IIHR–HYDROSCIENCE & ENGINEERING

The University of Iowa
College of Engineering

IIHR CURRENTS

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IIHR's *global reach*

CONTENTS

Follow IIHR, the Iowa Flood Center, and the Iowa Geological Survey on social media!

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On a Mission

PHOTO BY JIM HEEMSTRA

Sometimes, I lie awake at night, my head abuzz with new research plans and strategies for IIHR. And yes, at times, I worry. So much is riding on our efforts—better water quality for Iowans and the environment, improved flood resilience, a sustainable water future for everyone, and so much more.

But more often, I simply can't turn off my thoughts and go to sleep because I am so incredibly engaged with this work. I feel that we have an obligation to make a difference in the world. This is both a privilege and a responsibility. As you will see from the pages of this magazine, our work juxtaposes important local impact with true global significance. I believe Iowa can be a test bed for new ideas and strategies that can be expanded to a much larger scale.

A good example is our work in the area of water quality. How can we balance the needs of our agricultural economy with the very human need for clean water and a healthy environment? IIHR is uniquely qualified to help solve this problem. Working with landowners and other stakeholders, we're helping develop new strategies and approaches that can help us move toward a future in which a healthy ag economy co-exists with improved water quality.

As this magazine was going to press, we got the exciting news that the U.S. Department of Housing and Urban Development (HUD) would award $96.9M to the state of Iowa for flood infrastructure projects and a statewide watershed improvement program, the Iowa Watershed Approach (IWA). IIHR and the Iowa Flood Center played (and will continue to play) a key role in developing the program, writing the grant, and coordinating efforts with our many partners to reduce flood risks, increase community and watershed resilience, and improve water quality and the quality of life for Iowans in nine watersheds. We'll have more information on this transformational project in the weeks, months, and years to come.

More and more, I feel a sense of urgency as we address these issues. Can we find solutions in time? For me, the answer is clearly yes. IIHR is an amazing engine of innovation and imagination. If we approach our challenges with humility, tolerance, and courage, I believe we can find the way. Along with my colleagues at IIHR and our partner organizations, I am prepared to dedicate all my energy, intellect, and vision to improving water access, quality, and sustainability worldwide.

To do any less would be a failure of the intellectual spirit.

Larry J. Weber
Director, IIHR—Hydroscience & Engineering; Professor, University of Iowa Department of Civil & Environmental Engineering; Edwin B. Green Chair in Hydraulics

PHOTO BY BOB MODERSOHN

An appreciative crowd watches the unveiling of Scorpzilla on the banks of the Upper Iowa River near Decorah.

Scorpzilla Takes Decorah

A curious group of cameramen, adults, and children huddled alongside the cold, muddy banks of the Upper Iowa River near Decorah. They squished through the mud to form an arc around a mysterious large object, covered by a zebra-striped blanket flapping in the cold November wind. Dennis Wilson, who had transported the object from Denver, readied himself to unveil whatever waited beneath.

"I'd like you guys to meet your town's oldest resident," he said, revealing … what?

A model of *Pentecopterus decorahensis*, an ancient six-foot scorpion-like sea creature, stared into the crowd. Onlookers clapped for their new resident, "Scorpi." They clapped for the University of Iowa and Yale researchers who had found the 465-million-year-old fossil remains. They clapped for Wilson, the reconstruction artist who had brought the creature to life. They clapped for the Hildebrands, the landowners who had allowed a team of geologists and paleontologists to temporarily divert the river, revealing the fossils.

"We never thought that this would've been the outcome 10 years ago when we met the team," said Jane Hildebrand. "It's been really exciting."

The Hildebrands' land is within the Decorah impact structure, where a meteor struck some 465 million years ago. Beginning in 2007, Iowa Geological Survey researcher Paul (Huaibao) Liu and his team uncovered an amazing array of fossils in the area. The meteorite impact created conditions allowing the extraordinary preservation of a wealth of prehistoric fossils. The scorpion-like fossil is the oldest described species of eurypterids (the ancestors of modern spiders).

Jake Hildebrand said that he and his two brothers grew up playing in the area of the fossil find. "We never thought this creature could be here!" he added. Neither did Liu.

