.

It's not broke. Fix it.

Preventing damage to deteriorating water pipelines is cheaper and safer than waiting for them to break

BY ANDREA HRUSKA

The wear and tear on Ontario's water transport pipelines, along with inefficient water testing, is brewing up an underground storm for municipalities. That's prompted a University of Guelph researcher to look for ways to reduce contamination risks by identifying the cause and considering how water-testing procedures could be updated.

Prof. Ed McBean, School of Engineering, and his research group believe it's more efficient to identify underground systems that are at risk of fracturing before they break. More frequent maintenance is vital; isolating the parts of the system at risk will significantly reduce the likelihood of widespread contamination if a pipe breaks, he says.

McBean has identified several areas of a water transport infrastructure that could be at risk and reasons for that vulnerability. Those reasons include the pipes' age and composition.

"We need to better manage the assets," he says. "By making better decisions as to when the pipes should be replaced, we can avoid some water contamination that may occur beyond the treatment plant."

Problems with testing abound

McBean also believes current methods of testing contamination could be improved.

When a break occurs, the water supply is tested as soon as possible for contaminants. A combination of water-quality indicators can enhance pathogen detection, which helps authorities decide whether or not a boil-water advisory should be issued.

Unfortunately, it can take up to two days to get results from the first of these tests, potentially putting more people at risk in the meantime. Another problem is the

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Ahmad Asna, a post-doctoral fellow working with Prof. Ed McBean, examines a cache of fractured water pipes.

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high number of false positives that occur in those initial tests.

"A boil-water advisory can't be issued for every initial positive we get because of the high chance of a false positive after further testing," says McBean. "If there are hundreds of boil-water advisories, it makes for a 'cry wolf' situation and people will stop listening."

What's needed, he says, is an alternative testing method called real-time testing. In this procedure, the initial pathogen detection test and other water-quality indicator tests could all be done at the same time on a regular basis.

If a positive result is confirmed by the combination of tests, it can be considered reliable and timely, giving a municipality good reason to promptly issue a boil-water advisory, says McBean. Real-time testing will reduce false positives and substantially diminish the risk of drinking unsafe water, he says.

He collaborated on this project with Profs. Bahram Gharabaghi and Ramesh Rudra, Engineering; and Prof. Al Lauzon, Environmental Design and Rural Development.

Funding and support for this project have been provided by the Natural Sciences and Engineering Research Council and Public Safety and Emergency Preparedness Canada under the Public Health Agency of Canada.

McBean has held the Canada Research Chair in Water Supply Security since 2003. R

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Environmental Science Research Directory

The university has considerable breadth and depth in terms of research capacity in the environment. Unfortunately, it is often difficult to know "whom is working in what area" often in the next department or college. The Environmental Science Research Directory was created as tool to help identify environmental researchers at the University of Guelph.

Anyone can query the directory located at http://www.envsci.uoguelph.ca/people/research-directory or http://www.gie.uoguelph.ca/people/research-directory/ by subject, keywords, or name to locate researchers across campuses. The directory is designed to be dynamic and can be updated easily through an email request to fescoord@uoguelph.ca.

Faculty of Environmental Sciences

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Photo By M. Farid |

The sticky side of water and waste-water treatment

On the cover

Guelph microbiologists improve water treatment by better understanding bacteria's physical-chemical interactions

BY ARTHUR CHURCHYARD

Water and waste-water treatment systems could be improved with a better understanding of how bacteria behave. Little is known about the physical-chemical interactions of bacteria in these systems, such as how they stick to each other and other surfaces.

To that end, a University of Guelph microbiologist is working closely with engineers and operators of waste-water treatment plants to find new ways of advancing technologies, developing better strategies for water disinfection, and improving water sampling methods that detect harmful pathogens.

Prof. Steven Liss, associate vice-president (research services) and a faculty member in the Department of Environmental Biology, is leading a team of microbiologists exploring the interface between microbes and engineered environmental systems. Their goal is to equip engineers and operators with more effective techniques for removing water-borne pathogens.

"Collaborating across disciplines is extremely important in my research," says Liss. "By collaborating, we build tools in the laboratory that can be transferred to systems designed by engineers and operated by the water treatment industry."

He co-ordinates multiple projects that investigate the ways microbes behave in water and waste-water treatment systems.

For example, he and his collaborators at the University of Toronto are using a new technology called the membrane-aerated bioreactor (MABR). It is submerged in waste water and uses biofilms that develop when bacteria exude sticky molecules that allow them to form a film on surfaces such as filtering membranes. The MABR can support a biofilm on its membrane, which is fed with oxygen gas to support the biofilm. This process uses less energy than current technologies and can operate at higher capacities.

Graduate students Patrick Soo (left) and Bailey Davis study microbial risks in water systems.

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| Photo By Martin Schwalbe

▲ Continued from page 25

But undesirable biofilms can form and bind too tightly to a submerged MABR's membrane, a process called biofouling. When that happens, membrane permeability decreases, making the treatment system inefficient. Liss is investigating the mechanisms behind biofouling to contribute to better control strategies and system design.

Collaborating with industry partners such as GE-Zenon Environmental Inc., he is also using his microbiology expertise in applications such as improved industrial pulp and paper emissions processing and well-water sustainability in rural Ontario.

On the horizon, Liss sees his research progressing through continued studies of microbial flocculation and film structures that advance innovations in technology and improve understanding of important environmental processes. This work is directed in several key directions, including:

- minimizing environmental impacts of industrial emissions;
- further developing membrane bioreactors that would require less energy;
- better characterization of fixed film-activated sludge systems that use both suspended growth forms and fixed biofilms to treat waste;
- developing biorefining strategies for more effective waste-water treatment options; and
- studying the fate of pathogens in natural and engineered systems.

Liss's work will be supported by research associate Mahendran Basuvaraj, PhD candidate Sandra Tirado and master's students Patrick Soo and Bailey Davis. Tirado is focused on pathogens' transport, survival and ultimate fate in water systems. Soo is quantifying microbial risk in water systems to determine the exact consequences of different levels of tiny microbes called protozoans. Davis is studying enteric viruses in source water.

Funding for this research is provided by the Canadian Water Network; Agriculture and Agri-Food Canada through the Agricultural Bioproducts Innovation Program; the Ontario Ministry of Agriculture, Food and Rural Affairs; Environment Canada through the Best of Science program; the Ontario Centres of Excellence; and the Natural Sciences and Engineering Research Council.

Biofilms such as the dark substance on this pipe may be effective barriers that can break down contaminants before they enter water sources.

Those environmental cocktails called biofilms

Biofilms are extremely diverse in composition and can stick to almost any object whose surface provides sufficient water and nutrients, such as river rocks. The slippery covering that forms on them is a biofilm.

A biofilm consists of layers of micro-organism communities that can form in aquatic environments. Biofilms can contain bacteria, archaea, protozoa, algae and fungi, whose cells all produce an adhesive matrix that binds the micro-organisms together.

One of the beneficial properties of a biofilm is that it can help purify surface water and soil by breaking down organic wastes and pollution. This property allows researchers such as Prof. Steven Liss to use biofilms in waste-water treatment facilities.

And complex mathematical models may be used by researchers such as Prof. Hermann Eberl to understand how biofilms form and function in various aquatic environments. This is important to understand because biofilms can have positive effects on waste-water filtration but adverse effects on human health and water infrastructure if they function abnormally.

In the future, strategically placed biofilms in soil could act as a buffer zone for purifying drinking water by processing pathogens before they reach the water source.

Using math to solve a microbial mystery

BY NATALIE OSBORNE

Not all biofilms are a problem. In fact, mathematics is giving insight into how biofilms may actually help environmental engineers prevent groundwater contamination and protect drinking water.

University of Guelph mathematics professor Hermann Eberl says biofilms can create effective natural "bio-barriers" in the soil. In doing so, they keep carcinogenic pollutants such as polyaromatic hydrocarbon compounds, which result from burning fossil fuels, out of the water.

When biofilms flourish and expand deep underground — a process called bioclogging — they alter the arrangement of the soil particles they're attached to. They clog pores in the soil, which creates different pathways for water flowing through the ground. That affects the soil's nutrient delivery to micro-organisms and the biofilm's microbial population.

Understanding bioclogging may be the key to preventing groundwater contamination by engineering underground bio-barriers. The protective walls of microbes break down harmful contaminants before they reach the water source.

To understand how biofilms behave in different environments, Eberl is linking mathematical equations called quasi-linear diffusion-reaction systems to biofilm modelling.

Biofilm modelling is a multi-scale exercise. That means researchers must examine the microscopic biofilm to understand how its behaviour is influenced by a specific environment and, in turn, how it affects the environment.

Eberl says any attempt to accurately model biofilms in the soil with mathematics must include important details on how bacteria behave differently in variable environments and how they are interwoven with the physical processes.

"Once we understand the nature of biofilm processes, we can investigate why some bioclogging-based technologies work and others don't."

He hopes reliable theoretical models will help ecologists and engineers design and implement effective barriers to prevent groundwater contamination.

Funding for this research was provided by the Natural Sciences and Engineering Research Council and the Canada Research Chairs program. R

| Photo By Ed McBean

New membrane technology reclaims waste water

City, University join forces to improve public health

BY ROBERT FIELDHOUSE

Membrane filtration technology developed at the University of Guelph is now being used to turn waste water into high-quality water that could be available for industrial cooling, irrigation, recreation and even drinking.

Prof. Hongde Zhou, who holds a Natural Sciences and Engineering Research Council Industrial Research Chair in the School of Engineering, spearheaded the development of this technology, which is now being pilot-tested at the City of Guelph's waste-water treatment plant.

The facility is improving public health by removing water-borne disease contaminants and emerging organic micropollutants. It prevents contaminants from reaching the environment, increases sustainability through water reuse and reduces costs for manufacturers and municipalities worldwide.

"Water shortage is a serious problem in many parts of the world," says Zhou. "But with new technologies, especially in the membrane area, we should be able to help overcome this problem."

A membrane bioreactor — a chamber with waste-degrading micro-organisms and carefully configured membrane modules — forms the heart of the system. It offers a new filtration approach that combines traditional biological degradation and the separation of liquids and solids with filtration into a single step.

The bioreactor uses a novel hollow-fibre membrane made of synthetic materials that form extremely small pores. The hollow fibres increase the filtration surface area, producing superior-quality water, reducing the plant footprint and cutting costs. But instead of applying membrane filtration alone, the bioreactor integrates it directly with the biological breakdown of contaminants to further improve efficiency.

Photo By iStock

City dedicates space in million-dollar pilot facility for University research

Membrane filtration technology was invented in the 1950s but received little attention until recently. Eight years ago, Zhou joined forces with General Electric Water & Process Technologies (formerly Zenon Environmental Inc.) to develop ways to improve membrane filtration and reduce costs.

What makes Guelph's $1-million pilot facility unique are the large-scale ZeeWeed 500 membrane pilot plants fully dedicated to University research. The first major installation occurred five years ago; the facility underwent a significant upgrade last year.

