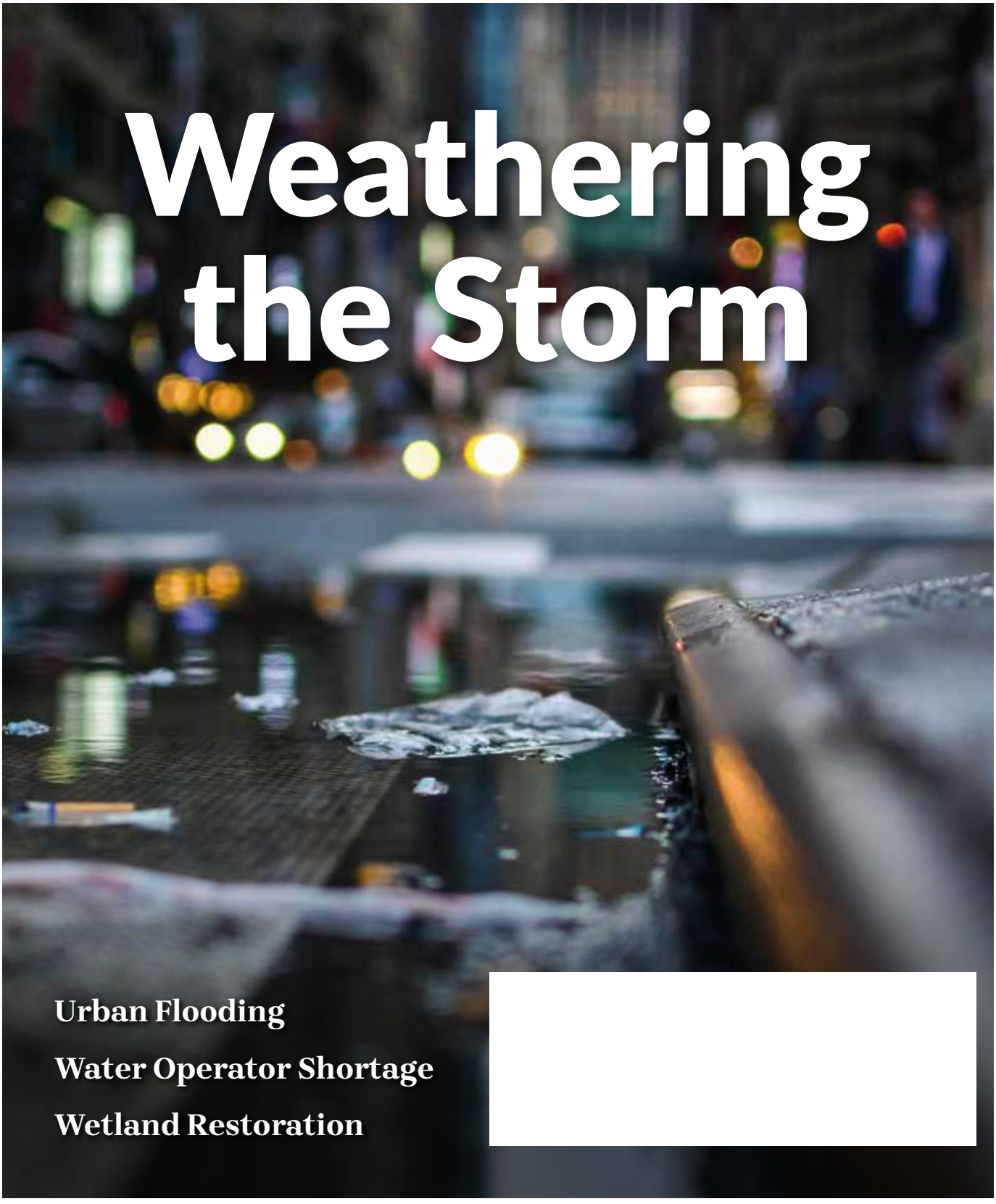
PROJECTS, POLICY, AND INNOVATION

JULY/AUGUST 2022

WATER CANADA



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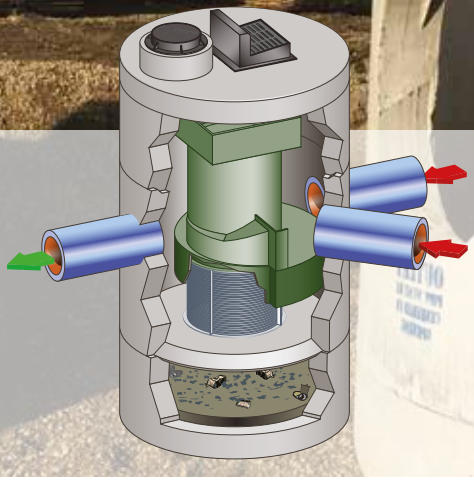

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The View From Here

BY JEN SMITH

HAVE YOU EVER STOOD BEHIND Niagara Falls?

If you attended the Canadian Water Summit this year, then perhaps you had the opportunity to don a yellow-hooded poncho, descend 125 feet in an elevator that made your ears pop, and slip and slide through passageways carved into bedrock to witness the sheer power of water through portals tucked up against the backside of the falls.

If you missed it, then let me paint you a picture: Imagine you took the water saver off your shower head at home. The water would come spilling out, unhindered by the restrictor valve. Now multiply that unfettered water stream by about a million and you're sort of closer to how powerful the falls are when you're standing there, pressed to the safety railing, at the mercy of spray and sound as a curtain of raw, untamed energy thunders past the tip of your nose.

Growing up in southwestern Ontario, I have been to the falls more times than I can count. I had been there, done that, and definitely bought the t-shirt. But getting up close and personal with the falls changed that. It was like seeing them for the first time. Standing on an observation deck that jutted out just shy of the base of the falls, with the constant pounding of rushing, cascading water nestled deep in my belly, I looked up and up and up until my neck cricked with the effort.

Viewing the falls from almost-ground level, trying in vain to find the concrete delineations between one shade of water and the next as I followed the cascade to where it swirled and whirled madly at the falls' feet changed everything. Close up, Niagara Falls is so much more than a cheesy, poorly-drawn image on a postcard: It's awe-inspiring.

Niagara Falls is quite literally water in action: It's constantly doing something, continually on the move to somewhere else, capable of creating power and forceful enough to literally carve into the earth and change its own trajectory.

And if I hadn't had the opportunity to see the falls from this vantage point, to have taken the time to read the historical plaques that lined the bedrock passageways, or to look up and up and up, I would've forever let Niagara Falls fade into childhood memories of funnel cakes and haunted houses.

It's amazing what can happen when we take a closer look at things.

From the outside, this magazine is all about big projects and bigger ideas that are helping to propel the water industry into the future. And while that's an accurate depiction, it's not the whole story. If you take a closer look, you'll see the people. The unsung heroes who tirelessly work to improve policy about water safety and sustainability (pg. 8); the ones who educate others on water protection, resiliency, and conservation (pg. 14); and the ones who work for not-enough money to make sure their communities' drinking and wastewater facilities run smoothly (pg. 18). Despite society's apathetic leanings, these heroes are barreling over the falls, forging their way forward to push us in a new direction, to remind us that we need to look at things from a different perspective.

When you look closely enough, their actions, both big and small, are changing the way we see and value water, and the way we move forward, together. And the view is breathtaking. WC

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ABOUT THE COVER

Climate-driven urban flooding needs practical solutions. How do we make sure we have the right tools for the job? Read more on page 16.

Vancouver's First Floating Habitat Brings Biodiversity to Trout Lake

Vancouver - On June 6, 2022, Vancouver's first floating ecosystem was assembled and launched onto Trout Lake as a pilot to improve biodiversity, plant and wildlife habitat in John Hendry Park.

Made from sustainable, non-toxic materials, the 60 square metre island is constructed from a series of interlocking platforms, and planted with native species such as sedges and rushes to support plant and animal life above and below the surface of the water.

Designed to improve water quality as the system grows, the island's submerged roots create a habitat for millions of microorganisms that consume algae, carbon, and excess nutrients to purify the water. A subsurface forest of roots provides shelter for fish, while varying platforms provide a nesting and preening habitat for birds. The island will be floated towards the middle of Trout Lake to reduce conflict with lake users.

"The impacts of climate change — unseasonably cold temperatures, extreme heat, extended drought — are a continued threat to Vancouver's environment and wildlife, we must do everything we can as a city to seek new, sustainable ways to support our greenspaces through this climate emergency," says Chad Townsend, senior planner of Environment and Sustainability at the Vancouver Board of Parks and Recreation. "Not only is this the a positive step in increasing biodiversity in John Hendry Park, it's also an experiment in testing innovative new solutions to support our local flora and fauna system-wide and improve the natural habitats in which they live long term."

Finding solutions to the world's water challenges

The floating habitat is the first of its kind in the Lower Mainland. Supplied by ecological technology company, Biomatrix Water, and donated by BlueTech Research, the island will be added to

Trout Lake Park in Vancouver, B.C.

Trout Lake in celebration of BlueTech Forum. Now in its tenth year, the forum brings together technology and engineering experts, investors, and thought leaders to find collaborative solutions to the world's water challenges. The installation will offset the carbon emissions of the event, held at Vancouver Convention Centre from June 7 to 8, with a percentage of each ticket going towards its funding.

"Through our work at Biomatrix, we aim to create an opportunity for people to reconnect with the natural world at the heart of the places where they live," said Galen Fulford, managing director of Biomatrix Water.

"Natural wetland water systems have been increasing biodiversity and water quality and providing habitats for plants and animals for millennia. The installation of a floating ecosystem at John Hendry Park is an incredible opportunity to help create more thriving ecosystems right within the city of Vancouver."

John Hendry Park renewal plan

Trout Lake is situated in John Hendry Park on the traditional territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlililw̓ətaʔɬ (Tsleil-Waututh) Nations.

Informed by local residents, the Park Board's recently approved John Hendry Park renewal plan is a long-term vision to ensure the park remains a vibrant and well-loved community gathering space for years to come. Improving biodiversity was one of the core goals identified by residents during recent engagement on park renewal priorities. WC

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YorkU and Champagne and Aishihik First Nations Working Together on Climate Change

Whitehorse, YT – Champagne and Aishihik First Nations (CAFN) and researchers at Yukon University are working in collaboration to address the effects of climate change thanks to a multi-year research project that will assess the vulnerability of the CAFN Traditional Territory to climate change and permafrost thaw.

The Honourable Daniel Vandal, Minister of Northern Affairs, announ- ced $429,028 in funding for the project through the Climate Change Preparedness in the North Program. He was joined by CAFN Chief Steve Smith, Dr. Lesley Brown, president and vice-chancellor, Yukon University, and Dr. Brendan Hanley, Member of Parliament for Yukon, at an event at Yukon's NorthLight Innovation Centre.

Melting permafrost ice is exposed along the gravel Dempster Highway and Ogilvie Mountains in the Tombstone Territorial Park of Yukon Territory.

Led by Dr. Fabrice Calmels, Research Chair with YukonU Research Centre's Permafrost and Geoscience research program, the project will study permafrost occurrence, characteristics, vulnerability to thaw, and the resulting impacts, based on priorities identified by the CAFN government. The Permafrost and Geoscience research program works closely with the community on research-based activities while learning about CAFN values, supporting cross-cultural awareness in research.

Permafrost thaw across the North and Arctic is destabilizing landscapes and infrastructure, affecting the health of lakes, rivers, fish, wildlife and traditional food sources. Data and results from this project will be available online through maps and storyboards to illustrate how the landscape potentially changes as permafrost thaws. This virtual platform will be accessible to community members and decision-makers and will help inform the planning and development of adaptive strategies.

The Government of Canada is investing in Indigenous-led and delivered solutions to help Indigenous and Northern communities adapt to the impacts of climate change in the North. The Climate Change Preparedness in the North Program supports Indigenous and northern communities and governments in increasing their capacity to adapt to climate change effects. Through community-led funding, the program helps build more climate-resilient communities across the North and Arctic.