"It's an unusual site and unusual to find such good fossils. I think Decorah is really famous now," Liu joked. The city and Scorpi will become even more famous when *The Strange Truth*, a documentary series, airs on the National Geographic Channel in early 2016. Other episodes will feature a lost nuclear bomb buried on a North Carolina farm, lightning strikes caught on video, face mites, and crows that mourn.

Liu said his main focus is to publish more of the research so it will be scientifically approved and accepted. "It's important, you know? Very rare stuff," he added.

Scorpi is large, but it's not the largest model Wilson has created. A nine-foot feathered dinosaur and a 30-foot crocodile skeleton are just two of his more impressive pieces. "I do extinct creatures," he says—a job very few artists can claim. He noted that the first model of Scorpi—made of Styrofoam, an epoxy resin, and deer antlers—is a prototype. The final product will live in Trowbridge Hall at the UI Department of Earth and Environmental Sciences.

"It's unlike anything we have," said Tiffany Adrain, collections management specialist. "It really brings it to life. I feel like if we turn our backs, it will scuttle off into the water."

As the crowd waited for the filming to wrap up, they overheard Steve Hildebrand thinking aloud, "I wonder what it'd taste like with butter?"

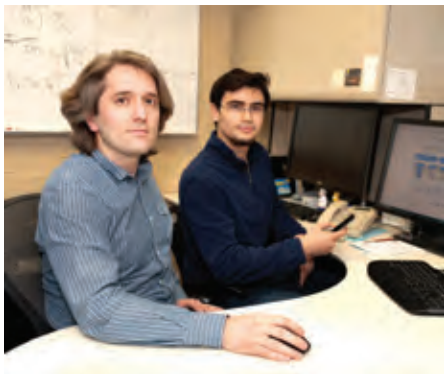
To learn more about Liu's fossil finds, see story page 12.

A Flood of Tweets

Flashback to 2008, when countless Iowans were stranded in flooded homes and businesses, waiting for help that must have seemed as though it would never come. Now imagine that with a simple post on Twitter, an emergency management team could quickly locate and rescue those individuals.

That's just one of the potential uses of the Iowa Flood Center's new social media flood prediction, preparedness, and response system.

The project will offer another layer of information on the Iowa Flood Information System (IFIS), an online Google-maps based platform relaying near real-time flood-related data. IIHR Assistant Research Engineer Ibrahim Demir, a specialist in hydroinformatics, says he realized IFIS was missing human input and that a "crowdsourcing" and citizen science approach could help fill the gap.



Ibrahim Demir (left) and Yusuf Sermet developed a new Twitter-based flood prediction, preparedness, and response system.

Even with 223 IFC stream-stage sensors and about 200 additional U.S. Geological Survey (USGS) gauges, Iowa isn't getting the whole picture. "Social media is an alternative source of information that can give us some idea about what is happening in those regions."

Muhammed Ali Sit, a visiting undergraduate researcher from Istanbul Şehir University in Turkey, indexed, analyzed, and mapped thousands of flood-related tweets. The researchers use natural language processing (NLP) algorithms, a form of artificial intelligence. They sift through the posts to find keywords that are part of a "flood ontology" developed by Yusuf Sermet, a graduate student on the hydroinformatics team, to avoid indexing unrelated

International Perspectives

Over winter break, a group of students traveled to northern India for IIHR's three-week International Perspectives in Water Resources Science and Management course. Led by IIHR research engineers Marian Muste and Allen Bradley, the students learned about agricultural watersheds where residents are seeking access to fresh water year-round. Student participant Harvest Ellis (left), who went on the 2014–15 trip, says she was surprised to learn how much work is required to implement and quantify the benefits of real-world projects. IIHR collaborates with UI International Programs to organize the class, which is held in late December and early January.

tweets. Because users sometimes have the location services turned off on their smart phones, the algorithm must also be able to successfully map tweets without an exact geo-location.

Geo-location is a key component of the project because the tweets fill in data from physical regions missed by stream sensors. Demir hopes to create a sort of virtual sensor using correlations between the tweets and actual observations. Live Twitter data streams could then be processed in real-time to issue flood warnings, in addition to the sensor-based warnings already released through IFIS.