Zhou says the technology has evolved step-by-step, resulting in lower costs not only for the membranes but also for the bioreactor operation and maintenance. In fact, they cost 80 per cent less than they did a decade ago.

The technology is integral to meeting increasingly strict regulations for removing contaminants, says Zhou. The bioreactor can remove nutrients such as nitrogen and phosphorus, which otherwise contribute to algae blooms that compete with fish for oxygen. It may also remove many biologically persistent organic contaminants.

This research and its benefits can span the globe, says Zhou, who believes the technology could also be used in developing countries to clean water. Some areas even take advantage of closed-loop systems where waste water is directly recycled without being returned to the environment.

"Our research is not only for Guelph," he says. "It makes a contribution in water-treatment knowledge that can be used worldwide."

Zhou works on membrane technologies with a number of collaborators: Prof. Steven Liss, associate vice-president (research services); Profs. Richard Zytner and Khosrow Farahbakhsh, School of Engineering; visiting scholar Shuguo Zhang; research associate David Heipel; graduate students Chris Potvin, Amanda Farquharson, Victor Zhang, Jennifer Pawloski, Zebo Long and Syed Wajahatand; and University of Waterloo civil engineering professor Wayne Parker.

This research is sponsored by General Electric Water & Process Technologies, the Canadian Water Network, the City of Guelph, the Ontario Research Fund, the Ontario Centres of Excellence, Environment Canada, and the Natural Sciences and Engineering Research Council.

Next: The local water movement

Creating Ontario-specific models will better protect the province's water sources

BY ARTHUR CHURCHYARD

Computer programs currently used by planners should be adjusted to Ontario conditions to better predict water quantity and quality with local information from provincial sources, say U of G researchers.

Profs. Ramesh Rudra and Bahram Gharabaghi of the School of Engineering are dissecting existing watershed models to learn how they could be improved. The enhanced programs could give water-resource managers better tools to keep water sources safe and clean.

"We are analyzing the strengths and weaknesses of these computer models to give Ontario water planners a reliable source of advice," says Rudra. "We hope our recommendations significantly improve the application of models for use in unique Ontario conditions."

Many of the water-planning models now used in Ontario were developed for conditions in the United States. But Rudra says a watershed model must be based on local hydrology to get the most out of it. That's why the Guelph team began studying information from Ontario government and conservation authorities to pinpoint the unique provincial conditions that should be represented in current watershed models.

The team has found that improving current watershed models to account for Ontario hydrological conditions will greatly enhance their accuracy. Rudra notes, for example, that spring melting sends large water quantities, soil particles and pollution into streams and lakes. Quantifying these contributions during the spring will help water planners, treatment facilities and dam managers handle the extra water volumes.

He also believes the water-purifying effects of wetlands should be given more weight in Ontario watershed models. Wetlands are needed in provincial water systems as a natural way of protecting drinking-water sources and should be conserved, he says.

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| Photo By Lake Simcoe Marine

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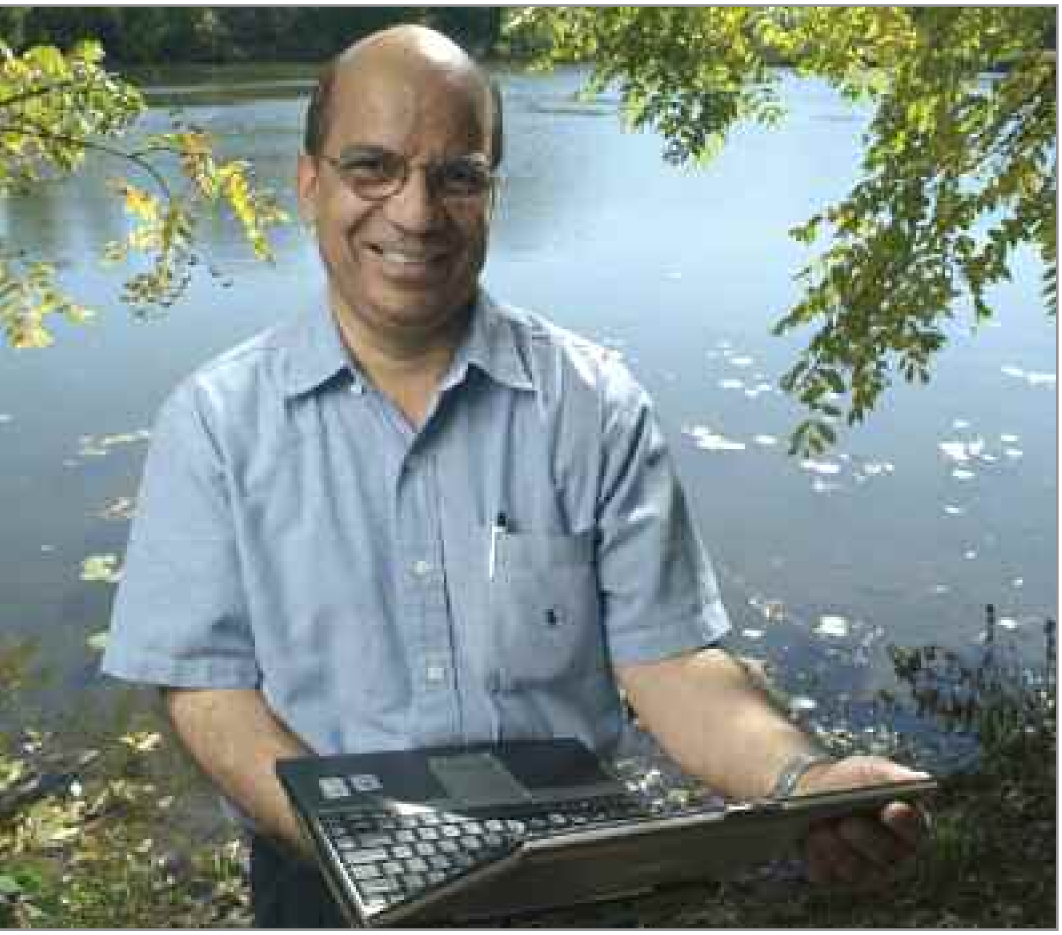

Prof. Ramesh Rudra is tailoring computer watershed models to Ontario conditions.

Water-source protection is taken seriously by environmental guardians such as the Lake Simcoe Region Conservation Authority. The authority uses a watershed model called the Canadian Nutrient and Water Evaluation Tool (CANWET). This model weighs economic costs and benefits, considers options based on social acceptability and then recommends the best management practices. These practices can sometimes be complicated, but they can also be as simple as planting a strip of vegetation beside a riverbank to prevent erosion along waterways. The Guelph Watershed Research Group has been involved in enhancing CANWET for application in Ontario conditions.

Distributed by Ontario-based Greenland International Consulting Engineers, CANWET is moving towards a user-friendly web-based service that could be used nationwide. Greenland International is staffed largely by University of Guelph alumni and hopes to incorporate the Guelph engineers' recommendations into their models.

Models such as CANWET aren't used just by conservation authorities, says Rudra. Governments use these models to make development plans such as Ontario's "Places to Grow" initiative, which encourages development in areas where the impact on source water will be minimal. By improving the suitability of these models, he and his colleagues in the Guelph Watershed Research Group will be improving the ability of water planners to protect water consumers from source to tap.

Funding for this research has been provided by the Ontario Ministry of Agriculture, Food and Rural Affairs; the Ontario Ministry of the Environment; the Ontario Ministry of Natural Resources; the Greenland International Group of Companies; and Ontario conservation authorities.

More information about the Guelph Watershed Research Group can be found at www.soe.uoguelph.ca/webfiles/watershed/Guelphwatershed.htm

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WATER@GUELPH

Research involving water is a theme that runs through the University of Guelph involving all colleges and campuses and all disciplines. We have over 20 centres, institutes, and working groups and 11 research chairs involved in the nature, delivery or quality of water. The Guelph Institute for the Environment (GIE) has taken the lead in linking these somewhat disparate groups together. The GIE hosted its first Water Colloquium at the Arboretum Centre in November 2008 to link water researchers on campus with each other and with government, industry and NGOs. This first event drew more than 100 participants including the majority of the University of Guelph's water researchers. Additional water@guelph events are under development.

GIE Guelph Institute for the Environment

Faculty of Environmental Sciences

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Photo By Martin Schwalbe |

The Speed is slowing things down

Guelph's population could be constrained by river's capacity to handle treated waste water

BY HAYLEY MILLARD

The Speed River flows south from its source near Orton, a small farm community about 20 miles from Guelph, and through the heart of the Royal City. That downstream flow brings fertilizer runoff and treated waste-water emissions to the city's share of the river. The Speed's capacity for assimilating these emissions could constrain the city's projected population growth, says Prof. Brady Deaton of the Department of Food, Agricultural and Resource Economics.

Last year, the province announced plans for Guelph to grow from its current population of 120,000 to a population of 183,000 by 2031. Based on the known assimilative capacity of the Speed River, Deaton and Nicole Coupland, an environmental science student majoring in natural resource management, realized Guelph's assigned population target did not match the river's assimilative capacity measurement.

Assimilative capacity is the ability of a body of water to safely hold a certain volume of waste, such as nitrogen and phosphorus emissions, without disrupting the water's ecology. Bureaucrats who keep tabs on population numbers know the assimilative capacity of every river in Ontario.

▲ *Continued on page 32*

The City of Guelph's population growth is limited by the Speed River's capacity for handling waste-water emissions.

| Photo By Rob McGill

▲ Continued from page 31

Last summer, the researchers set out to gain a better understanding of the Speed River's assimilative capacity and some of its limitations.

"It's vital to remember that Guelph is in a watershed area," says Coupland. "The assimilative capacity of the river is affected not only by the city's waste-water emissions but also by the emissions that come from upstream communities and farmlands."

Over the summer, she analyzed past water data, current technologies and appropriate legislature and water policies for the Speed's assimilative capacity. She reported her findings to a representative of the Grand River Conservation Area (GRCA), who informed her that phosphates were the GRCA's biggest concern for the future of clean river water.

Both phosphorus and nitrogen in excessive amounts can reduce oxygen in water and create nutrients for water-based bacteria, which cause algae to bloom. Municipal water treatment has advanced to the point where modest amounts of nitrogen and phosphorus can be removed, but phosphorus is more difficult to filter out than nitrogen is.

"The technology isn't there yet to isolate and properly remove phosphorus," says Coupland. "But on the other hand, technology can only take us so far."

This research was supported by the Department of Food, Agricultural and Resource Economics.

Keeping it clean upstream

Mark Anderson, Nicole Coupland's co-worker at the GRCA, says a more socio-economic method might be a viable solution to improving the Speed River's assimilative capacity. He says opening an environmental market between Guelph and upstream communities on the Speed has the potential to improve water quality. In an environmental market, upstream communities are paid to reduce their waste-water emissions by downstream communities whose water is suffering from the effects. This practice was successful in Cornwall, Ont., when farmers received financial incentives from downstream users to reduce nitrogen and phosphorus emissions.