"Yukon University is grateful for this funding from Government of Canada so that we can work in partnership with the Champagne and Aishihik First Nations to address the impacts of permafrost thaw on their Traditional Territory. YukonU's research programs are committed to exploring real-world issues that support our partners to build a more resilient North through our research expertise." said Dr. Lesley Brown, president and vice-chancellor Yukon University.

"*Shadhäla Äshèyi yèKwädän* (Champagne and Aishihik First Nations) is glad to continue this partnership to monitor and learn in places we are observing change in *Däkeyí* (our country). Our *dän* (people) are deeply connected to the land and carry a wealth of knowledge over many generations. We are taking an active role in monitoring and adapting to climate change as we are very concerned about its impacts on our country and people. This project is one important way we continue to care for the land, water and animals." said Kaaxnox, Dän Nätthe Äda (Chief Steve Smith). WC

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water's next

Water's Next Awards 2022

Celebrating Canadian water leaders and champions

Since 2010, *Water Canada* has hosted the Water's Next Awards to help strengthen and celebrate our national community of water leaders, champions, and innovators as a way of honouring the hard work of water sector professionals that all too often goes unrecognized by the general public. Clean drinking water, healthy rivers, safe wastewater discharge, and tools to help communities understand water are precious gifts to society, and our hope is that these stories will inspire the next generation of water leaders and innovators.

Thank you to the nominees, finalists, and winners for what you bring to the sector, for your vision, and persistence to protect our most precious resource. We proudly celebrate you in these pages.

Young Professional

Gregary Ford

Gregary Ford is the director of water programs at Swim Drink Fish Canada and the executive director at Niagara Coastal Community Collaborative—not a bad resume considering he has yet to turn 30!

A self-proclaimed data nerd, Ford actively tries to incorporate new technology wherever possible to better understand how to improve and manage the lakes. Not only did he lead an effort with Niagara College students to carry out high resolution drone surveys to support shoreline management, he also helped to design and implement VAST (visual assessment survey tool), crowdsource to fill essential data gaps and engage the public, and conduct an assessment of the status of Open Data in the Great Lakes in support of the Gordon Foundations Great Lakes Data Stream.

In addition to his commitment to embracing new technologies, Ford uses innovative approaches to solving complex societal issues affecting the Great Lakes. From working with Niagara College, leading and inspiring the next generation of water warriors, to his work with Swim Drink Fish as the coordinator of the recreational beach water quality community monitoring hubs, where he successfully created six self-sustaining hubs across the basin, his commitment to water has left lasting ripples. Ford has also conducted several restoration plantings along the Niagara coast as well as established a crowdsourcing citizen science program to assess beach health using cell phones.

Non-government Leader

Lindsay Day

As an avid kayaker who monitors her local lake, **Lindsay Day** intimately understands the water monitoring community. In her role as DataStream program manager, Day has played a leading role in building communities of water champions across DataStream's four hubs. Through cross-country collaboration with water monitors and leading the development of engaging communications tools, Day has led efforts to make DataStream accessible and informative. Her work increases the availability of open access water data, which can then be used to guide decision making.

Lindsay's storytelling skills have been put to use curating materials showcasing community-based water monitoring to overcome barriers to data sharing and have led the development of the innovative *Monitor's Guide to Water Quality*, which is in high demand among water monitors.

She also helped to bring together stakeholders from across the Great Lakes and Saint Lawrence region ahead of the release of Great Lakes DataStream. 39 groups have now contributed over seven million data points, sharing data that would otherwise not be available.

Water/Wastewater Operator

Ian Mcilwham

Ian Mcilwham is a Class IV Wastewater Operator who has worked in the water/wastewater sector for 30 years and is the Compliance Manager for Durham Region. He is also the current Chair for Canada's National Critical Infrastructure Working Group and the Canadian Mirror Committee Chair for ISO TC 224, which developed the International Standard on Crisis Management of Water Utilities (ISO 24518).

Mcilwham has been instrumental in developing Public Works emergency and continuity programs and in leading the response to COVID-19 for Durham Region water and wastewater since 2020.

As current chair of the Security and Emergency Management Committee for the Canadian Water and Wastewater Association (CWWA), which cooperates with Public Safety Canada and other federal departments concerned with emergency preparedness and national security to actively contribute to the knowledge base and federal programs related to critical infrastructure, Mcilwham has also co-authored the CWWA's Pandemic Response Plans.

His passion is working with Operators without Borders and has participated in utility resilience building in Belize and Barbados, training lab staff in Dominica, and developed SOPs for emergency events in Caribbean Water Authorities. Ian's next great challenge is aiding in re-establishing water and wastewater services as a member of the Water Quality Technical Working Group in Ukraine.

Business Leader

Pat Whalen

CEO of LuminUltra, **Pat Whalen** is no stranger to Water's Next Awards—after all, LuminUltra had the double-distinction of wastewater category winner and company of the year in 2021!

Whalen has led a significant scaling up of LuminUltra's production capabilities and expertise, opening a new state-of-the-art manufacturing facility to continue to focus developing COVID-19 testing solutions in clinical, environmental, and wastewater contexts with made-in-Canada solutions. In addition to the company's pandemic response, Pat's focus on remaining at the forefront of proactive microbial testing to stay ahead of problems, rather than reactive issue-based treatment, has saved time and resources for virtually all of LuminUltra's customers, spanning over 100 countries and a variety of industries and sectors.

Whalen has recently joined the advisory board of the University of New Brunswick's Fulcrum initiative to help provide insight to the university's Research and Innovation Partnerships program to strengthen the relationship between industry and academia, helping to identify and execute on opportunities that lead economic growth. He has also partnered with the Centre for Water Resources Studies at Dalhousie University, where many graduate students have been inspired to join the company after completing their studies, and is a long-time board member of BioNB, an organization that works with start-ups, established companies, associations, research institutions and governments to advance the bioeconomy in New Brunswick.

Government Leader

Abhay Tadwalkar

Working with the City of Toronto for 35 years, **Abhay Tadwalkar**, was involved in a number of projects to reduce costs and improve energy efficiencies, including Deep Lake Water Cooling, an innovative public-private partnership project that harnesses the renewable cold energy of the water at the bottom of Lake Ontario to cool commercial buildings in downtown Toronto. He also worked on the City's Corrosion Control Plan to control lead levels at the tap, and was instrumental in concept, design, and installation of a state-of-the-art pilot plant used for process optimization.

Tadwalkar's work has left operational impact on the cost and energy efficiency of some of the largest water and wastewater plants in Canada (a total of eight plants) that serve three million residents in Toronto and the Region of York.

A former president of the Ontario Water and Wastewater Association (OWWA), Tadwalkar has also volunteered for many water and wastewater projects in countries like Romania, Honduras, and Colombia.

Academic Leader & Steward of the Year

Dr. Markus Brinkmann

With more than 90 peer-reviewed publications in high-impact factor journals and a slew of awards under his belt, it's no surprise that **Dr. Markus Brinkmann** was the double award recipient of this year's academic leader and steward of the year.

Brinkmann is an Assistant Professor at the University of Saskatchewan School of Environment and Sustainability (SENS), the Global Institute for Water Security (GIWS), and the Toxicology Centre. An aquatic toxicologist by training, his research focuses on contaminants in the water cycle with an emphasis on urban runoff and wastewater and their impacts on aquatic organisms, specifically fish. Although water research can feel siloed, with many experts working within their own disciplinary boundaries, Dr. Brinkmann has been an advocate for breaking down these barriers to work across fields, disseminating and releasing information openly and freely, to help solve pressing water issues.

Prior to the pandemic, Dr. Brinkmann collaborated with the City of Saskatoon to measure pharmaceuticals in its wastewater, taking an ecosystem-focused approach to the assessment of pollutants in municipal water. With the onset of the pandemic in 2020, Dr. Brinkmann and his team pivoted that project to detect SARS-CoV-2, the coronavirus that causes COVID-19. By counting copies of a SARS-CoV-2 RNA sequence to estimate the viral load of the wastewater sample, they developed an early warning detection system that has been employed in many parts of Saskatchewan to help health authorities understand the local dynamics of COVID-19.

Dr. Brinkmann is also making important contributions to both the regulation of industry and the conservation of aquatic wildlife, specifically with regards to the chemical 6PPD-quinone that leaches from rubber tires. Among the first to document effects of this contaminant in Canada, Brinkmann and his team were also the first to identify mortality from 6PPD in brook and rainbow trout.

water's next PROJECTS

EARLY ADOPTION

York Region Wastewater Surveillance Team

Wastewater-based epidemiology (WBE) has provided real-time information on the health of populations for decades. With the onset of the COVID-19 pandemic it was realized that this approach could be applied to independently monitor for the prevalence of the disease in our communities.

York Region was a leader and early adopter of the technology and facilitated development of the approach in Ontario and Canada. In the summer of 2020, a Wastewater Surveillance pilot project was established with the University of Waterloo to detect the presence and quantity of the SARS-CoV-2 virus (COVID-19 viral signal) in wastewater. The project also linked closely with researchers at the University of Ottawa to support the method development and validation.

As the project evolved it became apparent that there was also a major need to provide an understanding of the prevalence and growth of variants of concern (VOCs) in communities. Working collaboratively with the University of Ottawa, the team applied methods to monitor for VOC in almost real time; initially Alpha, then Delta and Omicron (BA.1 and BA.2). This was reported directly to Public Health officials routinely for more than a year.

Preparing a qPCR plate at York Region's Wastewater Surveillance Program

This project has an incredible impact on not only wastewater operations because of the knowledge and experience in sample collection, but the method development for COVID in wastewater allowed for more accurate case counts in York Region as compared to clinical test results. York Region is using its wastewater surveillance data to supplement clinical and public health data to better understand COVID-19 transmission across York Region and the prevalence of variants of concern.

WASTEWATER

York Region Machine Learning Project for Managing I&I

Inflow and Infiltration (I&I) happens when water, groundwater, and stormwater enter the wastewater system through sump pumps, downspouts, and/or through holes or cracks in the pipes. Excessive I&I, especially from rainfall, consumes sewer capacity and overloads the treatment system. Not only can this cause surcharges and overflow to the environment, it also increases a risk to public health.

Proactively managing I&I is critical to enhancing system resilience to climate change, freeing up capacity taken by non-sanitary water and reducing risks of overflows, and York Region looked to do just that by developing a machine learning model. By leveraging real-time data collected from York Region's rainfall and sanitary flow monitoring network, which consists of 357 active flow monitors and 71 rainfall monitoring locations, along with historical rainfall data, the machine learning model is able to help York Region make better-informed decisions, support operational efforts, and minimize costly impacts to both residents and the environment. The first of its kind, this network is one of North America's largest and most advanced, and is capable of effectively mapping hot spot I&I areas and forecasting how the system will react to rainfall events.

EDUCATION AND OUTREACH

Water Movement

Indigenous water operators are critical in preventing drinking water advisories (DWAs) through their role in maintaining the integrity and reliability of their facility equipment and processes. Operators in Indigenous communities face more complex challenges than operators in non-Indigenous communities. The remoteness of many of their facilities translates to prolonged lead times on equipment parts and limited access to expert troubleshooting, as well as mentorship and collaboration opportunities. To combat this, Water Movement aims to provide a collaborative online space and a learning platform for Indigenous water operators.

With a collaboration zone where operators can troubleshoot, learn best maintenance practices, share important lessons learned, and ask questions, and a comprehensive video library that features easy-to-follow instructions demonstrated on site by Indigenous water treatment operators, Water Movement provides the resources to improve, optimize, and sustain equipment and processes, a leading cause of water advisories in Indigenous communities.

Water Movement also seeks to raise awareness amongst the next generation of water leaders, connecting Indigenous youth through lunch and learns, non-technical and technical workshops, and campaigns designed to educated students about water in Canada and careers in engineering and in the water sector.

York Region

WATER RESOURCES

City of Guelph and AECOM Canada Ltd.

In 2007 the City of Guelph completed their first Water Supply Master Plan (WSMP) to ensure the long-term future of water supply resources for drinking water. As the City of Guelph is almost completely reliant on groundwater resources for its potable water supply, it was important for the City to consider how to ensure sustainable water takings to meet population growth. In 2014, the WSMP was updated, and in 2020 was updated again with the goal of developing a reliable and sustainable supply of water for both the current and future needs of Guelph's inhabitants in a safe and cost-effective matter that ensures environmental sustainability while meeting the growth targets provided by the Province of Ontario for 2051.