Clearly communicated hashtags such as #IAFlood or #FloodHelp could help emergency response teams assist those in need. Demir hopes to expand the project to other social media platforms.

Demir says they will release the new functionality on IFIS in early 2016 before the flood season. "I'm really excited about this project," says IFC Director Witold Krajewski. "It is yet another layer of information that we can provide to Iowans regarding floods. It also builds off our technological capabilities and complements our observation and modeling systems."

Heating Up in Paris

Editor's Note: IIHR Research Engineer Jerry Schnoor attended the climate talks in Paris in December 2015 as a member of the media; he sent this report.

The Paris climate agreement was truly historic. Never before have 196 countries agreed unanimously on an action plan to respond to climate change. Never before have 150 heads of state met at one time in one place to talk about anything. It happened in Paris.

But the Paris Agreement was also a compromise. It provides stronger ambition than any previous meeting, but it is voluntary by nature and, therefore, purposefully short on penalties for nations that do not meet their pledges. Also, it provides a framework for rich countries to finance adaptation and "loss and damage" for the most vulnerable countries, but it does not specify a total amount or how much each country will pay or receive.

"…prospects for the planet and people are much brighter than they were on
Jerry Schnoor, IIHR Research Engineer

We recognize that the pledges for emission reductions are an important component of the agreement, but they do not go far enough. They result in an "emissions gap" between what is pledged and how much is actually needed to limit global warming to less than 2° Celsius. That's the current goal of the agreement, but there is a "stretch" goal mentioned to strive for 1.5° (see photo). Right now, it is estimated that pledges would result in a warming of more than 2.7° by the end of the century compared to preindustrial times.

Island and coastal nations are already being affected by sea-level rise. The countries most severely impacted are seeking funding from the Green Climate Fund, which was founded as a part of the agreement to help vulnerable nations respond to climate change. They seek more than $100B each year from developed countries. Some of the money will go for adaptation, to build infrastructure that will withstand greater storm surge in the future. But part of the money will be dedicated to repair the loss and damages due to our changing climate.

As a historic compromise, the result of the Paris accord is a first step in the right direction. It defines a process to update pledges every five years and for developing nations to contribute to emission reductions and to the

ly a few months ago."

climate fund as they become wealthier. In the meantime, the responsibility to cut emissions and to contribute funds lies with those rich countries that emitted most of the man-made greenhouse gases in the atmosphere, and that possess economies capable of transitioning from the fossil fuel age to renewable energy sources.

With this Paris accord, prospects for the planet and people are much brighter than they were only a few months ago. But much work is still needed to close the emissions gap and to raise funding required for adaptation by vulnerable countries.

Climate activists in Paris speak out for a tougher target of 1.5° Celsius rather than 2.0°.
Photo by Jerry Schnoor

Sweet Spot

IIHR's new plaza is popular in good weather for meetings, breaks, or just watching the river roll by.

Before the Storm

A thunderstorm gathers over Old Capitol on the UI Pentacrest.

PHOTO BY ANETA GOSKA

Water Quality: Knowledge is Power

New resource provides water-quality data with the click of a mouse

If you stood on the banks of the Iowa River in Iowa City, watching the water flow by, it wouldn't look much different than water in any other river in the state. Because the eye can't see the difference, it's easy to forget that water quality is a serious problem in many of Iowa's waterways.

Researchers at IIHR—Hydroscience & Engineering are bringing water quality out of the shadows and onto your computer screen. With the click of a mouse, Iowans can now access real-time water-quality data using IIHR's new suite of online tools, the Iowa Water-Quality Information System (IWQIS).

"It's a huge breakthrough," says IIHR Director Larry Weber. "I think IWQIS offers a way for people to start to understand water quality and to explore on their own to get information."

No-wait Water Data

IWQIS is much like the widely-used Iowa Flood Information System (IFIS), which provides up-to-the-minute flood-related information. IWQIS displays near real-time water-quality data. A network of in-stream sensors across Iowa provides the data, which are presented in a user-friendly interface. Thanks to the success of IFIS, landowners around the state have come to expect that IIHR's data will be easily available. Weber says that when he heard landowners were asking for the water-quality data, he knew the time was right to launch IWQIS.