GIE Guelph Institute for the Environment

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- contributing to the development of effective environmental policy by providing balanced and authoritative information
- creating opportunities for networking between University of Guelph researchers, policy makers and the community, such as Water@Guelph and Sustainability Day

WATER@GUELPH

Greening the Campus SUSTAINABILITY DAY

www.gie.uoguelph.ca

Faculty of Environmental Sciences

Managing water at 625 C

That will be the water temperature in the next generation of CANDU reactors

BY KATHARINE TUERKE

At 625 C, a reaction between two substances is unpredictable, even with water. That presents a challenge for the conceptual design of the next generation of CANDU nuclear reactors. The novel supercritical-water-cooled reactor will use exceptionally high water pressures and soaring temperatures to generate electricity. It's now in the early planning stages for construction in 2030.

To assess the interactions among reactor materials, pH and possible chemical additives put into the water at 625 C to minimize corrosion and radioactivity transport, U of G chemistry professor Peter Tremaine is using a high-resolution Jobin Yvon Raman spectrometer funded by the Canada Foundation for Innovation (CFI) and a microprobe that identifies chemical species.

"The long-term viability of these new reactors depends on our ability to predict and control water chemistry," says Tremaine.

Here's how the reactor works. Nuclear fission heats the high-pressure water to supercritical temperatures. The water then flows through highly efficient turbines to produce electricity. Hydrogen gas produced from the steam by a new thermochemical process will increase the energy released from enriched uranium, the nuclear power source.

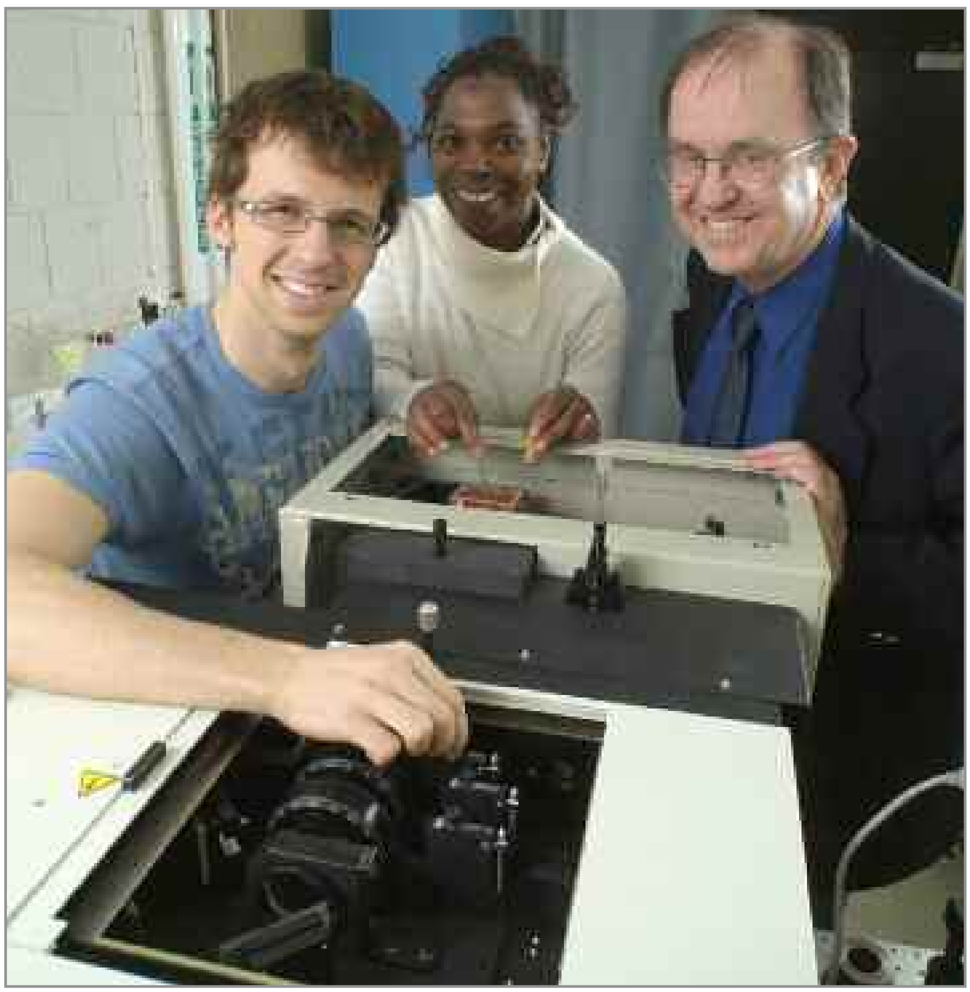
This technique will more efficiently extract electricity from nuclear fuel, along with hydrogen gas that can be used to replace natural gas and petroleum as fuel for new "green" carbon-free technologies.

But there's not much of a road map to follow. Tremaine calls this "frontier hydrothermal chemistry" because of the future reactors' unique water chemistry and because only a limited number of experimental studies on aqueous solution chemistry extend beyond 300 C.

A few challenges threaten the reactor's efficacy at higher temperatures, he says. These include corrosion, contaminant transfer within the reactor, and the effect of the extreme temperatures on the reactor's materials. They must all be controlled to keep radioactive particles out of the steam turbines.

The new spectrometer and other instruments in Tremaine's lab will measure ionization and association constants, which determine how acids, bases, dissolved metals and organic compounds react under extremely high temperatures and pressure by using quantitative equations. His goal is to produce models that can predict the behaviour of chemical additives for the new CANDU reactor design.

This research was supported by the CFI, the University Network of Excellence in Nuclear Engineering, the Natural Sciences and Engineering Research Council, Atomic Energy of Canada Ltd. and Natural Resources Canada. R



Prof. Peter Tremaine and graduate students Melerin Madekufamba (left) and Francis Brosseau use a microprobe to identify chemical species in water when producing models that can predict the behaviour of chemical additives for the new CANDU nuclear reactors.

Wetlands, not wastelands

Here's an environmentally friendly way to purify rural runoff with little maintenance

BY ANUPRIYA DEWAN

Constructed or artificial wetlands can play a significant role in purifying water on farms. They act like giant filters in treating surface water that passes through them before being released back into streams and rivers. Deep root masses in wetland plants and soil naturally extract and neutralize contaminants to enhance water quality.

Research at the University of Guelph suggests that these wetlands — based on nature's own model — can be constructed on farms to filter waste before it trickles into water systems. Maintaining these wetlands is inexpensive and provides an additional benefit — they're completely environmentally friendly.

Prof. Rob Gordon, dean of the Ontario Agricultural College at U of G, is collaborating with industry partners and universities to better design these wetlands to reduce farms' environmental impact by treating waste water at its source.

"Our goal has been to reduce rural wastewater contamination while also improving air quality," says Gordon. "These wetlands even enhance the esthetic value and biodiversity of farms."

Here's how an artificial wetland works. Water is treated through physical, chemical and biological processes that include microbial degradation of organic material, settling and filtration of solids, plant nutrient uptake and binding of phosphorus to the soil.

In most cases, 70 to 90 per cent of the concentrated waste-water pollutants are reduced through these systems.

Surface-flow wetlands, the most common to Eastern Canada, may consist of one cell or multiple cells where the water surface is exposed to the atmosphere. Individual cells often contain deep and shallow zones. Shallow zones operate at a depth of 15 to 25 centimetres and are covered with aquatic plants, typically cattails and bulrushes. Deep zones are up to 100 centimetres deep and usually make up 25 per cent of the wetlands' surface area. These deep zones allow solid particles to settle and help increase the length of time waste water is in the wetland.

Several farms in Eastern Canada have used artificial wetlands for more than a decade with the help of Gordon's graduate students, who have provided the farms with data and ideas on improving the design of these wetland systems. The research aims to better assess whether cold-climate applications will allow all wetlands to remain functional throughout the year. To date, systems have been developed to treat runoff from solid manure, dairy farm wash water, abattoir waste water and tile drainage discharge, as well as various types of domestic waste water.

They're certainly needed. Livestock farms produce waste water year-round. A dairy farm, for example, can produce several hundred litres of wash water at every milking. That water can't be disposed of unless it's treated to remove fats and milk solids, which have very high biochemical oxygen demand. Gordon designed systems in his previous post at the Nova Scotia Agricultural College.

"As long as the wetland receives the type and amount of waste water it's designed for, it should act as a low-cost treatment system for many years," says Gordon.

This project is a collaborative effort of a number of organizations, including the Canadian Water Network, the University of

Photo By Jamie Reaume |

Guelph's Alfred Campus, the University of Vermont, Dalhousie University and the University of Waterloo.

Funding for this project has been provided by industrial partners and government agencies, including the Natural Sciences and Engineering Research Council and the Agricultural Adaptation Council.

Wetlands naturally purify the water in nearby streams and rivers. Artificial wetlands could be constructed near farms to treat waste-water runoff.

Small farms need environmental management support

Environmental practices require substantial money ... and that's something small farms can lack

BY ANDREA HRUSKA

Small farms with modest gross farm sales are failing to implement as many best management practices (BMPs) as bigger operations with significantly higher sales, say University of Guelph researchers.

Prof. Glen Filson of the School of Environmental Design and Rural Development (SEDRD) and his team of graduate students surveyed small, medium and large crop and livestock farms in 2005 and 2006. They asked farmers along five southern Ontario watersheds — Raisin Region, Lake Simcoe, Maitland Valley, Grand River and Ausable Bayfield — how they implemented BMPs and how many they implemented.

The researchers found that small farms lack appropriate money, labour and knowledge to implement BMPs. That's distressing, says Filson, because BMPs are scientifically sound management techniques that help farmers reduce water contamination and soil erosion and improve air quality.

Examples of BMPs are riparian buffer strips between crops and streams, fencing livestock off from streams and properly storing pesticides and manure.

"When farms aren't adopting best management practices, it becomes a chronic problem that adversely affects water quality," says Filson.

His research group found that farm size, the adoption rate of best management practices and, to a lesser extent, age and education predicted farmers' gross sales. The study also revealed that nearly two-thirds of the farmers surveyed in 2006 were unaware of legislative regulatory acts such as the Clean Water Act and the Nutrient Management Act, which are designed to prevent water contamination.

Small farms along watersheds like the Grand River should implement best management practices to protect the water nearby.

But many farmers still expressed concern about what they perceived to be a shift from voluntary environmental management, such as adopting an environmental farm plan, to legislated farming regulations.