The study aimed to develop water supply alternatives which incorporated emphasis on water conservation and efficiency, water reuse, water loss controls, local sustainability, and optimizing the City's existing resources. It also looked at innovative approaches to traditional assessments and systems like water loss, water efficiency, and conservation through science and traditional knowledge through extensive consultation with stakeholders and Indigenous communities.

Funded through the City of Guelph's Water Utility Capital Budget, and building off the successes of the 2014 plan, the updated WSMP was able to support increased population growth with little change in overall water demand, while putting emphasis on conservation efficiency, demand management practices, restoration of groundwater off-line municipal wells, understanding of potential implementation of aquifer storage recovery systems and of development of new wells outside the city boundaries, while researching long-term projects such as the use of surface water.

DRINKING WATER

Halifax Water

After discovering that homeowner rebates and discount programs weren't effective ways to expediate the replacement of lead service lines, Halifax Water implemented Get the Lead Out, a program that aims to have all lead service lines removed by 2038. Approved by the Halifax Water Board and the Nova Scotia Utility and Review Board, the program was launched in March 2021 and is funded entirely by the utility's water rates. The first of its kind in Canada, Get the Lead Out has greatly streamlined lead service line replacements in the municipality through strategic planning and improved organization. By coordinating replacements with the municipality on paving projects and through larger Halifax Water capital projects like water main renewal, cost sharing on reinstatement with the municipality can occur and the larger scale of the projects means a lower cost per replacement.

Individual replacements are also completed each year with priority given to customers who are most at-risk from lead exposure. To achieve lower unit replacement costs for this, individual replacements are batched together into larger projects.

Get the Lead Out also allows for the development of programs in the future to target replacement by density, public health risk, equal geographic representation, and point of sale, ensuring that by 2038, all lead service lines are removed from the system.

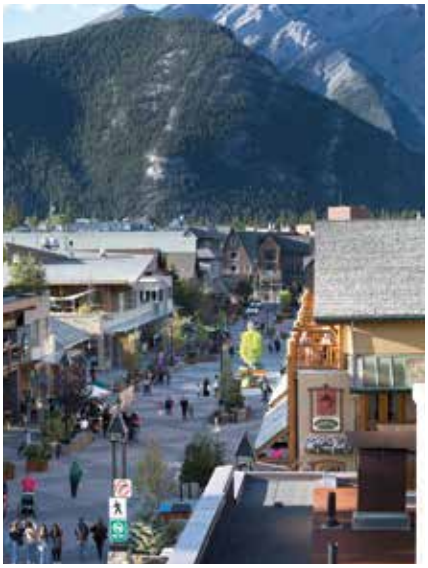
STORMWATER AND PROJECT OF THE YEAR

The Bear Street Redevelopment project

Installed in 2021, this $9.5 million reconstruction project, undertaken by the Town of Banff, aimed to create a pedestrian-first street in the heart of the town that also efficiently managed stormwater.

The entire street is designed with an offset centre swale draining to a trench drain, that also works as a high point to prevent ponding during major rainfall events or snowmelt. The trench drain slopes internally toward in-line catch basins that direct water into the top of soil cells via perforated pipe where the topsoil was left low to provide additional stormwater storage capacity for major events. The soil cells both mitigate stormwater and support tree growth in the downtown area, and the system also provides a passive water source and sufficient uncompacted soil volumes. As part of a customized stormwater network, the cells are able to filter and treat stormwater, eliminating 80-95 per cent of total suspended solids, before it is discharged into the Bow River. Further, sensors within the soil cells activate irrigation of the trees when needed, ensuring healthy plant growth and overall long-term effectiveness of the system.

This system offsets some of the requirements for water from the Town's potable network for irrigation, and in turn the energy requirements to treat and deliver that water to the Bear Street irrigation. WC



Dark Horse Company

The Bear Street Redevelopment Project in Banff is this year's winner in both the stormwater and project of the year categories.

DUC research biologist Bryan Page examines the factors influence a wetland basin's ability to retain nutrients.

Nature-based Healing

Wetland conservation for healthy lakes BY JULIE POLLOCK

DECISIONS MADE TODAY AT EVERY LEVEL of government and civil society will determine the future of summer holidays and day trips to local lakes in Canada. Hundreds of ponds, rivers, and lakes are increasingly impaired each year by algal and cyanobacterial outbreaks that affect more and more watersheds.

Changes in climate, combined with land pressures and agricultural drainage, are adding up to earlier and more frequently favourable conditions for algae overgrowth. These outbreaks can produce dangerous levels of toxins and use up oxygen at the expense of other aquatic wildlife, including fish.

We know there is an efficient and relatively inexpensive solution for chronically sick lakes that can be implemented at individual and community scales. Research consistently shows that habitat restoration protects water quality in working landscapes. Specifically, large-scale restoration of wetlands has the power to substantially reduce nutrient levels flowing downstream into our rivers and lakes.

Lake Erie in southwestern Ontario is one of three chronically sick Canadian lakes that are monitored by satellite for EOLakeWatch, the Government of Canada's algal bloom reporting system. It's a relatively shallow lake that receives high levels of nutrients, washed away from mainly non-point sources such as fields and lawns. Every year, Lake Erie coughs up harmful blooms that threaten the drinking water of 12 million people in Canada and the United States.

In recent years, Ducks Unlimited Canada (DUC) has led hundreds of wetland conservation projects on private and public lands in the watersheds north of Lake Erie. The program is part of a strategy in the Canada-United States Great Lakes Water Quality Agreement that's intended to reduce phosphorus loads washing into the lake.

Requisite restoration

Pascal Badiou, PhD and fellow scientists from DUC's Institute for Wetland and Waterfowl Research, conducted a study of newly restored small wetlands on the Ontario agricultural landscape. According to Badiou, "The overall goal was to quantify nutrient retainment under different hydrological conditions in new small wetlands—those that have been restored within the previous five years."

Based on this, the team developed a peer-reviewed protocol for monitoring and assessing the recently restored small

Ducks Unlimited Canada

CASE STUDIES IN COMMUNITIES

FOR YEARS, DUC has been demonstrating the wide range of functions that wetlands can provide in both rural and urban landscapes, from naturalized wastewater lagoons, naturalized stormwater settling ponds, bioremediation and naturalized stormwater retention basins. For further reading on some of the work DUC is doing visit www.watercanada.net/duc-wetlands-work.

Wetland restoration offers hope for improved water quality even for areas where most of the natural wetlands have been destroyed.

Algal blooms like the one pictured here are threatening the drinking water safety of the 12 million people in Canada and the United States who depend on Lake Erie's waters.

wetlands. Through the Ontario program, they connected with rural landowners with new "edge-of-field" wetlands set in a low-lying area that receives runoff from the surrounding agricultural landscape.

Eight landowners granted access to field scientists to install research equipment and conduct frequent water-sample collections and other monitoring including weather readings, inflow and outflow readings, water level visuals, and trail cameras to capture wildlife attracted to the wetland.

Bryan Page, lead author of the study report, *Determining the Nutrient Retention Capacity of Newly Restored Wetlands in Southwestern Ontario for a Second Water Year*, explains that many factors influence a wetland basin's ability to retain nutrients, and capturing all facets of those interactions can be complex. That makes each study important to the gains of broader understanding of wetland habitat restoration.

The Lake Erie study showed that the newly restored wetlands retain nutrients, such as phosphorus and nitrogen, in all four seasons and under a wide range of conditions. "We were lucky in that the field research took place over two very distinct hydrological years with notable weather events for comparison among sites," Page said.

For the most part, the study wetlands efficiently captured nutrients, including soluble reactive phosphorus (SRP), a bioavailable form of phosphorus that increasingly impacts water quality in Lake Erie and makes up a large proportion of the overall phosphorus load. The mean total of phosphorus retained was 11.7 kilograms per hectare, per year. These levels are well in line with other relevant studies in freshwater wetlands.

"There's a metric called the phosphorus assimilation capacity for how much phosphorus a wetland can assimilate and lock away," said Page. "A freshwater wetland in North America should be able to assimilate 10 kilograms of phosphorus per hectare, per year, and that's really close to what we found is being retained in our wetlands on average every year.

What's important about that is that even though we're putting phosphorus into these wetlands and it's being retained, there's a really good chance that most of that is being assimilated and locked away so that the ecological integrity really isn't being hampered."

Page points out that the basins in the study are designed for waterfowl based on earlier research by DUC. "We saw through trail camera recordings that breeding waterfowl pairs and other wildlife do use these basins. And these basins are providing society with water quality benefits as well. This is taking place even though they're not optimized whatsoever for water quality benefits."

The findings caught the attention of DUC colleagues at Ducks Unlimited Inc. in the United States. Badiou and his team are now collaborating with his American counterpart, Ellen Herbert, PhD, and the research has moved to the south side of the lake.

"Lake Erie has experienced repeated algae blooms that shut down fisheries and beaches and impact drinking water for millions of people on both sides of the border," said Herbert. "Like birds, water doesn't respect boundaries."

Nutrients enter water in runoff from landscapes as water flows downstream. A large lake receives nutrients from its entire watershed, which can span multiple provinces and states.

The work is moving forward with big questions about strategic habitat restoration on working landscapes. DUC's academic colleagues at the University of Waterloo are taking the data from both studies and modeling targeted restoration scenarios that can help optimize the power of small wetlands.

Knowledge leads to action

Everyone can participate and benefit from wetland restoration. It's supported by the insurance industry as part of extreme weather mitigation. It's carried out by farm landowners as part of an environmentally responsible farm plan. It's implemented by municipal drainage engineers as part of an agricultural drainage strategy. The eight landowners who allowed their wetland restoration projects to be part of the nutrient study are prime examples of how people can take up the challenge of protecting their own communities.

Restoration returns effective natural infrastructure (i.e., wetlands, grasslands, forests, waterways) to the land. DUC has collaborated directly with many communities to restore and create highly functional wetlands that support cleaner water—building the case that communities can heal their own lakes when they come together to restore the lost functions of wetlands in their watersheds.

A future of strategic wetland restoration can meet and match priority setting for clean water, biodiversity and people. Individual decisions—from private landowners, local decision makers and water professionals—can make the difference between a future of plunging into a lake's welcoming waves and one restricted by the dangers of "sick" lakes and their frightening impacts on people, pets, livestock, and wildlife. WC

Julie Pollock is an environmental writer and communicator for Ducks Unlimited Canada.

Ducks Unlimited Canada

One size doesn't fit all

Finding a solution for Canada's growing urban flooding problem

BY PHILIP GRAY, P.ENG, P.E.

Mulderphoto

ONE OF THE MOST TANGIBLE AND COSTLY effects of global climate change is major, often catastrophic, floods. In Canada, where upwards of seven million people live in either a coastal or riverine flood plain, it's clear that the impact of climate change-driven massive precipitation events, spring freshets, and rising lake levels have been taking an increasingly heavy toll on Canadian communities in recent years.

At the same time, the recorded instances of urban flood events in Canada have been steadily mounting over the past decade, with the costs of repairing the damage caused to residential properties—particularly the flooding of home basements—cumulatively registering in the hundreds of billions of dollars during this period.

According to a study published in February 2022 by the Intact Centre on Climate Adaptation at the University of Waterloo, flooding—and more precisely residential basement flooding caused by extreme weather events—accounted for more than half the nearly $2 billion in average annual property damage claims in Canada between 2009 and 2021. That figure is at least a four-fold increase over the $250-$450-million annual average of insurable residential losses recorded between 1983 and 2008.

While there is debate as to how dramatic the increase in overall mean rainfall has been over the last several decades, there have unquestionably been a number of intense, damaging rain events in Canada.

Failing infrastructure

However, when it comes to urban flooding events, extreme weather is often not the only culprit. In fact, the cost of property damage caused by aging, failing urban stormwater collection and sanitary sewer systems that are unable to handle historically normal capacity may be even higher than that caused by so-called atmospheric *rain bombs*, such as the one the city of Toronto experienced in July 2013.