Assistant Research Engineer Ibrahim Demir, the chief architect of IFIS and IWQIS, says that this new information will empower Iowans to use a science-based approach when making decisions that affect water quality. IWQIS offers information on current nitrate levels, watershed boundaries, and other variables that may vary from site to site, such as:

- Dissolved oxygen
- Temperature
- pH
- Specific conductance

"Water quality by its nature is a little more technical than streamflow and water surface data," Weber says. "We've gone another layer deeper in understanding what the water is transporting." IWQIS puts the data into context so users can understand what's good and what's not so good in terms of nitrate levels and the other parameters.

Straight from the Stream

IIHR's network of 28 water-quality sensor sites is the backbone of IWQIS. Each site has one to three sensors deployed,

IWQIS is available now at **iwqis.iowawis.org**. Check it out and let us know what you think! E-mail your comments to iihr@uiowa.edu.

(Facing page) IWQIS will look familiar to users of the Iowa Flood Information System (IFIS). (Left) Thomas Stoeffler inspects a water-quality sensor on Rapid Creek near Iowa City.

bringing the current numbers of sensors in the field to more than 60. IWQIS also reports data from U.S. Geological Survey (USGS) sensors. The remote sensors collect water-quality data every five minutes and automatically relay the information to the IWQIS database every 15 minutes for dissemination on the web.

Users can display the data in several different ways, including a graph combining multiple views of the data. A summary of all the sensors is also available, with sensor location, upstream area, last reported data, and additional variables.

In 2016, the network will expand to include 55 sites statewide. New sensors will complement the current network to determine statewide nitrate load estimates.

Grants from the Roy J. Carver Charitable Trust, the Iowa Nutrient Research Center, and the U.S. Department of Housing and Urban Development made the network possible.

In 2015, the Carver Charitable Trust awarded another grant to develop the online system and to engage focus groups in testing the platform to make sure it is user friendly and effective.

Let Them Be

Studying Prairie Potholes of the Northern Great Plains

immense flocks of migratory birds once blackened the skies over North Central Iowa. These abundant waterfowl took advantage of the wetlands that characterized the Prairie Pothole Region of the northern Great Plains. The retreat of the most recent glaciers about 12,000 years earlier had left behind thousands of depressions in the otherwise flat landscape, shallow marshlands that provided habitat for wildlife of all kinds.

(Above) Keith Schilling is part of an interdisciplinary team studying prairie potholes. (Top) Prairie potholes in North Central Iowa reappear after every big rain. Photo courtesy of Lynn Betts, NRCS

In the late 1800s, sport hunters from the cities traveled through the wetlands on popular excursion trains. They slaughtered huge numbers of birds in a single day. Market hunters killed even more. At about the same time, tile drainage was transforming the vast network of wetlands that had once covered about a quarter of the state into a tidy checkerboard of cropped lands, destroying much of the previously lush nesting habitat.

Farmed Wetlands

But even in the face of so much change, the prairie potholes are still there, waiting for a chance to return. In Iowa, the vast majority (95%) of these former wetlands are now farmed, although they often don't make a profit. The potholes tend to be too wet to produce consistent crop yields, and too dry to function as a normal wetlands. "They still collect and retain water, but they've been intensively drained for agriculture," says IIHR Research Engineer Keith Schilling.

Wetlands

The Environmental Protection Agency (EPA) funded the study of eight representative sites in North Central Iowa to learn whether farmed prairie potholes still function as wetlands, providing environmental benefits to the landscape and wildlife. Schilling studied the groundwater and hydrology of the farmed wetlands.

The team also included DNR biologist Vince Evelsizer, who sampled the wetland to study the water quality; Iowa State University Professor Steve Dinsmore, who looked at migratory bird use of the farmed wetlands; and non-game DNR biologist Karen Kinkead, who studied frogs, salamanders, and other creatures in the potholes. IIHR graduate student Stephanie Then is analyzing the hydrologic data.

Misplaced Expectations

Schilling says he expected to find that high water tables were providing most of the ponded water in the potholes. He was intrigued to learn that this was not the case. The typical prairie pothole ponds after a rain because the dense, mucky soil prevents water from infiltrating the ground quickly. The water table is disconnected from ponding, Schilling explains.