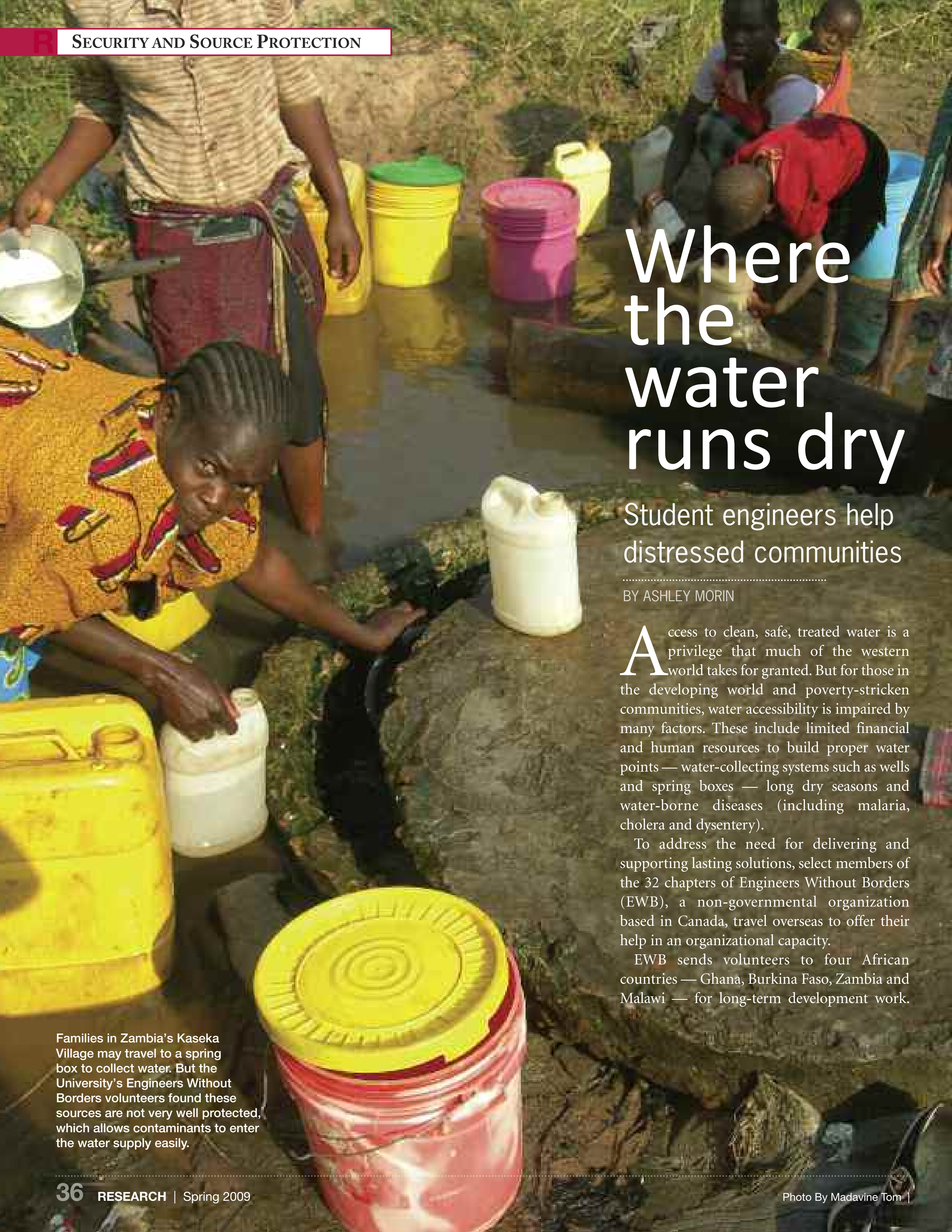
Filson suggests restructuring government programs so that small farmers can be better compensated for implementing BMPs. But he found that even though farmers usually want to be paid for producing goods and services, they don't want to be subject to environmental auditing in return for those payments.

He'd also like to see improvements in agricultural extension to improve farmers' awareness of appropriate BMPs.

"There's been slow and steady progress towards better water quality, but we have to find better ways of helping farmers produce goods and services in an environmentally friendly way that protects our water."

Other collaborators in this work include Filson's former graduate students Sridharan Sethuratnam and Pamela Lamba, as well as SEDRD research associate Bamidele Adekunle.

Funding and support for this project were provided by the Ontario Ministry of Agriculture, Food and Rural Affairs and the Ontario Ministry of the Environment.



Where the water runs dry

Student engineers help distressed communities

BY ASHLEY MORIN

Access to clean, safe, treated water is a privilege that much of the western world takes for granted. But for those in the developing world and poverty-stricken communities, water accessibility is impaired by many factors. These include limited financial and human resources to build proper water points — water-collecting systems such as wells and spring boxes — long dry seasons and water-borne diseases (including malaria, cholera and dysentery).

To address the need for delivering and supporting lasting solutions, select members of the 32 chapters of Engineers Without Borders (EWB), a non-governmental organization based in Canada, travel overseas to offer their help in an organizational capacity.

EWB sends volunteers to four African countries — Ghana, Burkina Faso, Zambia and Malawi — for long-term development work.

Families in Zambia's Kaseka Village may travel to a spring box to collect water. But the University's Engineers Without Borders volunteers found these sources are not very well protected, which allows contaminants to enter the water supply easily.

Photo By Madavine Tom

Volunteers tackle a number of high-priority issues, including the need for clean water, and work alongside community leaders to help them enhance their skills to benefit their communities. The volunteers may also assist with problems identified by the villagers themselves, such as how their limited local resources could be used more effectively.

"In the past, western technology was often dragged overseas as a solution to development problems, saying: 'This is the way you do things,' which is completely wrong," says Jim Arnold, an agricultural engineer with the Ontario Ministry of Agriculture, Food and Rural Affairs and a member of the Grand River professional EWB chapter. "To drive change, technology must be shaped to fit local needs and be incorporated into a community's social, cultural and economic realities."

U of G environmental engineering student Madavine Tom was among the EWB Junior Fellow volunteers who spent four months in Africa during the summer of 2008.

Tom was involved with water security initiatives and sanitation efforts in Zambia, working with communities on how to prevent problems related to water contamination. Her assistance was focused on maintenance tips for upholding water points and better hygienic practices.

She found that communities using wells and spring boxes encounter multiple sources of contamination. The coverings and concrete aprons of cement that enclose a circular spring box can crack in the dry season, permitting rain, dust, dirt and stagnant water to enter the source.

Even the buckets used for collecting drinking water contribute to contamination. Because stagnant water serves as a breeding ground for mosquitoes, the spread of malaria continues to be of great concern.

What's more, Tom noted that contaminants from human and animal feces tracked past water-collecting areas on the bottom of shoes can pass into the drinking-water sources, which can lead to chronic intestinal health problems.

The tasks Tom helped with in Zambia included testing water at community water points to determine sources of contamination. Owners of the water points were also surveyed to collect technical, environmental and socio-economic data on how the facilities are maintained. The goal was to gain insights into improvements that could be made.

Kim Jusek, an environmental engineering student who volunteered in Ghana last summer, says EWB's local school outreach presentations are equally important to the work being done overseas. One part of this initiative is called "Water for the World." Outreach presentations centred on this theme inform students about water-borne diseases and water use around the world.

"EWB teaches you a different approach to problem solving that makes you rethink what you're doing and experience life on a whole new level to really make a difference," says Jusek.

Prof. David Lubitz, Engineering, faculty adviser of U of G's EWB chapter, agrees.

"Essentially, if you take a university-centric approach, there's a lot more to learn than just what's on your transcript," he says. "Engineers Without Borders is a path by which you can become involved and make your difference, which brings a whole different set of rewards in terms of marks and individual achievements." R

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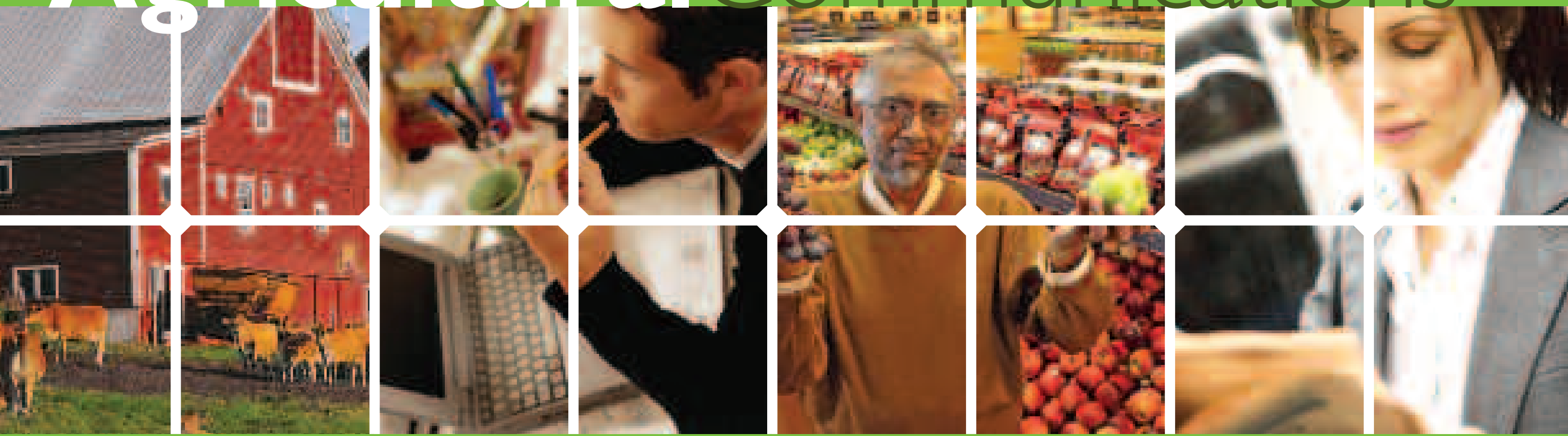