Of course, when cities like Toronto have to manage sewer and drainage infrastructure that in some cases is approaching 100 years in age and is characterized by combined sanitary and stormwater drainage pipes, it's not surprising that large parts of the systems do not come close to meeting today's design standards. Even w here portions of sewer and drainage systems may have been upgraded to more modern standards in the 1960s, '70s, or '80s, they often still come up short of what is needed to adequately handle increasing stormwater runoff and wastewater flows.

To be clear, the problem of climate-driven urban flooding has been exacerbated by a combination of aging urban sewer infrastructure and flood mitigation design practices that have not lived up to their promise, coupled with growth and intensification in already dense urban areas.

Right tools for the job

For Canadian municipalities, being able to accurately assess and ultimately mitigate the risk of flooding within their local area, whether it be from overland stormwater flow or sewer backup, requires having the right tools to do the job.

Although stormwater drainage systems are technically not connected to sanitary sewage systems, there is, under the right conditions, the opportunity for these separate systems to impact one another during significant events, even more so when taking into account older combined sewer systems. This is further complicated when considering the potential influence of receiving waters, such as lakes, creeks, and rivers. Consequently, a comprehensive approach to evaluating flood risk should include all types of systems and drainage conditions.

When an urban basement floods, it is often a sanitary sewage backup driven by excess inflow and infiltration. Equally, it can be a result of storm sewer backup driven by an overloaded storm sewer or through overland flow entering a window well or other vulnerable locations around a building. The flooding situation can be further complicated by the possibility that riverine flood water has backed up into the storm system or flowed overland into neighbourhoods.

Any municipality trying to understand the risk of flooding in their community in

CLOCKWISE: City sewer system drainage pipe under inspection. The City of Calgary after major flooding in 2013 that resulted in residential displacement, business interruption and infrastructure damages. The blue shading represents areas most likely to experience flooding during an urban flooding event.

order to develop effective mitigation and protection measures needs to consider all drainage systems and conditions to identify how stormwater runoff flows overland, is intercepted by the storm drainage system, and how it influences wastewater systems. This is now possible with the availability of accurate elevation information (LiDAR) and 2D flood modelling tools to assess and analyze how overland flow systems work and where storm runoff goes, and what systems it may influence.

2D flood modelling

Today, a number of sophisticated 2D flood modelling software solutions are available to help municipal engineers better understand and mitigate the flood risks in their area, whether it be in an urban, riverine, or coastal setting.

One of the key benefits of 2D technology is that it enables a more comprehensive assessment of the potential flood risk to important infrastructure that wouldn't typically be captured or seen in an older dual-drainage or 1D flood risk study.

The volume and type of data needed to prepare a 2D model are not that dissimilar to a more traditional 1D model. Both require good infrastructure information, typically contained within municipal GIS systems. The critical component of 2D modelling is surface elevation data with a resolution that is on the order of +/- 20cm vertical accuracy or better. This information is critical to defining the surface where features, such as roads or other drainage features or surfaces are clearly defined. This level of precision can be used by a 2D flood modeller for extremely accurate predictive and remedial flood planning.

Simpler tools may be effective

Unfortunately, as the prioritization of flood mitigation and protection planning has become more prevalent in towns and cities across Canada, the use of complex and expensive proprietary 2D flood models is becoming more common and an almost automatic *de facto* standard approach, when simpler, faster, cheaper tools may be a more effective option in many cases.

Make no mistake, 2D flood modelling offers many compelling benefits, but it isn't necessarily best suited for all flood planning exercises, particularly when assessing smaller areas with simpler systems.

For instance, urban flood risk can often be mitigated by taking steps to reduce the inflow of water to the local sewer system and increasing the flow capacity and water storage capability within the system. There are obviously many factors that need to be considered and analyzed to arrive at the best mitigation solution, but the need for 2D modelling is not always there.

Collaboration is key

In fact, the best solution for many municipal engineers looking to address an urban flooding problem may not be about technology at all. The key is often to talk directly to other municipalities that are using a variety of different planning and modelling tools and discuss what has worked and what hasn't under a wide variety of scenarios. In particular, for smaller municipalities with limited resources and in-house technical capabilities, the willingness to collaborate with other municipalities or agencies is critical.

While many municipal jurisdictions across Canada are wisely earmarking funds and actively upgrading their stormwater collection and sewage infrastructure to help abate the risk of urban flooding, the potential for widespread, damaging floods remains extremely high.

Thus, whether dealing with stormwater or wastewater systems, municipalities need to continuously and objectively evaluate the flood risk scenario confronting them and make informed decisions about which flood prevention and mitigation planning strategies and tools will work best for their specific needs. One size fits all approaches should always be avoided. WC

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IBI Group

Water, Water Everywhere and Not a Drop to Drink

A closer look at Canada's water operator shortage

BY SAUL CHERNOS

BEYOND A VAGUE SENSE OF THIRST, MANY of us give little thought to the water that flows forth crisp, clean, and translucent bordering on invisible, when we turn on the tap. Unrestrained and with almost reckless abandon we let the tap fill our glass, with at least some evading the glass before swirling into darkness; more, if levels of attention and awareness wane at this most crucial moment.

For thousands of people across Canada, however, moments of thirst present an entirely different experience. From coast to coast to coast, most starkly in Indigenous communities, potable water and the treatment plant operators who labour to keep systems safe and working effectively are a precarious resource.

By the bucket

It's been a scant few decades since James Trimble hauled water by bucket from the one-inch-diameter above-ground steel pipe lining the streets of Aklavik in the Northwest Territories. The hamlet, one of Canada's northernmost communities, is surrounded by water. The Arctic Ocean offers an endless vista to the north and west, the Mackenzie River skirts the east and south, and smaller creeks and streams abound. Yet, stunningly, Aklavik lacked indoor plumbing as recently as the late 1970s and early 1980s.

"You went out to the road, turned on the tap, filled your bucket and carried it back into your house," Trimble recalls. That was in the warmer months. In wintertime, the pipes shut down and Trimble and other young people fetched ice from the river to supply water for cooking, washing, and drinking.

Established in 1912 as a Hudson's Bay Company trading post, Aklavik held its own for the first half of the century. With a population of more than 1,600 people of mostly Inuit and Dene, but also Métis and non-Indigenous heritage, Aklavik served as a regional administrative centre for the territorial government. By 1953, however, perennial flooding drove the government to develop a new community, Inuvik, 63 kilometres to the east, and relocate there.

While some 600 people chose to remain in Aklavik, the network of pipes

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You get communities where the water's been so bad, or where you've had well water for so long, even when you put a good system in, people don't trust it.

L-R, Kahkewistahaw First Nations water plant. (l-r) Maintenance manager, Hilliard Bobb, Kahkewistahaw operator, Alvin Alexson, Deon Hassler, and Standing Buffalo First Nations operator, Nelson Goodwill.

proved more than an inconvenience. It's believed that warm summer days and a 24-hour sun nurtured a build-up of *Helicobacter pylori*, bacteria that has troubled the community and has been linked to a sharp rise in stomach cancers. However, it was a growing desire for flush toilets and other conveniences taken for granted by most Canadians that proved the catalyst for an eventual move to indoor plumbing, with water delivered by truck.

"People wanted water in their house so they didn't have to haul it by pail," Trimble explains. "If you wanted a flush toilet in your house, you had to have a tank and system to hold the water."

Trimble went on to work for Indigenous communities in British Columbia, Labrador, and Ontario before joining the Atlantic First Nations Water Authority as operations manager a year ago. He, too, tested positive for traces of H. pylori, but eliminated the bacteria with help from medication. Still, as a water professional, he's acutely aware Aklavik's piped water never underwent any testing, and he understands the lasting preference some of the community's oldest residents have for ice blocks despite ready access to certifiably potable tap water.

Deon Hassler

Boiling water for decades

Trimble says Indigenous communities across Canada that have experienced long-term contamination of their wells and cisterns share a similar lack of faith. "You get communities where the water's been so bad, or where you've had well water for so long, even when you put a good system in, people don't trust it."

Deon Hassler, a circuit rider with the File Hills Qu'appelle Tribal Council in Saskatchewan who trains and mentors water and wastewater system operators in 11 member communities, says two communities are under long-term boil-water advisories. While projects are underway to address the underlying issues, work has stalled for nearly two years while Indigenous Services Canada (ISC) and various project engineers review and reevaluate project details.

"One (of those communities) has been over 25 years and I think the other one is 13 years," Hassler says, expressing frustration that ever-changing plans and revisions add to both the time lag and the eventual cost. "The first design wasn't appropriate," Hassler says. "It couldn't handle all the (naturally occurring) iron, manganese, and ammonia."

Boiling will destroy bacteria, of course, but heavy metals and some other contaminants remain, and Hassler points out something deeply unsettling—while most residents drink bottled water, some "can't afford to go to town and get bottled water so, yes, they are drinking the water."

The new facilities will likely become operational sooner or later, but the cycle seems endless. Hassler recalls stories about "hauling water" and "personal lagoons" in the not-so-distant past, and he sees a multi-pronged problem. To start with, he's clearly piqued by government officials choosing to fund generic systems designed without specific consideration of a region's unique geology or other local needs. However, this is exacerbated by a widespread lack of appreciation for water operators who are largely dedicated, hard-working, and industrious, yet tend to be older and sometimes lacking in the kind of formal education and training that would enable them to properly navigate the vagaries of highly technical systems.

"A lot of these water plants are designed and picked by ISC and by engineers and handed over to the community," Hassler says. "There isn't much training. It's kind

Deon Hassler and operator, Dale Desnomie (left), flush water mains and check hydrants on Peepeepkisis First Nations.

of like, here you go, this is what you do, and then they're gone. And so a lot of our operators are stuck. They only have their Grade 10. We don't have a lot of younger people with a standard Grade 12 education or GED, so they need help troubleshooting a lot of the problems."

While non-Indigenous communities, especially rural ones, are also facing an operator shortage, this is generally attributed due to a lack of enthusiasm many young people have for the trades. After all, industries as diverse as trucking and construction are also decrying a lack of young, skilled workers. However, the shortage Indigenous communities across Canada are experiencing is particularly acute.

To a considerable extent, the issue boils down to money. Skilled workers in resource industries such as mining and oil and gas often earn six-figure salaries, yet operators in Indigenous communities frequently earn little more than minimum wage, especially if they are still in the process of obtaining all of their certifications. Furthermore, the work environment is often demanding and budgets are tight.

"Some operators aren't getting full hours, so sometimes on weekends they're only paid for two hours a day," Hassler says, noting that operators often use their own equipment and borrow supplies from neighbouring communities.

As operations and maintenance manager with Lytton First Nation in British Columbia's Fraser Canyon, Warren Brown oversees everything from water and wastewater to roads and band council buildings. His crew of six includes two water operators, both of whom have earned their certifications yet are frequently asked to do unrelated work, even though they drive more than 150 kilometres daily looking after seven distinct water systems as well as individual septic systems over a patchwork of 56 reserves.

And that doesn't include special projects. Working closely with water and engineering professionals, for instance, Brown and his team recently completed a pilot project that saw ultraviolet-based point-of-entry water systems installed inside five houses that were too isolated to be served by the First Nation's mainline systems. The occupants had long been on precautionary long-term boil water advisories and were wary of the new technology. However, Brown and his team gradually won them over, to the point that the homeowners handed them keys so the systems could be regularly monitored.

Yet, even though it's safeguarding a basic necessity of life, the operations and maintenance department is cash-strapped and Brown has to manage funds carefully to ensure he can pay his operators more than the provincial $15.65 minimum hourly wage. Brown says maintaining a warm, collegial working environment also helps promote operator retention.

Still, Brown knows plenty of operators elsewhere who have left, or talked about leaving, for far better pay for comparable water-related work at oil and gas project sites. "They pay more," Brown says frankly. "One drilling site was advertising for a certified Level 2 water operator to take water samples and whatnot, and the starting rate was $42 an hour."