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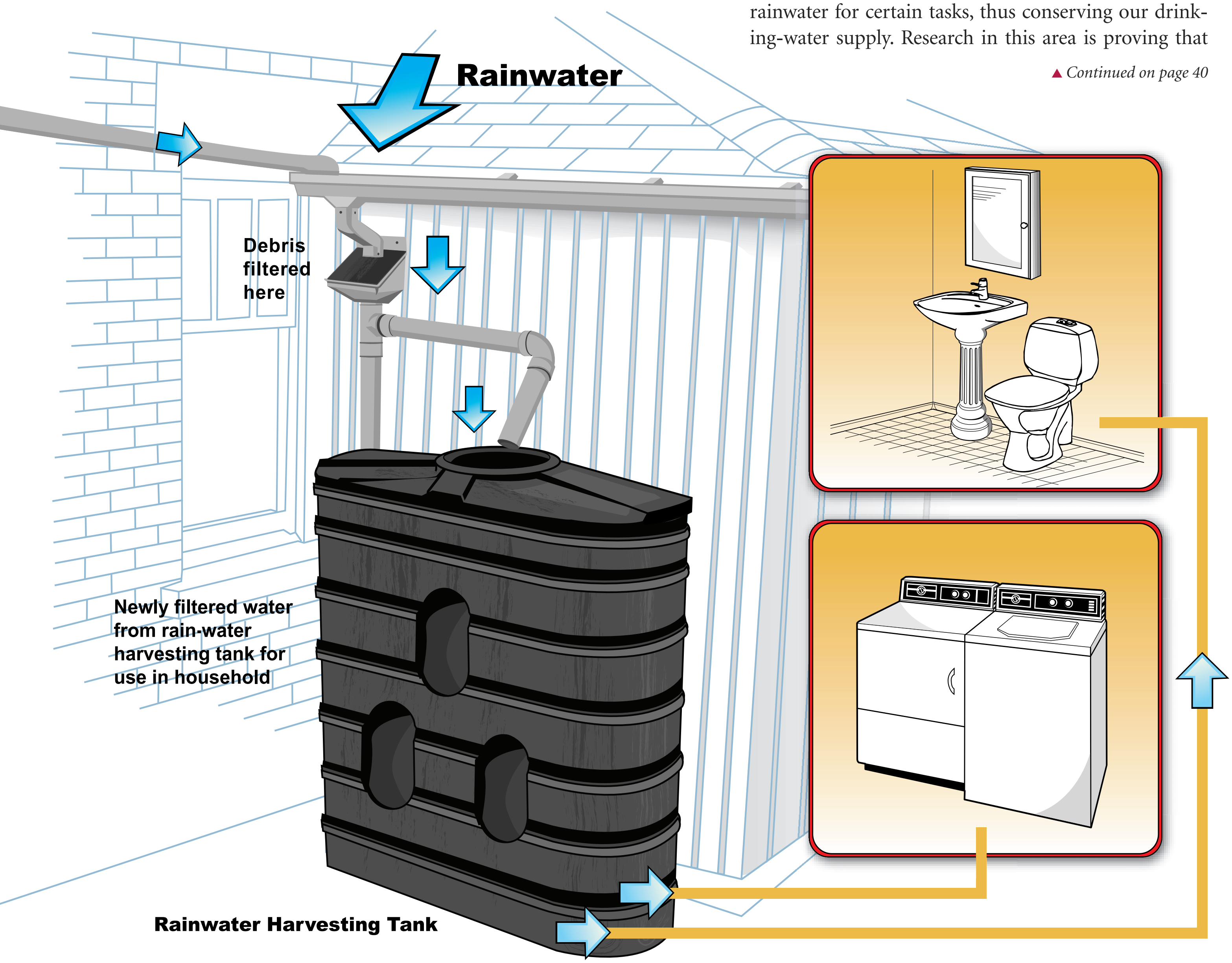
Catch the rain

Conserving drinking water begins by using second source of water: rain

BY ANDREA HRUSKA

Climate change, growing populations and aging infrastructure are challenging the belief that there will always be lots of clean water, says a University of Guelph researcher. But new rainwater harvesting technology could allow more households to collect and reuse rainwater for certain tasks, thus conserving our drinking-water supply. Research in this area is proving that

▲ *Continued on page 40*



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▲ *Continued from page 39*

rainwater harvesting could be one of Canada's answers to growing concerns about drinking-water shortages.

Prof. Khosrow Farahbakhsh, School of Engineering, suggests Canadians take a closer look at how they're using the nation's water supply. He says up to 40 per cent of a household's water needs can be met by using rainwater instead of potable water.

Potable water is the highest-quality water available. It's essential for drinking purposes, but it's also being used to wash cars, to do laundry and for industrial applications.

In all these situations, rainwater would be a suitable alternative because it, too, is of high quality. Farahbakhsh's rainwater harvesting technology could be a big step towards using this form of reclaimed water more substantially.

"Our idea that water is an infinite resource has to change," he says. "When we move from supply-side management to a demand-side management approach, we learn that our demands for water are diverse, and our sources of water supply should be, too."

This realization will change the way we design and implement drinking-water systems, he says.

Farahbakhsh's proposed rainwater harvesting system involves equipping a house with a large tank under or above ground that could hold up to 10,000 litres of rainwater. Pipes along the edge of the roof would collect and direct rain flow from the roof into the tank. The first half millimetre of rainfall rinsed off the roof would be diverted away from the tank, but the rest of the higher-quality rainwater would be collected. The stored rainwater would then be pumped into the house as it's needed. If the tank empties before the next rainfall, groundwater or potable water would be available as a backup source.

Farahbakhsh has already taken the first steps towards water conservation by installing his own rainwater harvesting tank under his front lawn. His family is using rainwater for laundry and flushing toilets, as well as for outdoor use. In 2008, they used more than 70,000 litres of rainwater. This, along with other conservation measures, reduced their water consumption by 70 per cent.

For their conservation efforts, Farahbakhsh and his family were recently awarded the City of Guelph's inaugural Water Conservation and Efficiency Award in the residential category.

The cost to implement a rainwater harvesting system may vary, depending on its size and type of installation required. Farahbakhsh and his research team are currently working with provincial governments in Ontario and Alberta to modify current regulations to make it easier to get a permit for a rainwater harvesting system and its extended use.

Several municipalities, including Guelph, are keenly interested in rainwater harvesting and are planning to provide rebates to people interested in installing such systems. Farahbakhsh is also working with industries to extend rainwater harvesting beyond residential applications.

"As a society, we can do much better conservation-wise than what we're doing now," he says. "Imagine if everyone drops their potable water consumption by 50 or even 70 per cent?"

Funding for this study has been provided by the Ontario Centres of Excellence, the Canadian Mortgage and Housing Corporation, the Canadian Water and Wastewater Association, the ministries of Municipal Affairs and Housing in Ontario and Alberta, the cities of Guelph and Calgary and the Region of Durham.

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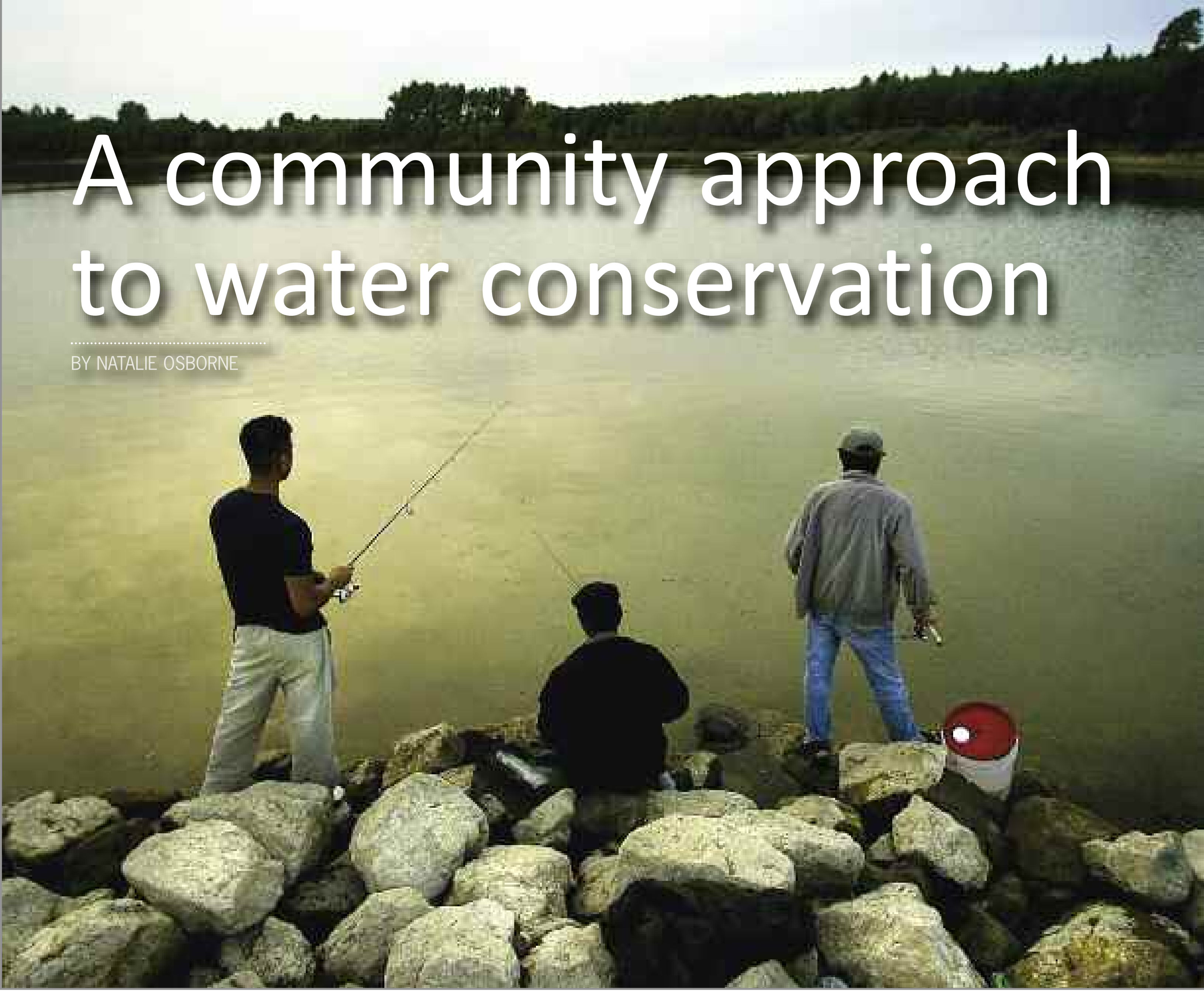

A community approach to water conservation

BY NATALIE OSBORNE

Watersheds along the Grand River are home to nearly one million people. How each individual along the Grand uses the water affects not only the quality of this resource but the quality of life for their neighbours, too.

To keep Ontario's surface waters healthy, rural and municipal communities alike must take responsibility for their actions, says Prof. John FitzGibbon, School of Environmental Design and Rural Development. A program he helped create called the Exceptional Waters Approach is designed to help communities along the Grand take initiative in preservation. The program promotes integrated watershed-based stewardship.

"It examines many environmental and biological factors that affect watersheds and encourages every individual living on a watershed to become actively involved with its care and protection," says FitzGibbon.

Limiting runoff from cities and farms is a continuing concern, and the agricultural community has had some success in addressing it, he says. In fact, Ontario farmers have done more than any other sector in the province to conserve and protect water, by reducing their pesticide use and implementing conservation plans.

For municipalities, enforced regulations on lawn watering and esthetic pesticide use, as well as advanced drainage systems in new housing developments, is where stewardship appears to be heading.

The Exceptional Waters Approach has also led to the development of a manual that will help more communities with watershed management. Trout Unlimited Canada has already used the manual as a model for its watershed management programs.

Other programs that have been developed to share the same community focus as the Exceptional Waters Approach include Adopt-a-Watershed, a non-profit organization that promotes educational enhancement and environmental stewardship, and the Watershed Report Card, a community-based watershed monitoring program.

Other University of Guelph researchers involved with this stewardship work are Profs. Paul Sibley, Environmental Biology, and Andrea Bradford, Engineering.