Brown, who speaks regularly with neighbouring Indigenous and Settler communities to discuss the various water related issues they all face, says low pay and challenging working conditions are evident in Indigenous communities across Canada. In many cases, operators work alone and it's hard to take holidays and attend professional development courses.

"Sometimes it's all a Band can afford," Brown says, noting that communities are often largely reliant on ISC funding, which doesn't always meet First Nations' needs. However, Brown acknowledges that ISC is largely beholden to federal government policies. "It goes way up to the top as to what can be done to give First Nations a real-world wage," he says.

Ultimately, band councils decide how money is spent, yet securing funding for water can be a struggle when there's multiple vital needs. "In order to get clean drinking water," Brown asks, "do we divert more funds towards the operations and maintenance department and take it away from welfare and social assistance programs or from community-based food programs?"

For Brown, respect for water and water operators goes hand in hand, and it's that message he bears when speaking with his band council and touring schoolchildren around one of his community's water treatment plants. "It's important people understand how much work goes into making their water safe, so we don't have water restrictions in the summertime and so we can have that nice cup of clear water to drink." WC

Saul Chernos is a freelance writer for Water Canada.

THIS ISN'T THE END OF THE STORY. In the next issue of *Water Canada*, we'll continue to explore the challenges water operators and communities, both Indigenous and non-Indigenous, face on a daily basis. And we'll discuss potential solutions, including unique collaborations, dedicated education programs, and other innovations. Stay tuned!

Deon Hassler

What do wetlands *really* do for our water?

They help protect us from flooding.

CASE STUDY:
CAMROSE CREEK, ALBERTA

Research shows that wetlands, serving as natural infrastructure in this Alberta watershed, provide ecosystem services and environmental benefits at an estimated value of:

- $1.25 million in flood protection
- $1.8 million in social benefits
- Approximately 900,000 tonnes of carbon stored

They clean it.

CASE STUDY:
ST-PIERRE-JOLYS, MANITOBA

When the town of St-Pierre-Jolys began using a wetland to clean water flowing from its lagoon, water tests showed that phosphorus levels dropped significantly.

- Phosphorus in the lagoon water was more than 70% higher than allowed by provincial guidelines.
- On average, the wetland reduced phosphorus load by 60%, bringing it well below the concentration allowed by provincial guidelines.
- The phosphorus in the wetland-treated water was lower or more diluted than the river water it was released into.

They protect rivers and lakes from algae blooms.

CASE STUDY: SOUTHERN ONTARIO

Research near Lake Erie has shown that restored wetlands are effective at removing excess nutrients that can fuel blue-green algae outbreaks. Wetlands in the study all received surface-water runoff from agriculture fields. Findings showed the wetlands:

- Retained 60% of soluble reactive phosphorus.
- Retained 46% of total phosphorus and 47% of total nitrogen

Freshwater is necessary for supporting life and our well-being. It shouldn't threaten us. **But the consequences of climate change and habitat loss are impacting Canada's water supply.**

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Ducks Unlimited Canada

Improved monitoring and mapping of critical landscape elements are vital to maintaining water quality.

One Problem, Many Variables

The challenges with protecting our source water BY JEN SMITH

WHAT STARTED AS A DISCUSSION ON protecting our source water became a deep dive into how climate change is impacting quality freshwater sourcing in Canada. In a country with so much water, it can be easy to take for granted that it will always be there, ready to pour out of our taps and through our sprinklers.

A complex issue

From the abundant water of Ontario, to droughts and flooding, sometimes in the same season, in the prairies, "the when and where water appears is really changing how things are, how we're served by our water, how complex the situation is, and how we need to make sure our water sources are resilient," says Terry Rees, the executive director with the Federation of Ontario Cottagers' Association (FOCA).

The varied experiences across the country echo just how vast Canada's water problems can be.

According to Rees, Ontario has done "an admirable job since the implementation of the Clean Water Act," a multiple-barrier approach implemented after the Walkerton tragedy in 2000, that ensures that the water sourced, treated, and delivered meets the highest standards.

"One of the things that the Clean Water Act in Ontario did was it took a watershed approach to protecting our water, which is vital because someone is downstream of somebody," says Rees. He also points out that there's more that needs to be done as there are still areas in Ontario that don't fall under the protection of the Clean Water Act.

Krystal-Anne Rousseau, staff lawyer with the Canadian Environmental Law Association and water policy coordinator for CELA's Healthy Great Lakes program, agrees, noting that what needs to be considered is whether or not water resources are being sufficiently identified and protected, especially when it comes to handing out approvals for projects like building subdivisions. "Current line use planning tools are really discretionary," she says. She mentions that many legal issues that come up deal with how the sources that aren't protected under the act are being handled. For example, subdivisions being built on sensitive groundwater resources and relying on private wells or septic systems that aren't covered by the Clean Water Act.

While the majority of Ontarians do have access to quality water, Rees points out that there is still a good portion of Ontarian outside of water protection areas. Rousseau adds that although the Ontario government has done a lot to implement the recommendations in the reports, there is almost 20 percent of the population left unprotected. She says that "most of those people are coming from vulnerable and disadvantaged communities, a lot of Indigenous and First Nations communities," which Rees agrees sends a "mixed message" that, according to Rousseau, still needs "a lot of work to make sure that source water protection is really improved upon and expanded to all Ontarians if we're really going to fully protect everyone as was the purpose of the Clean Water Act."

Kim Stephens, executive director of the Partnership for Water Sustainability in British Columbia, looks at source water protection from a B.C. perspective.

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He observes that while B.C and Ontario face some of the same issues, there are a number of differences in the way water is understood and handled. Although B.C does have large water (Fraser and Columbia Rivers), the water people use is from B.C.'s small systems, according to Stephens. And while these vulnerable small systems have faced quality issues in the past, these issues are now being overshadowed by a quantity issue. "As a result of a changing climate, the water cycle has changed, and that has altered the seasonal water balance." Says Stephens. "And so even though it rains a lot, our dry weather periods have gone from where we used to think in terms of a drought, a rain free period, of three months. Now we're talking six months. And last year kind of drove it home, didn't it? With heat domes, and atmospheric rivers, and record flooding, just the sheer impact of the change in the seasonal water balance and the implications."

In terms of where B.C. is right now, Stephens believes "is the consequences of not having somebody at the cabinet table who is accountable and responsible for water." In the case of British Columbia, the responsibility is dispersed through six ministries and that has consequences.

Pascal Badiou, PhD, a research scientist with Ducks Unlimited Canada, Institute for Wetland and Waterfowl Research, notes that on a national level Canada is making progress with regards to implementing source water protection plans, with the focus on natural infrastructure, ecosystems like wetlands and grasslands, and is "starting to see those reflected in various provincial policies, federal policies, and funding initiatives." There have also been significant investments in research and consultation, which he hopes will translate into best management practices through extension activities and supporting applied research.

Badiou cautions that "keeping Canada's water safe through source water protection is the going to require sustained efforts and investments, including things like improved monitoring of engaged systems, mapping of critical landscape elements, such as remaining intact grasslands and wetlands that are vital to maintaining water quality and the health of those fresh water sources going forward."

Keeping Canada's water safe through source water protection is going to require sustained efforts and investments, including things like improved monitoring of engaged systems, mapping of critical landscape elements, such as remaining intact grasslands and wetlands that are vital to maintaining water quality and the health of those fresh water sources going forward.

-Pascal Badiou, PhD, research scientist, Ducks Unlimited Canada

Climate change

Stephens recognizes the role climate change has had specifically on those small water systems in B.C. that people rely on. He explains how water balance works: Since the earth is a closed loop, the volume of water doesn't actually increase, rather it's all about distribution. "So," according to Stephens, "if you're getting hit harder during the wet season, of course there's less water in the dry season." And in places like British Columbia, extended dry seasons with less water can spell disaster. Because B.C. depends on smaller systems for their water supply, it leaves them vulnerable, and they must rely on extremely calculated operational decisions to ensure that there is enough water to span the season. Stephens notes that "when you're in a drought, you can't make more water."

Rees agrees adding, "When water doesn't arrive or arrives all at once, that changes the nature of how our systems naturally deal with it and by extension the availability of clean and abundant and safe water."

Badiou points out another effect of climate change: the eutrophication of our source water. Eutrophication is a process of excess plant and algal growth due to the increased availability of nutrients (like nitrogen and phosphorus). Although it occurs naturally over time, human activities have accelerated the rate. "We know climate change can increase pressure on freshwater resources and actually speed up the eutrophication process." Ultimately, "climate change and eutrophication can interact synergistically to increase greenhouse gas emissions, thereby further contributing to climate change going forward."

Rees concurs with Badiou's assessment, stating that "the chemical and biological-changes that happen as our waters warm and the advent of blue green algae blooms in water where it's never appeared before, even in systems that aren't eutrophic, that aren't high phosphorous-type systems, is going to be something we're going to need to be well aware of. And that's why we need to have resilient systems that can tolerate not just the conditions we've got today and that we've observed over the last decades, but we need to be planning ahead to make sure we've got recharge areas and retention and the ability to manage through times when we may have a lack of water that's audible and may not be easy or possible to treat."

Extended dry spells can mean disaster for small water systems.

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To help accomplish this, Rousseau calls for specific guidelines to be put into place, as too often the guidelines are too general and don't take into consideration that the impacts of climate change are going to be "variable from watershed to watershed."

The varied effects of climate change on water in Canada is a complex challenge. Badiou points out the tendency to look at the source water protection problem stressor by stressor rather than looking at it holistically. But by "acknowledging the impact of multiple stressors, whether it's climate change, eutrophication, or invasive species, and how the combined effects of those will interact is going to be hugely important." An incredibly complicated endeavour in and of itself that is only further complicated when "you consider that in the context of a nearly continuous supply of emerging contaminants, including things like illicit drugs, pesticides, synthetic, and natural hormones, personal care products, antibiotic resistant genes, and pharmaceuticals, you can see how that combination becomes increasingly complicated to tease apart and figure out the impacts."

Sustainable solutions?

Part of it is responsibility. Rees notes that, "We're all responsible, both as individuals and families and the people that we elect, the way we vote our dollars. A lot of the responsibility for our land use decisions start at the provincial level and are delivered by our municipal level of government."

Part of it is looking at how we use our lands, how we integrate Indigenous knowledge, and how we educate ourselves.

Join a conservation group, contact your local government, and as Badiou sums it up: "Get out and enjoy nature because it's really that link that keeps it top of mind and will help inform decisions down the road and how you account for your role as a person in protecting source water." WC

Bonnybrook Wastewater Treatment Plant

Graham

From Waste Gas to Five Megawatts of Power

The Bonnybrook Wastewater Treatment Plant

BY GEORGE KOCH

AS SOLIDS ARE BROKEN DOWN BY BACTERIAL and physical actions in sewage treatment, large volumes of gases are generated. Known as "biogas," these gases, which are full of impurities, have long been allowed to vent into the atmosphere, contributing to the malodorous air associated with wastewater treatment. Thankfully, more modern wastewater facilities are capturing and safely incinerating or *flaring* their biogas, and in recent years, some plants have begun adding portions of their biogas to commercially sourced natural gas and burning the mixture to produce steam or modest amounts of electricity, while still flaring most of their biogas. Calgary's Bonnybrook Wastewater Treatment Facility is one such site.

Today, Bonnybrook is taking biogas handling to the highest level: Using all of its biogas as the primary fuel source to meet its needs for electric power and industrial steam for its advanced treatment process. A first in Canada, the Bonnybrook Cogeneration Expansion Project is currently undergoing commissioning and system operational testing in preparation for handover to the City of Calgary.

Collaboration and complex processes

The ambitious $60 million, 3-year project custom designed by Stantec and general contracted by Graham, not only introduced a new operations concept for the Bonnybrook wastewater team, it also required vendor-packaged equipment sourced from around the world during the height of the COVID-19 pandemic. Meeting these challenges and keeping the project moving forward became a case study in applied cooperation among the design, construction, and City of Calgary teams.