Research funding was provided by the Ontario Ministry of Agriculture, Food and Rural Affairs; the Ontario Ministry of Natural Resources; Environment Canada; and the Agriculture Advisory Council.

| Photo By Canadian Press Images

Graduate student Patrick Schwieder will be testing different types of reclaimed water on turfgrass plots this spring and summer to see if it could be used to irrigate golf courses, which would conserve more municipal water for the drinking-water supply.

Shades of grey

Can reclaimed water work for irrigation?

BY KATHARINE TUERKE

Field irrigation and water conservation sound like strange bedfellows, but not if the irrigation water is reclaimed water. It's a practice used in Europe and some areas of North America. And Prof. Katerina Jordan, Department of Plant Agriculture, thinks it deserves more attention here in Canada, too.

This spring and summer, Jordan's graduate student Darra Hudner will be testing the effects of reclaimed water on turfgrass growth and soil quality. The water used will come from three sources: an animal processing plant in Cambridge, Guelph's waste-water treatment plant and roadway runoff that is channelled into an irrigation pond.

Reclaimed water contains nutrients useful for plants' growth and fertility. Jordan says using this water for field irrigation is a more practical choice than using municipal water supplies, which should be conserved for drinking water.

"Recycled waste water, runoff and animal processing waste water are all potential irrigation alternatives to municipal or natural water sources," she says. "But first we need to understand the environmental implications of irrigating with these types of reclaimed water."

Hudner will test the environmental effects of the three reclaimed water sources by introducing each to different turfgrass plots at the Guelph Turfgrass Institute and Environmental Research Centre. Turf quality, growth rate and root depth will be assessed before and after the water treatment.

He'll also investigate the effects of reclaimed water on soil microbial populations. And finally, he wants to determine if higher nutrient levels found in some types of reclaimed water would change plant tissue levels and the soil micro-organisms involved in nitrogen cycling. That would affect the amount of fertilizer required for field crops.

Hudner, who will be conducting this study as his master's thesis research, will be working alongside Jordan and Prof. Eric Lyons, Plant Agriculture. Prof. Kari Dunfield, Land Resource Science, has also collaborated on this study.

This project is supported by the Ontario Ministry of Agriculture, Food and Rural Affairs and the Ontario Turfgrass Research Foundation.

Photo By Martin Schwalbe |

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I'm drinking *what?*

Process used to purify drinking water may not be so pure itself

BY KAITLYN LITTLE

Previously unnoticed but harmful compounds in drinking water have been found by a University of Guelph researcher. He's traced the majority of these chemical compounds back to the water purification process. But exactly how many such compounds are present in a single glass of drinking water, and to what degree they threaten our health, is still a question mark.

Few labs have the technology to complete the kind of in-depth analysis that would reveal these compounds. But Prof. Wojciech Gabryelski, Department of Chemistry, is hoping his studies will provide some insight into the compounds' chemical properties and draw attention to the need for new ways of testing and screening water for compounds that could be high-risk.

"The goal is to develop a robust method for rapid screening, which water-quality labs could easily use, to make sure more compounds are detected and analyzed frequently and in a cost-effective manner," he says.

Water analysis with a newly developed mass spectrometer lets Gabryelski separate each compound in a water sample. He's found that tap water can contain up to one million different chemical compounds. His new testing method is unique because current water-analysis methods are able to detect only a limited number of water contaminants.

He believes a portion of the disinfecting chemicals used in water purification is transferred into drinking water. Indeed, he found traces of chlorinated pollutants in his water analysis. Past epidemiological studies have linked these chemicals to fetal stress during pregnancy.

Gabryelski also uncovered a group of nitrogen-containing water pollutants called nitrosamines, which have been proven to damage DNA and can contribute to various types of cancer.

The next step in his research involves studying the most toxic nitrogen-containing contaminants found in drinking water. He'll examine the chemistry of selected compounds called biomarkers. Knowing the chemistry of these compounds will also help researchers determine how to detect them during water testing, as well as before and after treatment processes.

This research was funded by the Natural Sciences and Engineering Research Council and through infrastructure support from the Canada Foundation for Innovation.

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Video offers best practices for water controllers

BY ARTHUR CHURCHYARD


The pilot wetland system at Institut Agro-vétérinaire Hassan II, Rabat, Morocco, is Prof. Chris Kinsley's answer to cleaning waste water with limited labour and energy, by using plants and sediment naturally found in wetlands.

A video outlining how to correctly test water is now available on DVD. It was produced by First Nation communities in partnership with Health Canada and Prof. Chris Kinsley, a faculty member at the University of Guelph, Alfred Campus, and manager of the Ontario Rural Wastewater Centre.

Kinsley says the interactive video effectively educates water technicians (called controllers) with footage of obvious errors and correct procedures in collecting and analyzing water samples. For each task, the technician must select the correct procedure before continuing to the next step in the video.

Water controllers are vital to First Nation communities, where water contamination is a chronic issue. The controllers test water for bacterial contamination and chlorine levels to ensure safe drinking water in their communities.

The video is available by DVD and online to serve as an accessible curriculum for new water controllers.

Constructed wetlands improve waste-water quality

The development of training tools to help protect remote community water systems is a natural extension of the Ontario Rural Wastewater Centre's mandate for providing training and research in decentralized waste-water management.

Kinsley and researcher Anna Crolla are developing technology that can clean waste water with little labour or energy input. One such option is a constructed wetland, which uses natural wetland processes to filter and degrade waste-water contaminants. The wetland plants, usually reeds or cattails, play an important role in treatment through sediment aeration, sludge stabilization and evapotranspiration, and by providing support for biofilm growth.

Kinsley and Crolla have designed and evaluated constructed wetland technologies for more than a decade, with systems treating waste water at individual homes, town lagoons, farms and landfills as well as afar — a gold mine in the Surinam jungle, comfort stations in Algonquin Park (construction starts this year) and arid regions of Morocco, where treated waste water becomes a valuable source of irrigation water for local farmers.

"A constructed wetland basically runs itself," says Kinsley. "By not depending on mechanized systems requiring highly trained operators and specialized equipment, rural or isolated communities can effectively manage their own waste-water infrastructure and save money in the long run."

The water-testing equipment described in the DVD is commonly used in First Nation communities across Canada as well as in isolated communities worldwide. He believes the training video and its curriculum will be widely disseminated.

The first copy of the DVD was presented to the Odanak Band Council. The second copy has already travelled with Health Canada to an Organisation for Economic Co-operation and Development water meeting in Germany and to a United Nations water conference in Uganda.

The video was developed with the Centre de Santé Odanak with financial support from Health Canada. R

| Photo By André Dumont

Detecting a deadly water-borne disease

Still, the parasite *Cryptosporidium parvum* is not routinely monitored in water testing

BY HAYLEY MILLARD

Cryptosporidiosis, one of the most common water-borne diseases in the world, has made thousands of North Americans ill over the past two decades. Yet water-testing facilities still don't have a means of regularly screening for the micro-organisms responsible for the disease.

Profs. Jack Trevors and Hung Lee of the Department of Environmental Biology may have an answer. They've engineered antibodies that can help detect *Cryptosporidium* parasites before they get into drinking water.

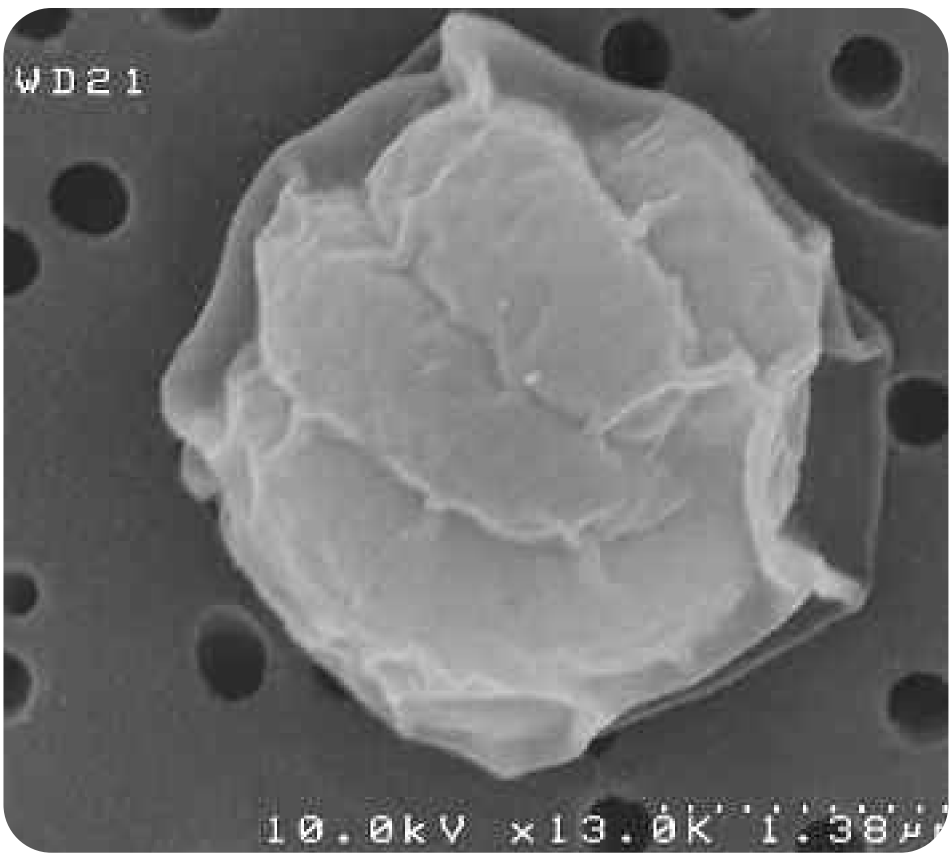
Cryptosporidium can originate from farm animals and other mammals. The protozoa are transferred to water through fecal contamination that may enter surface water, groundwater or wells.

Cryptosporidiosis can cause gastrointestinal illness and acute diarrhea. The illness is typically short-term, but its symptoms can be life-threatening for young children, the elderly and people who are immuno-compromised. Proper waste management usually prevents the oocysts (the hardy thick-wall form of the parasite found in the environment) from entering the water supply.

"Boiling water does kill the parasite, and boil-water advisories are issued when *Cryptosporidium* is suspected in drinking water," says Lee. "But earlier detection would lessen the potential of a large-scale outbreak."

In 1993, a cryptosporidiosis outbreak in Milwaukee resulted in more than 100 fatalities and 400,000 cases of gastrointestinal illness, making it the biggest water-borne disease outbreak in U.S. history. Although cryptosporidiosis outbreaks haven't occurred on such a large scale since, there have been smaller ones throughout Canada over the past decade.

The *Cryptosporidium* species that often infect humans are *C. hominis* and *C. parvum*. The latter can stem from a broad range of hosts, including cattle. Both species can survive in the hardy oocyst form for extended periods outside their host. In addition, the oocysts are highly resistant to water treatment — specifically chlorine-based disinfectants.



Cryptosporidium oocysts (pictured here) are highly resistant to chlorinated water treatments.

Photo By Nick Pokorny |

That's where Trevors and Lee's research comes in. They've isolated recombinant antibodies that bind specifically to the oocyst surface. These antibodies detect only *Cryptosporidium* in the water and don't respond to any other common pathogens. This detection method could serve well in *Cryptosporidium* tests, with minimal false positives.

The recombinant antibodies can be used in an immunofluorescence assay, which is the method recommended by the U.S. Environmental Protection Agency for *Cryptosporidium* testing in water samples. With a microscope, the researchers can easily see fluorescent oocysts and determine the level of *Cryptosporidium* in the water sample.

In addition to oocyst detection, the researchers found that the recombinant antibodies could prevent the oocysts from infecting human intestinal cells during in vitro experiments. This indicates it may also be possible for researchers to use the recombinant antibodies for immune-therapeutic purposes.

Now, Trevors and Lee are moving this research into *Cryptosporidium* genotyping, which will provide further information as to whether the *Cryptosporidium* strain in tested samples is *C. hominis* or *C. parvum*. With such information, water testing could potentially help in determining the source of the pathogen.

"In the end, it really will be cheaper to monitor and prevent the problem than it is to fix it," says Trevors.

Graduate students and research associates in the Department of Environmental Biology also involved in this study are Melissa Blears, Edmund Chung, Christine Carey, Jeanine Boulter-Bitzer, Nicholas Pokorny, Magda Kostrzynska, Megha Duggal and Ramon Carreno.

Other collaborators are Prof. Chris Hall, Environmental Biology; Stephanie De Grandis, a researcher in U of G's Laboratory Services; Susan Weir of the Ontario Ministry of the Environment; and Garry Palmateer, former lead scientist at GAP EnviroMicrobial Services in London, Ont.

This research was funded by the Ontario Ministry of the Environment; the Ontario Ministry of Agriculture, Food and Rural Affairs; the Natural Sciences and Engineering Research Council; and the Canadian Water Network. R

A threat to tradition

Climate change raises issues of water quality in some Canadian Inuit communities

BY ASHLEY MORIN

Climate change is affecting weather patterns, and these in turn have various environmental effects that are especially noticeable in the North. Bodies of water can be affected by heavy rainfall, flooding and runoff, with the potential to degrade surface-water quality and increase the risk of water-borne diseases.

Against this backdrop are the traditions of northern Canadians, particularly the Inuit. Despite government health rules against drinking raw surface water, some people in northern Labrador's Inuit communities still prefer to collect drinking water directly from streams and brooks. The choice may stem from taste preferences or social customs, but the potential for exposure to bacteria in the water should be understood as a possible health threat to these communities and their traditions, says Sherilee Harper, a master's student in the Department of Population Medicine.

Harper is working with Prof. Scott McEwen to determine how extreme weather conditions affect water and, in turn, human health.

"Just because the water was safe 50 years ago doesn't necessarily mean it's safe today," she says. "We have warmer climates and more periods of heavy rainfall that might present new risks."

▲ Continued on page 48

High school students in Rigolet work on media campaigns to present to their community, taking messages from graduate student Sherilee Harper's workshop series on weather, water and health.

| Photo By Northern Lights Academy

▲ Continued from page 47

According to Environment Canada, the Atlantic region has experienced a 10-per-cent increase in precipitation and a 30-centimetre rise in sea level in the past half-century. These environmental changes can amplify storm surges, which may become strong enough to cause property damage and flooding.

The chance of a water-borne illness outbreak can double during the six weeks that follow significantly heavy rainfall because of flood-water contamination from sewage, wastes and chemicals.

Harper is using her research to educate high school students in the Inuit communities about the potential risks of drinking untreated water straight from lakes and rivers, and how *E. coli* and other enteric bacteria in the water can affect their health.

She's also working with local teachers, providing students with media packages that include digital video cameras to produce their own educational materials for use in the broader community.

"The scientific results of this project will be important, but the actions taken in response to the results are equally important," says Harper.

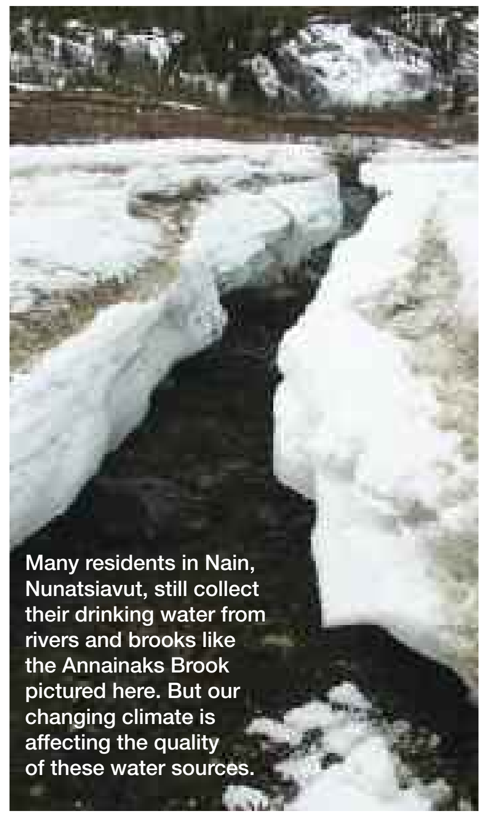
Others involved in this project are adjunct professor Victoria Edge of the Public Health Agency of Canada, Corinne Wallace of the United Nations University, the Nunatsiavut government, the Nain Inuit community government and the Rigolet Inuit community government.

Funding for this research is provided by the Public Health Agency of Canada, ArcticNet, Communities of Practice in Ecohealth Canada through the International Development Research Centre, and Nasivvik through the Canadian Institutes of Health Research.

Adapting to change

New research connects water management systems, climate change

BY MATTHEW DICICCO



Many residents in Nain, Nunatsiavut, still collect their drinking water from rivers and brooks like the Annainaks Brook pictured here. But our changing climate is affecting the quality of these water sources.

With Australia facing its worst water crisis in years, excessive rainfall in Canada and boil-water advisories for millions, the impact of climate change and its effect on water supplies are being felt worldwide. Researchers at the University of Guelph are looking at whether adapting to this change is possible, especially in First Nation communities, where water treatment capabilities are limited.

Prof. Khosrow Farahbakhsh, School of Engineering, is examining how to develop adaptive capacity to manage the impact of climate change on drinking-water supplies. Adaptive capacity describes a water system's ability to adapt in response to environmental stresses and hazards without failing.

Farahbakhsh says many small communities in Canada have conventional and centralized water management systems with limited adaptive capacity that may not respond well to environmental changes.

"Even an increase in rainfall changes the microbiological surface-water quality, which can have an impact on water supplies," he says. For example, extreme downpours in Vancouver resulted in a boil-water advisory for more than one million people in 2006. He adds that the economic impacts are severe in areas where the water systems' adaptive capacities are low.

First Nation communities with relatively small watersheds and low adaptive capacity may quickly feel the full effect of changes in water quality. But if these communities implemented more diverse, multiple-barrier water management strategies, the risk of microbial contamination would be greatly reduced. These improved water systems would have a higher adaptive capacity, says Farahbakhsh, who adds that such water management strategies go beyond treatment technologies to take into consideration culture, sociology, institutions and economics.

Next, he wants to transfer his findings to other communities across Canada.

"Over the next four years, we hope to develop tools that First Nation and remote communities could use to improve the adaptive capacity of their own water systems."

Also working on this research are University of Regina engineering professor and Canada Research Chair Gordon Huang and Prof. Ronald Stewart, head of the Department of Environment and Geography at the University of Manitoba.

Funding for this work is being provided by the Canadian Water Network and the Public Health Agency of Canada.

Photo By Sabrina Sturman |

Clean enough for fatheads

This minnow variety can survive in weakened oil sands tailings water

BY MARIA DOMBROWSKY

Oil extraction has left more than one billion cubic metres of contaminated water tailings behind in Alberta's oil sands. Up to 3,000 litres of water are needed to process one tonne of oil sand, and during this extraction, toxic acids and salts become concentrated in the water. U of G researchers want to see if the contaminated water will affect aquatic organisms' ability to rebuild natural ecosystems in the tailings ponds.

Doctoral student Richard Kavanagh, working with Prof. Glen Van Der Kraak of the Department of Integrative Biology, is examining how the contaminated water would specifically affect fathead minnows, a species native to the oil sands region. The study is looking at minnows' reproduction in tailings pond water.

Although the contaminated water produced from mining oil has been a major environmental concern for mining companies trying to re-establish functional ecosystems on the land they've been using, it appears the minnows are for the most part unperturbed.

The tailings pond water Kavanagh has been studying is contaminated with naphthenic acids, a natural constituent of oil sand. When these acids are fresh, they're highly toxic to different organisms. Water is used to separate the oil from the sand, and as the acids move into the water, it becomes contaminated. After one to two years, the acids degrade and become less toxic.

Kavanagh began studying the fathead minnows in 2004, exposing them to either aged tailings pond water or a mixture of the aged water and clean water. He monitored egg production, fertility, hatching success, survival and the size of the minnows' gonads and livers.

By 2007, the research had shown that the tailings pond water had no significant effect on hatching success, egg production, fertility or gonad and liver size when naphthenic acid concentrations were below 30 mg/l. At concentrations above this, lower plasma sex steroid levels and lower egg production were observed.

"The research results show it can be possible for these minnows to sustain their populations as long as the contaminant concentrations in the water are low, as in the aged tailings pond water," says Kavanagh. "Developers plan on creating lakes filled with a mix of contaminated and clean water to try to dilute the harmful constituents. We're testing this water mixture to see if a productive ecosystem would be viable in these lakes in the future."

He and Van Der Kraak are working with Guelph PhD graduate Rick Frank, Kent Burnison of Environment Canada, University of Waterloo professor George Dixon and University of Windsor professor Jan Ciborowski.

Funding for this research is provided by the Natural Sciences and Engineering Research Council, the Canadian Water Network and the Canadian Oil Sands Network for Research and Development. R

The reproduction of fathead minnows, a native species to the Alberta oil sands region, is becoming a concern in tailings ponds.

| Photo By Fisheries and Oceans Canada

No-hassle

Dealing with nutrient deficiency in transition dairy cattle — cows between lactation periods — can be gruelling. The animals have a naturally suppressed appetite at this time, which can cause them to reduce their feed intake by up to 30 per cent before calving (researchers aren't exactly sure why).

But Prof. Vern Osborne of the Department of Animal and Poultry Science noticed their water intake remains the same. Now he's taking advantage of this observation through water management on the farm.

Over the past seven years, Osborne has been studying water as a vehicle to transfer nutrients to animals at physiologically demanding times, such as during transition. He says this research could save farmers time and money because cattle consume four times more water than feed.