"This facility is designed with a certain intent, and it's going to be run by the client, so the collaborative approach we took to ensure we had a positive outcome is one that I'll take forward to future projects," says Andrew Buchner, Stantec's B.C. Practice Lead for Water and resident engineer for the project. "It's the only way I see to commission a complicated project, especially one that is unique to all of the key parties."

The steam turbine generator will be used to create additional plant or will feed the future thermal hydrolysis process facility.

Graham

Although Bonnybrook's new cogeneration facility is small by power plant standards, its technical complexity is greater than that of a commercial gas-fired electrical generating station with 100 times the output. The power plant provides both combined-cycle power generation and cogeneration of power and heat.

"Cogenerations of power and steam is totally different from wastewater treatment, which is the facility's core business," says Jifan Liu, the City of Calgary's Project Manager. "It is technically complicated and there are a lot of components that all need to work together. Our technology goals were significant, and we are using the most advanced gas turbine, steam turbine, and the latest biogas conditioning and water treatment systems."

The intricacies include the capability to handle an adjustable fuel mix of biogas and commercial natural gas. Because biogas production varies greatly along with wastewater treatment volume, a low-pressure biogas storage bubble was included. The power plant must also satisfy regulatory requirements that it always operate with at least some biogas. Even so, some natural gas will be required from time to time.

A Solar Turbines Inc. Centaur 50 gas turbine-driven generator set (CTG) gas combustion turbine is coupled to a generator producing 4 MW of power. All waste heat from the CTG is cycled through the heat recovery steam generator (HRSG) where steam is produced. That steam is then either sent to the steam turbine generator (STG) to create additional power or will feed the future thermal hydrolysis process (THP) facility — part of Bonnybrook's Plant D expansion — that will make waste solids more digestible and, in turn, produce even more biogas. The steam surface condenser (SSC) condenses all excess steam not used by the STG or THP back into feed-water. A gas-fired steam boiler is included to provide a backup steam source. Incoming water for steam production also requires complex purification. Gas compression and chemical feed systems are further elements.

"This plant has a lot of interesting features," says Kyle Jensen, Stantec's Electrical and Process Design Engineer. "Using biogas as a fuel is interesting in its own right. It only contains about half the energy of commercial natural gas. And it comes with a host of impurities, including highly toxic hydrogen sulfide, or H_2S, which requires careful handling." For safety and to avoid damaging the turbine, the process design includes sophisticated gas conditioning, cleaning, and dehydration to remove impurities such as siloxane, housed inside a robust blast-proof gas conditioning room. H_2S, however, remains part of the fuel inlet stream and is safely incinerated during engine combustion.

The complex design, in turn, required sophisticated electrical and control systems, including a motor control system, switch-gears, and cabling room. The new plant had to be integrated in three different ways: with Bonnybrook's wastewater treatment system, with its existing reciprocating-engine cogeneration plant, and with the facility's power system, which draws from Alberta's electrical grid. "You have three different power sources all producing electricity, that all have to talk

to each other through the power control system," notes Cedric McIntosh, Graham's Project Manager.

Set up for success

Construction began in October 2019 and the technical complexity immediately made itself felt. "There was a lot of research and development as we went, there were a lot of changes as we went, and we had to do a lot of work to optimize the schedule to fit the changes and work with the consultant and owner to end up with a product that is useful," recalls McIntosh. This stemmed from the fact that a lot of key technical information wasn't initially available to Stantec.

"The team solved a lot of problems during the project," says McIntosh. "It required people recognizing the challenges, where they came from, and how we could all work together in good faith to solve each challenge towards a favourable outcome. A lot of that success has to do with the relationship we have with the City and with Stantec."

The pandemic's arrival in March 2020 caused immense problems. In addition to the by-now-familiar productivity-sapping effects of working under COVID-19 protocols, supply chain issues hit this project particularly hard. "We had a truly international supply chain, and certain factories around the world simply shut down in the pandemic, so there were serious challenges in getting equipment," says McIntosh.

In addition to serious delays in fabricating and shipping the physical items, vendor reviews of shop drawings and vendor site inspections were all delayed, cancelled, or had to be moved online.

"The supply chain issues related to COVID were some of the biggest challenges," agrees Stantec's Buchner, who has over a decade of experience working on wastewater facility design. "The issue-for-tender design was based on certain vendor packages and assumed pieces of equipment, but we did not even get pricing from some of the intended vendors." Having to switch vendors midstream contributed to significant delivery delays on some of the large equipment packages.

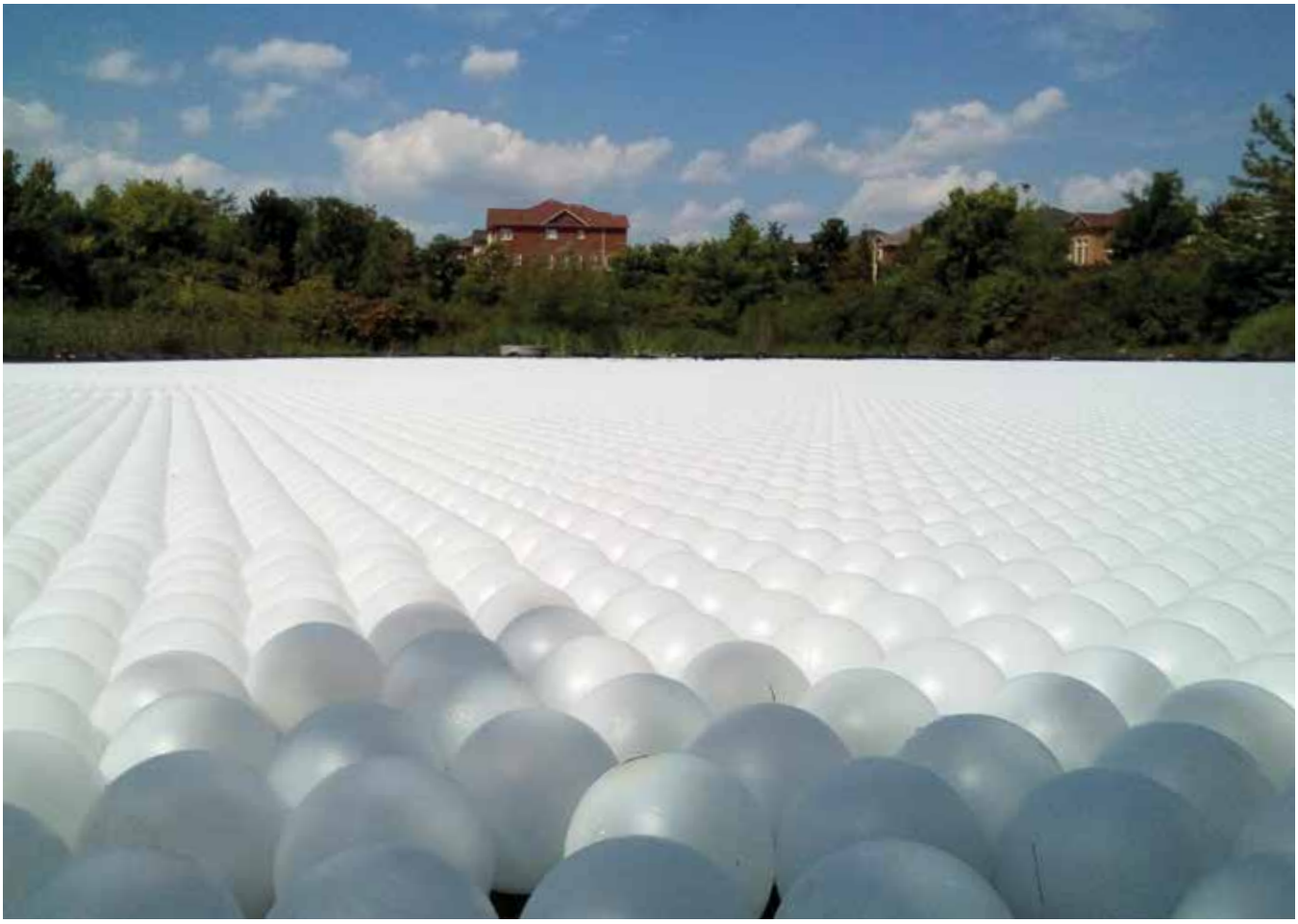
Creative thinking was applied to re-sequence equipment installation and other key tasks. Under normal sequencing, large equipment packages are placed on-site and the building envelope is later constructed around them. But when delays on certain packages like the steam turbine generator threatened to halt the entire project, Graham decided to leave a large gap in the building's second-floor envelope. Once the package finally arrived, it was craned into position, inserted and placed inside on its skid mounts, after which the building was enclosed.

As construction proceeded, another critical focus was setting up the Bonnybrook team for successful plant operations. "The seriousness of the process—moving from handling waste sludge to producing high-pressure steam—is a step-up for the Bonnybrook operators," notes Jensen. "Keeping the operators safe for the long run became a key part of project planning."

Planning began early to create a comprehensive commissioning and handover process with extensive hands-on training. "Just getting handed a facility at the end of commissioning by a contractor, which often happens, would not work here," says Buchner. "Here, the whole team is going through commissioning and training together." This has proved to be a key decision, says Jensen.

While delivering the Bonnybrook Cogeneration Expansion Project has been a complicated and difficult process, Liu is excited by what the new facility will deliver once it is fully operational in July. "This project will enable us to consume all of the biogas produced by the plant," he says. "It will create energy savings for the facility and greatly reduce external consumption of electricity, which will reduce our power bill, and also improve the overall reliability of our power supply." If a civil disaster such as another major flood were to hit Calgary, for example, Bonnybrook could continue operating under its own power. As Liu sums it up: "I'm optimistic that we will achieve the objectives we set at the beginning of the project." WC

George Koch is a researcher and writer based in Calgary who has written extensively about construction and public infrastructure.



Hollow, high-density polyethylene balls cover the surface of the Esker stormwater management pond in Brampton, Ontario.

Keeping Cool

Protecting aquatic species with thermal mitigation

BY LISA ROCHA, TIM VAN SETERS, AND ERIK JENSSEN

THE URBAN HEAT ISLAND EFFECT AND RISING summer temperatures affect more than just our air-conditioning bills. Freshwater ecosystems are at risk as well, as even small changes in water temperature can cause migration of freshwater species and population decline.

In urban areas where stormwater is managed through detention facilities like ponds, this warming effect is further exacerbated. Although these facilities enhance water quality by removing pollutants and reducing erosion and flooding issues downstream, they can also be significant contributors to thermal enrichment of streams, as the water they detain is subject to significant heating during summer months. Pond outlet temperatures are often more than 7°C warmer than inlet temperatures and well above the tolerance threshold of several cool and cold freshwater fish species across Canada.

Cold-water priority

In Ontario, this has been recognized as a concern by the Ministry of Natural Resources and Forestry, which has developed thermal targets and guidelines for development in areas that provide habitat for the endangered cold-water species, Redside dace. While protection and recovery of Redside dace populations have been the main impetus for the push toward addressing thermal enrichment of streams in the Greater Toronto Area, populations of many other cold water fish could also benefit from these measures.

One such example is the declining Brook trout, which thrive in very cold streams (< 20 °C). Today they are confined to mostly headwater areas within the Lake Ontario basin and are estimated to occupy only 21 per cent of their historic range. Modelling of future climate scenarios by Toronto and Region Conservation Authority (TRCA) in 2020 found that compared to those in warm and cool

TRCA

streams, cold-water fish communities are the most at risk of extirpation within the TRCA jurisdiction over the next 80 years if no adaptation measures are undertaken.

Cool strategies

Thermal mitigation refers to a range of practices that are designed to either prevent or reverse summer warming of stormwater, typically in urban and suburban areas. They can be categorized based on where in the drainage network they are applied—within the catchment area, within the stormwater pond block, or at the receiving stream – or according to the ways in which they protect streams from thermal impacts.

For example, one important technique is to release only cooler water from stormwater ponds, which can be achieved through the construction of bottom draw outlets in deeper ponds, or the installation of real-time outlet controls that only release water during the night when temperatures are lower. Other common practices like cooling trenches and vegetated outlet channels focus on cooling down pond outflows; while shading practices, like shoreline plantings and floating islands, are meant to prevent pond water from warming up in the first place. Other strategies focus on reducing total runoff volumes by enhancing infiltration and evapotranspiration, resulting in less thermally enriched water released into streams. These practices provide stormwater treatment and flow control allowing stormwater pond sizes to be reduced, and in some cases, wet ponds can even be substituted for dry ponds, which have a lower warming impact.

Over the past few decades, several of these thermal mitigation practices have been implemented and monitored in southern Ontario with results showing varying degrees of cooling effectiveness and viability with respect to operation and maintenance needs. However, finding technologies that are easy and cost-effective to implement as retrofits to existing ponds can be a challenge.

New approaches

Recognizing the limitations of existing measures, the City of Brampton partnered with the Sustainable Technologies Evaluation Program (STEP) to explore the efficacy of new thermal mitigation approaches through pilot studies. STEP is a collaborative effort involving the TRCA, Credit Valley Conservation, and the Lake Simcoe Region Conservation Authority focused on fostering broader implementation of sustainable technologies through research, guideline development, and outreach.

Stormwater retention ponds can be significant contributors to thermal enrichment of streams.

Pilot evaluations were focused on practices that are cost-effective, easy to maintain, capable of meeting thermal targets, and can be applied either on a new site or as a retrofit to an existing facility. Two thermal mitigation technologies were selected for piloting at two different ponds in Brampton: pond surface shading with shade balls and a geothermal outflow cooling system.

Pond surface shading

In the surface shading pilot, 75 per cent of the pond's surface was covered with high-density polyethylene balls that were contained within a floating turbidity curtain barrier system. The site was monitored over three summers, during which time the pond's inlet and outlet temperatures were compared pre- and post-installation, as was a nearby pond that served as an experimental control.

Data collected showed that the shade balls did not cause a significant or consistent reduction in pond warming relative to baseline conditions or the control pond. Further investigation showed that water directly underneath the balls was warmer than water at the same depth in the unshaded area, suggesting that the balls were creating a heating effect at the pond's surface.

During small-scale experiments conducted as part of this study, the cooling performance of other ball colours were also investigated, including black balls and white balls that had received a coat of reflective paint. This testing revealed that the black balls kept the water beneath them coolest, resulting in median water temperatures nearly 2°C cooler than beneath the white balls.

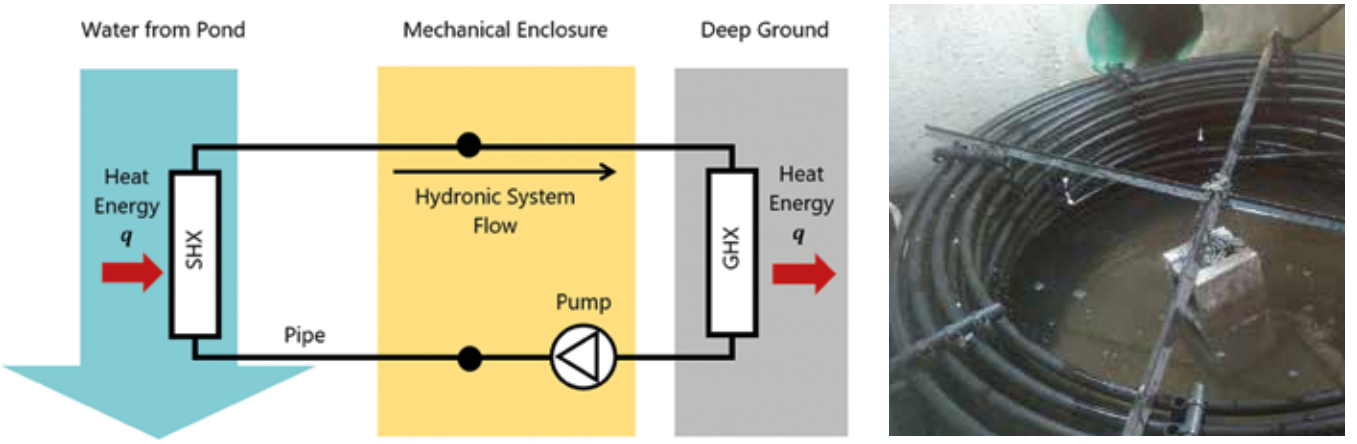
Ultimately this pilot demonstrated that while the specific product tested wasn't effective in preventing warming, shading alternatives should still be considered as part of the toolkit of thermal mitigation best practices, albeit not as standalone measures.

Geothermal cooling

Passively cooling pond outflows using technologies like cooling trenches is a well-established thermal mitigation approach, with performance varying significantly from site-to-site. Geothermal technology takes this technology one step further by actively using the stable cold temperatures deep underground as both a source and a sink for heat energy. While typically deployed in conjunction with a heat pump to create an energy efficient heating and cooling system for a building, geothermal was applied in this pilot to passively cool warm stormwater pond outflows instead. The system consists of a 183-metre deep geothermal borehole, or ground heat exchanger (GHX), connected in a closed loop with a stormwater heat exchanger (SHX) (see Figure 1).

The SHX in this pilot were made from

TRCA



L to R: Figure 1. Schematic diagram of the pilot geothermal stormwater cooling system. The coil of high-density polyethylene pipe used as the stormwater heat exchanger (SHX) in the geothermal cooling pilot.

inexpensive coils of polyethylene pipe, installed inside a space-efficient vault downstream of the pond outlet. A heat transfer fluid is pumped continuously through the closed loop. When warm pond outflows move through the vault on their way to the stream, they pass over the coils of the SHX which absorbs heat and, via the circulating fluid, rejects it to the deep ground using the GHX. This cycle can be used to continuously cool warm stormwater outflows as they leave the pond.

The pilot included only one borehole to provide the data that would allow for development and calibration of a system model capable of predicting how cooling performance varies based on changing design parameters. Using the model, cost optimization calculations can be undertaken to determine the lowest cost number of boreholes and length of pipe required to meet the target outflow temperature. For the pilot site, the model developed predicted that with no geothermal cooling in place, pond outflows would exceed 24°C about 50 per cent of the time from June 1 to September 15, but if a system that included four-to-six boreholes was installed, outflows would remain below 24°C for 95 per cent of that time. Geothermal systems are space- and cost-efficient, suitable for retrofit applications and visually unobtrusive, making it a great solution for thermal mitigation of stormwater pond outflows.

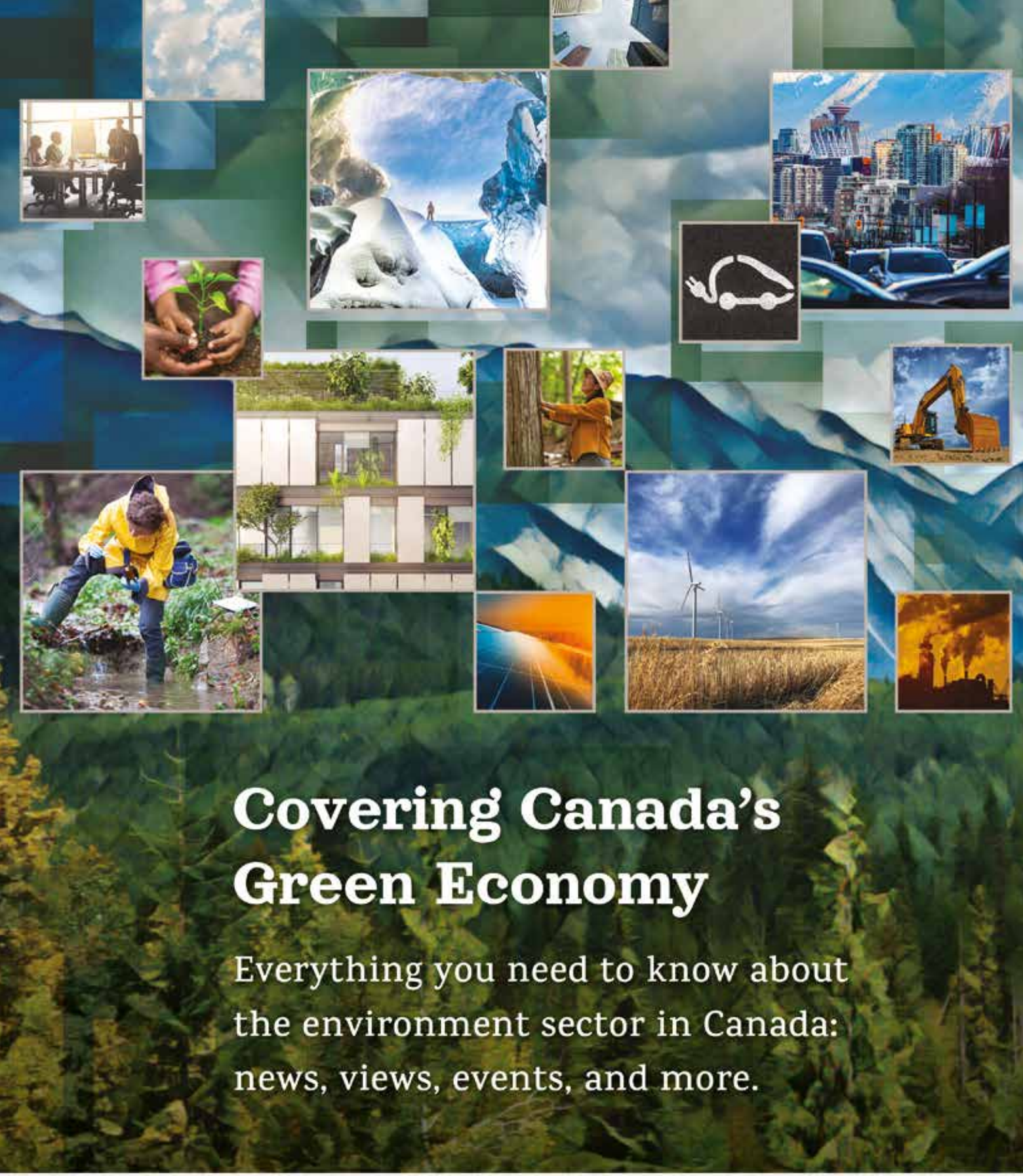
Creative combinations

Finding creative combinations using a toolbox of approaches tailored to the unique character of each site helps optimize individual technologies, reduce cost, and improve overall effectiveness. This means seeking out opportunities across the landscape to absorb and infiltrate water, providing shade where feasible, using cool water deep in the stormwater ponds to reduce outlet temperatures, and relying on active cooling techniques to provide a final boost before water is released to streams. WC

Lisa Rocha is a project manager with the Sustainable Technologies Evaluation Program (STEP) at the Toronto and Region Conservation Authority, who specializes in sustainable water management.

Tim Van Seters manages the Sustainable Technologies Evaluation Program (STEP) at the Toronto and Region Conservation Authority.

Erik Janssen is an analyst with the Sustainable Technologies Evaluation Program (STEP) of the Toronto and Region Conservation Authority.



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The Bruce Fellowship

Creating a ripple effect in Canadian freshwater policy

BY DR. PAM SUGIMAN

ERIKA C. BRUCE, PHD, AND HER LATE HUSBAND, Geoffrey F. Bruce, shared a vision for Canada: To be a world leader in freshwater policy. As a compassionate and well-traveled global citizen, Erika has seen firsthand the challenges faced by water poor communities. She and Geoffrey shared the concern that Canada, a country with such exceptional freshwater resources, does not have stronger policies in place to protect these precious bounties.

"Freshwater is not only important for our people, communities, and businesses," said Erika. "It's a strategic resource that impacts issues of Indigenous rights, issues of security, political conflict, transportation, privatization and more—all aspects of policy and governance."

It was this perspective and her late husband's long-time commitment to advancing freshwater policy that prompted her to establish the Geoffrey F. Bruce Fellowship at Toronto Metropolitan University (TMU) five years ago.

The Bruce Fellowship, which funds two fellows each year, has made important contributions from its inception with impacts that continue to grow with each new cohort of Fellows. Dr. Carolyn Johns, a professor in the department of Politics and Public Administration at TMU who oversees the Fellowship, describes it as having important "ripple effects," helping expand the freshwater policy community, as well as the thinking and research that can shape Canadian water policy.