"We're working towards developing supplements that can be administered through water and changed throughout the day to amend an animal's metabolic activity," he says. "So if a cow needs extra energy in the morning, we can create that cocktail for her and deliver it through water."

Prof. Vern Osborne and graduate student Carolyn Borsy found water is the best way to deliver necessary nutrients to transition dairy cattle between lactation periods.

nutrient vessel

Water can be managed as a just-in-time delivery system for important minerals

BY ASHLEY MORIN

Osborne says this technique is "just-in-time" nutrient delivery on an as-needed basis. It could replace the traditional drenching method, in which farmers orally administer large doses of liquid nutrients to cattle through a syringe or bottle. Instead, they could simply pump nutrients into the animals' water supply, which the cattle can consume on their own.

"We can really help that transition cow when it comes to her reduced energy during the first week of lactation," says Osborne. "This is a nutrient management tool that's not invasive to animals and is extremely adaptable at the farm level."

The next steps in his research include investigating the potential of adding a flavouring agent to the water that would encourage intake. To date, he's found that young calves love orange flavours, but older cows do not. Gaining a better understanding of their taste preferences is a key part of this project, he says.

Other researchers involved in this study are Profs. John Cant and Brian McBride, Animal and Poultry Science.

This research was funded by Dairy Farmers of Ontario and the Ontario Ministry of Agriculture, Food and Rural Affairs.

| Photo By Martin Schwalbe

How wood preservative affects aquatic organisms

BY NATALIE OSBORNE

By using microcosm pools to model aquatic environments, researchers have revealed that creosote, a wood preservative, may impair reproductive success in fish when it leaches into surface waters.

A study that evaluated the effects of creosote in aquatic ecosystems, led by Prof. Keith Solomon of the Department of Environmental Biology, found that exposure to creosote could decrease the production of vitellogenin (Vtg), a protein responsible for egg yolk formation in female fish. If egg yolk decreases, fewer nutrients are supplied to the embryo, limiting reproductive success.

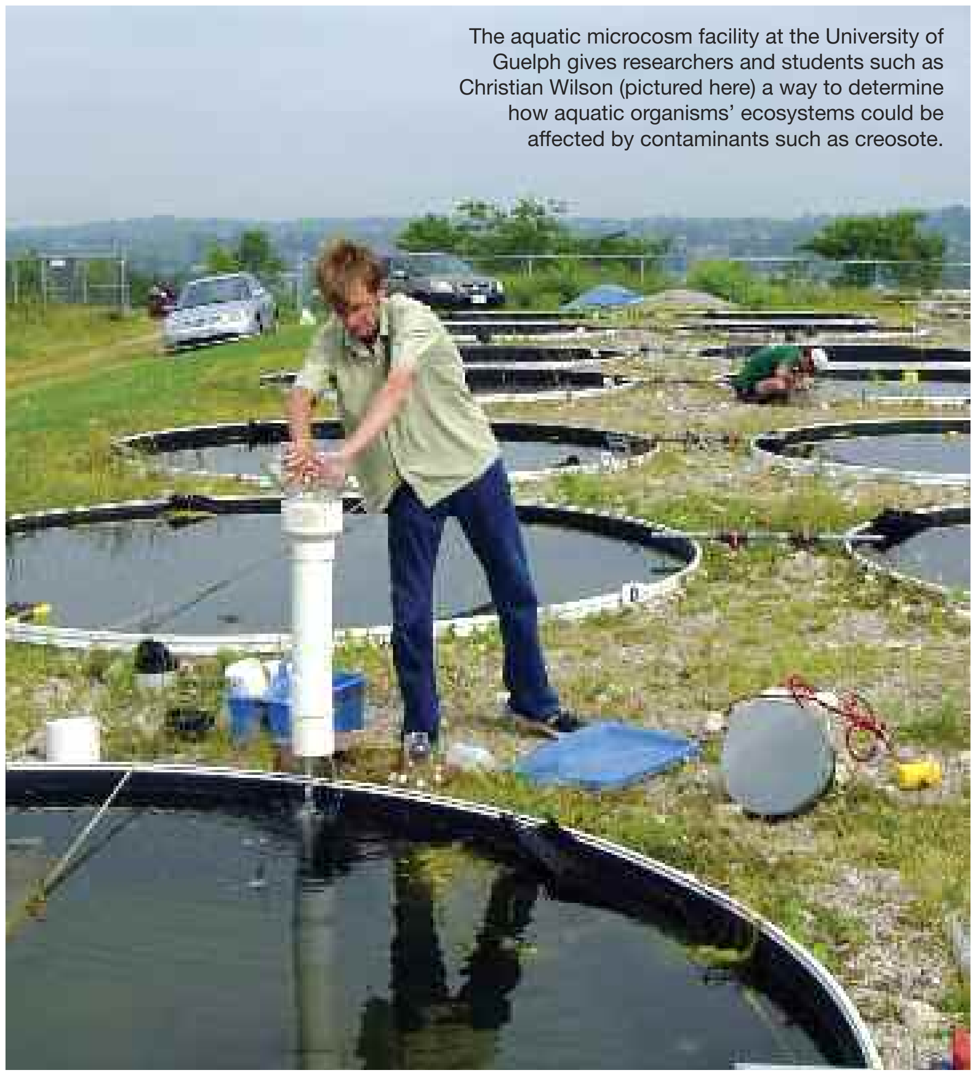
Creosote is used extensively on telephone poles and in the wood on railway tracks and some docks. To study the effects of the preservative, researchers treated three microcosm pools at U of G's aquatic microcosm facility with creosote concentrations at zero, three and 10 microlitres to litres (µl/L). Female rainbow trout were added to each pool, and weekly samples of plasma Vtg levels were taken from the fish.

Initially, no difference was found between the treated and untreated pools. But after 28 days, the Vtg concentrations in fish exposed to creosote levels of three and 10 µl/L were 15 times lower than in the control group.

Exactly how creosote impairs Vtg production is still unknown, but the results from the microcosms have shown that inappropriate use could result in surface-water concentrations that reduce reproductive success in fish, says Solomon. This could lead to dwindling wild fish populations in the future.

"We get data that allow us to say: 'Is this a problem or not?' and that's very useful information," he says. "If it's not a risk, then you can carry on doing it more comfortably. If it is a risk, then you need to find ways to reduce the risks or find alternatives."

Solomon's data on fish and other organisms in the microcosms have helped establish more appropriate environmental standards for creosote use, and water-quality guidelines have been adjusted to protect the environment and enable its correct use.



The aquatic microcosm facility at the University of Guelph gives researchers and students such as Christian Wilson (pictured here) a way to determine how aquatic organisms' ecosystems could be affected by contaminants such as creosote.

U of G's aquatic microcosm facility is the only one of its kind in Canada. Research there has included comprehensive investigations of polycyclic aromatic hydrocarbons, haloacetic acids, fluorinated surfactants, pesticide mixtures and veterinary and human pharmaceuticals.

The creosote research involved Jim Sherry of Environment Canada, Jim Whyte of the U.S. Geological Survey, University of Waterloo professors Niels Bol and George Dixon, and research assistant Audrey Gamble and Profs. Herman Boermans and Neil Karrow of U of G. Funding for this study was provided by Environment Canada and the Canadian Network of Toxicology Centres.

Photo By Keith Solomon |

Water

Where city meets country

The OMAFRA-University of Guelph Partnership is committed to enhanced water quality in Ontario. Researchers are looking for answers to many complex questions, including:

- How land use practices affect water levels
- The pathway and fate of contaminants
- How climate change impacts water management

Read more about the partnership's research priorities at

- uoguelph.ca/research/omafra/themes_priorities

Find out more about the OMAFRA-U of G Partnership at

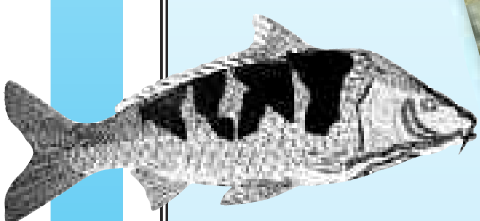
- uoguelph.ca/research/omafra
- omafra.gov.on.ca/english/about/uofg

Ontario

UNIVERSITY of GUELPH

CHANGING LIVES IMPROVING LIFE

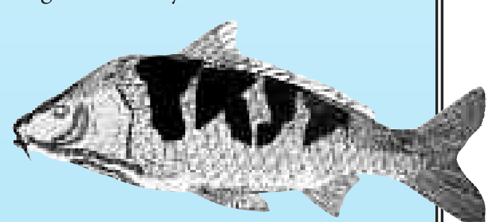
Read more about the partnership's commitment to water research in the water management issue of the *Research* magazine, posted at uoguelph.ca/research/learn/index.shtml



Koi carp, the million-dollar "swimming flowers," graced the cover of the summer 1995 edition of *Research*, which was focused on aquatic science expertise. At 72 pages, it remains the magazine's biggest-ever issue. It was also the first issue to go online and can be viewed at www.uoguelph.ca/research/ publications/Assets/HTML_MAGS/oasis/ index.html.

Among the contributors to that edition was student photographer Trina Koster, a 1994 fine art graduate of U of G who now has her own photo studio in Guelph. One of the main writers was Anne (LeBold) Douglas, BA '96, who went on to launch a magazine called *DogSport* with her husband, Andrew, BA '91. The two writers are now working as communication professionals for the Guelph Food Technology Centre and McCormick Global Communications.

The scientific advisers for the publication were Profs. Paul Hebert, Rich Moccia and David Noakes. Hebert, then chair of the former Department of Zoology, is now the driving force behind the Biodiversity Institute of Ontario and the Barcode of Life. Moccia, an aquaculture specialist in the Department of Animal and Poultry Science, is currently interim associate vice-president (research) agri-food and partnerships. Noakes, then a faculty member in the Department of Zoology, is now a professor and senior scientist at the Oregon Hatchery Research Center.



This page design reflects the 1995 edition of Research magazine

Infrastructure Means Innovation

When most people think of infrastructure, they likely think of roads, bridges, and sewers—the things we all use daily but probably take for granted.

The research and development community needs infrastructure as well—the equipment, laboratories, databases, and the buildings necessary to conduct research and to attract some of the best scientific minds in the world to Canada. Without the infrastructure, there would be no research.

But does this benefit Canadians? Does it make our lives better, easier, and healthier? Does it make Canada more competitive? Does it make Canadians more prosperous and more productive?

The answer at every turn is a resounding YES!

Since its creation in 1997, the Canada Foundation for Innovation (CFI) has committed almost $4.5 billion in support of 6,200 projects at 129 research institutions in 64 municipalities from coast to coast. These investments have led to breakthroughs in areas such as health, natural resources and energy, information and communications technologies, and the environment.

To read more examples of how CFI-funded infrastructure leads to innovation—with major impacts for Canada, and improved quality of life for Canadians—visit our online magazine at:
InnovationCanada.ca

Canada Foundation for Innovation
Fondation canadienne pour l'innovation