"I am very grateful to Erika for creating this incredible opportunity for us to shape the future of freshwater policy and support the next generation of freshwater policy leaders," said Carolyn.

Creating a water policy community

For Dr. Edgar Tovilla, one of the inaugural Fellows, one of the greatest benefits of becoming a Bruce Fellow was the opportunity to engage with diverse members of the water policy community, both through Carolyn's network and the Water Policy Cafés that she established as part of the Bruce Fellowship.

"I was able to engage with a community of like-minded individuals brought together by our shared interest in freshwater policy," said Edgar, who is now the senior manager of Waterworks Operations for the Municipality of Markham. "We were working on very diverse and different topics, which helped bring new perspectives to my research."

Like many other Fellows, Edgar has remained connected with the community,

Toronto Metropolitan University

Toronto Metropolitan University

attending the Water Policy Cafés whenever possible and participating in shared initiatives like a formal submission on the creation of the Canada Water Agency.

Dr. Madeleine Martin, a 2018-2019 Fellow, also saw great value in the welcoming and supportive community fostered by Carolyn. "I workshopped my PhD proposal there and got very helpful feedback," she said. "It's a very friendly environment to discuss things because everyone is looking to lift each other up and help out."

Madeleine, who recently accepted a role with Natural Resources Canada, added that the Water Policy Café "helped create a bridge between academic and non-academic world. It's easy to get tunnel vision in academia, but engaging with people working in water policy in other settings helped me explore other options and advance my career."

Similarly, current Fellow Lana Marcy shared that participating in the Water Policy Cafés and meeting some of the other Fellows made her even more excited about being part of the community. "The Water Policy Café has been one of the best experiences of my Master's program," she said. "I felt so empowered and proud of the work that I was participating in and contributing to, and it was a great source of new resources."

Shaping policy through Fellowship-supported research

This supportive community is informing diverse research with real-world impacts. For some fellows, such as Edgar Tovilla, this involves direct application. Not only does he apply his research in his day-to-day work for the city of Markham, he is also involved in developing new stormwater and wastewater management standards with the Canadian Standards Association and the Ontario Ministry of the Environment. Edgar also supervised one of the other Bruce Fellows, Andre Setodeeh, in a municipal water policy internship that resulted in Andre landing a job with Toronto Water.

For others, their research may be used to inform policy development, shaping the future of freshwater in Canada. 2020-2021 Fellow Miranda Black's research on Toronto Island and surrounding waters and the ways that Indigenous Peoples are calling out for better water stewardship, including water and land claims, could help provide important context for water policy in the Great Lakes. Miranda, one of two Indigenous Fellows to date, hopes that her research will "help policy makers see Indigenous Peoples as inherent rights holders that need to be recognized and sovereign nations."

Edward Millar, a 2019-2020 Fellow, also sees an opportunity for his research on participatory water monitoring programs in Ontario and citizen science to inform how public policy approaches and reflects citizen science. Edward also found that being a Bruce Fellow shaped his research, with the explicit policy focus encouraging him to think more about this than he might have otherwise. "It helped ground my exploration in concrete outcomes that could be relevant outside of academia," he said. "There is a lot of community-based water monitoring in Canada but it hasn't historically been at the forefront of policy here. That's starting to change. I hope that my research can help inform how citizen science is an important part of water policy and to make sure it is valuable in protecting freshwater."

Continuing legacy

"The first five years of the Bruce Fellowship have exceeded my expectations," said Carolyn Johns. "I see even greater possibilities for the next five years and beyond. I look forward to attracting more exciting candidates from a wider range of disciplines, such as law and political science, and institutions, as well as creating more applied research partnerships. We're also planning to host an international water policy conference in 2023 and are working to build a close relationship with the newly formed Canada Water Agency, hopefully one that creates even more value and opportunities for our Fellows."

Erika Bruce shares this enthusiasm. "I have been very impressed and gratified by the calibre of the Fellows and find it quite extraordinary how they have devoted themselves—their time and their energy—to researching subjects that are so important and often overlooked," she said. "I hope that ultimately they will be able to contribute in a practical sense, with the application of recommendations from their research to water policy." WC

For more information or to discuss support for research projects, visit torontomu.ca/bruce-fellowship/.

Dr. Pam Sugiman is Dean of Arts at Toronto Metropolitan University. The Faculty of Arts houses the Department of Politics and Public Administration and offers a Master's degree in Public Policy and Administration, as well as a PhD in Policy Studies.

After two decades of leadership, **Bernadette Conant**, CEO of the Canadian Water Network is passing on the torch. Bernadette has made lasting impacts on the water community in Canada and around the world. Her focus on end-user needs as a starting point for research collaboration was ground-breaking for its time and foundational for the organization. Today, CWN is a national intermediary forging alliances with leaders in and adjacent to the water sector who share a common goal of advancing community goals through water management.

BERNADETTE CONANT

"CWN has benefitted tremendously from Bernadette's leadership as the organization morphed from a Network of Centres of Excellence (NCE) to the current not-for-profit organization that helps build communities of the future through water," said Carl Yates, Chair of CWN's Board of Directors. "We thank Bernadette for her contributions to the water sector and know she will continue to make an impact in the next chapters of her life."

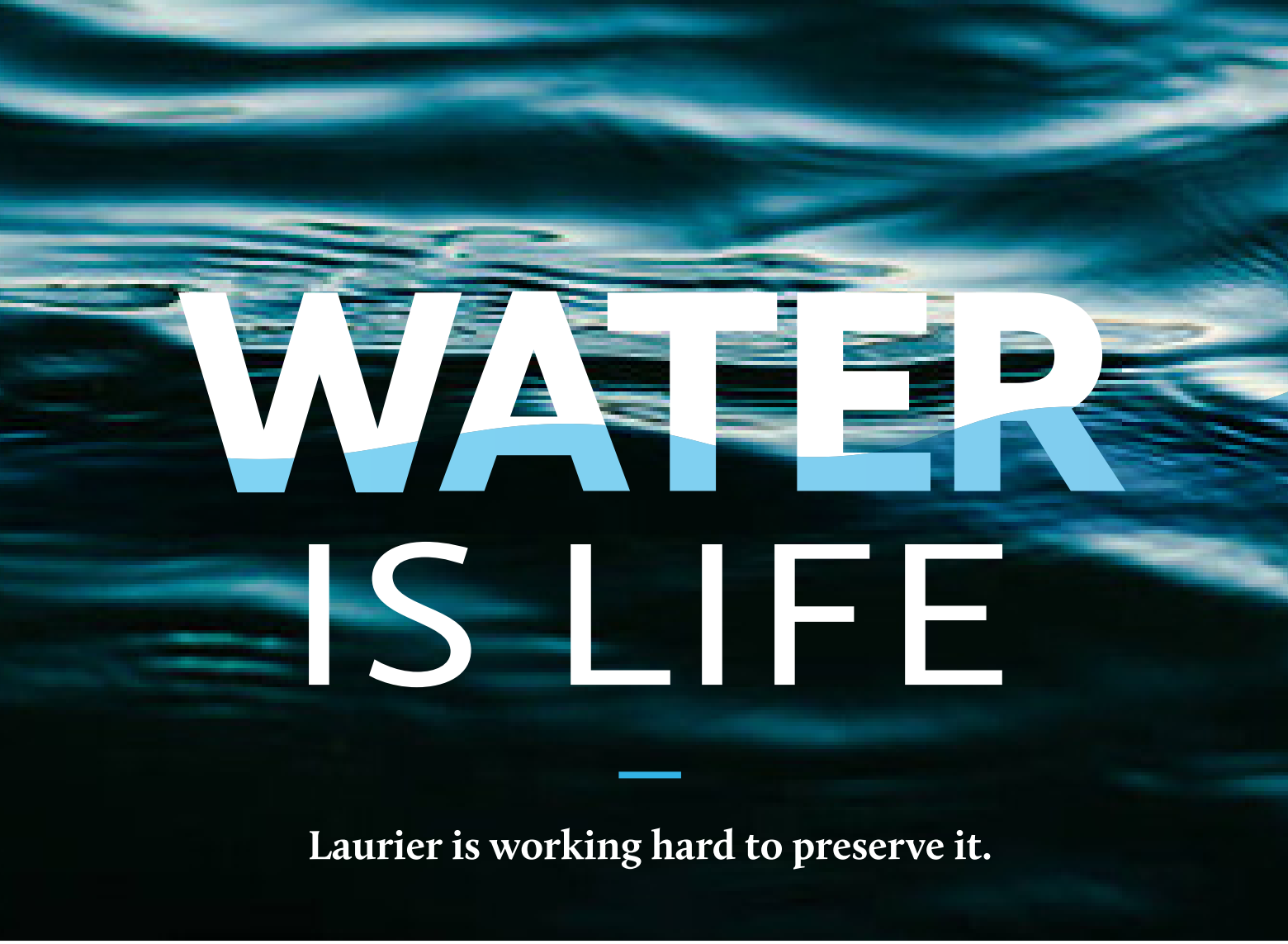
Nicola Crawhall is the new CEO of the Canadian Water Network.

Nicola has over 25 years of professional experience in leading and supporting municipal networks and shaping water governance and policy. For over a decade, Nicola served as the Deputy Director of the Great Lakes and St. Lawrence Cities Initiative, a binational association of mayors that promotes the protection and restoration of one of the world's greatest sources of freshwater.

NICOLA CRAWHALL

"I'm thrilled to be joining CWN as its next CEO," said Nicola. "Now more than ever, Canada needs a strong network of communities that promotes sustainable water management at the national level and drives innovative and forward-looking actions at the local level."

I look forward to working with communities to grow and strengthen our national network to meet our shared challenges through water."



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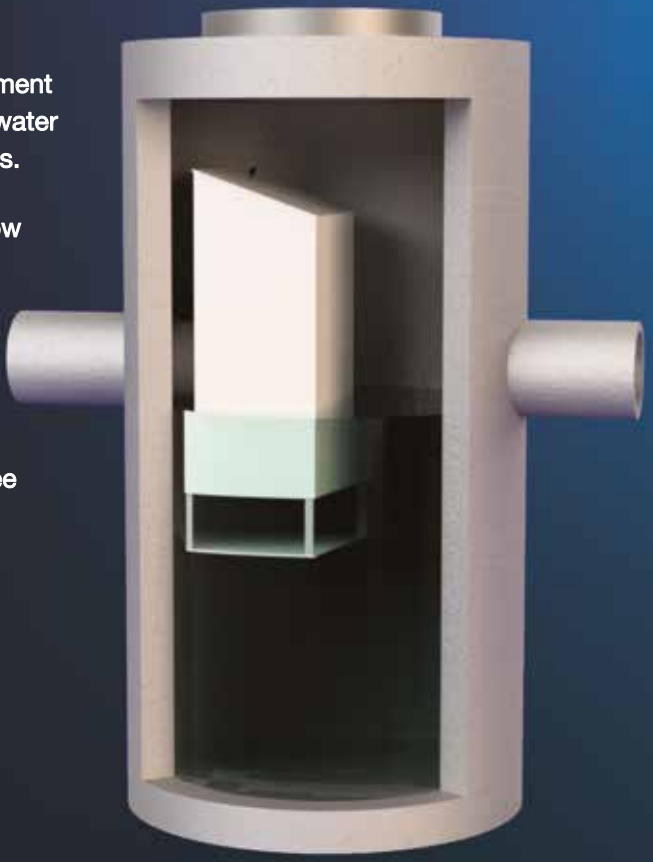

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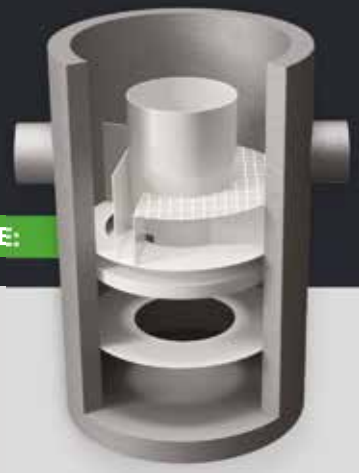

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