He also expected that the farmed wetlands would process nutrients, as intact wetlands do. “We observed very little if any processing,” Schilling says. “One well had more than 100 mg per liter of nitrate. That’s among the highest I’ve ever seen in groundwater.” [Note: The EPA maximum is 10 mg per liter.]

He believes the farmed prairie potholes are so well drained by underground tiles, they simply do not have the proper conditions to process nitrate.

Fixing a Pothole

He hopes farmers will look hard at the areas that rarely produce a good crop and consider returning them to their natural state. It doesn’t take long for nature to reassert itself. Schilling says his colleagues found insects and larvae in the soil, lying dormant until there was enough water for them to hatch. “Year after year after year, they waited,” Schilling says. “Then all of a sudden we had enough rain that it ponded for a month, and they hatched.” Birds, too, return almost immediately after the sites pond. “Especially during the migratory season in the spring, we saw thousands and thousands of birds using these potholes,” Schilling explains.

Schilling says some farmers are moving to restore their prairie pothole wetlands, thanks in part to efforts such as the Natural Resources Conservation Service’s Wetlands Reserve Program. Newer initiatives focus on precision agriculture and management of fields for profitability. “The idea and the hope is that with this better mapping of profitability within fields, we can get momentum to convert some areas back to natural conditions, and just stop farming wet areas that never make any money,” Schilling says.

“If we want to gain ecosystem benefits, we have to let them be wetlands.”

Next Sto

something

strange was happening near Decorah. Iowa Geological Survey (IGS) geologists had seen mysterious rocks brought up by well drillers in the area—samples so different from those collected just a few miles away. The Jordan aquifer, which commonly provides well water for residents in that part of the state, was strangely absent around Decorah. Locals had also been finding odd coal-like burnable rocks in the area for decades — rocks that turned out not to be coal after all.

What could be going on at Decorah? (Cue the *Twilight Zone* music.)

In early December 2004, IGS researchers Bob McKay and H. Paul Liu were doing fieldwork near the Upper Iowa River, in that "Twilight Zone" area near Decorah. McKay leaned over the water to pick up an intriguing piece of shale and tumbled into the chilly water. Liu tried to pull his colleague out, but McKay dove in and came out with a shale sample from an outcropping in the riverbed.

Strange Shale

Researchers were intrigued by the strange shale sample, which contained some extraordinary fossils. Liu was the first to suggest that Decorah could have been the site of a meteorite impact—basically, a crater.

Scientists have not only identified and confirmed the Decorah Impact Structure, but Liu and his team also found an astonishing collection of fossils there. The well-preserved fossils are numerous and unusual; the site represents one of only a few such "Lagerstätten" (the scientific term for a deposit of extraordinarily well-preserved fossils) from the Middle

p: The Twilight Zone

Researchers uncover extraordinary fossil deposit near Decorah

Ordovician period, roughly 465 million years ago.

National Science Foundation funding in 2010 made it possible for Liu and his colleagues to erect a temporary dam to divert the Upper Iowa River so they could excavate the only outcrop of the shale. They found more than 5,000 fossils—many unknown to scientists until now—in the slabs of shale.

Nightmare Fodder

One of the most dramatic finds was the *Pentecopterus decorahensis*, a giant sea scorpion. The creature, the earliest and largest such animal of that period, sported a long head shield, a narrow curving body, and huge scary claw-like limbs that could easily trap its unfortunate prey. The Pentecopterus' modern relatives include spiders, lobsters, and ticks. Imagine a six-foot tick (cue the scary music again).

Working with colleagues at Yale University, Liu has been able to form a picture of how this predator looked and what its life was like in the shallow and likely brackish waters that covered Northeast Iowa millions of years ago.

Besides *Pentecopterus*, a eurypterid, Liu and his colleagues discovered fossils (some with impressions of soft tissue) of other previously unknown creatures, including conodonts (extinct, eel-like creatures), phyllocarids (shrimp-like organisms), jawless fish, algae (quite rare), spores from some of the earliest known land plants, and other enigmatic fossils that have yet to be identified. It's the kind of find that scientists who study these ancient creatures live for—"the discovery of the decade in early Paleozoic paleontology," as one reviewer exclaimed.

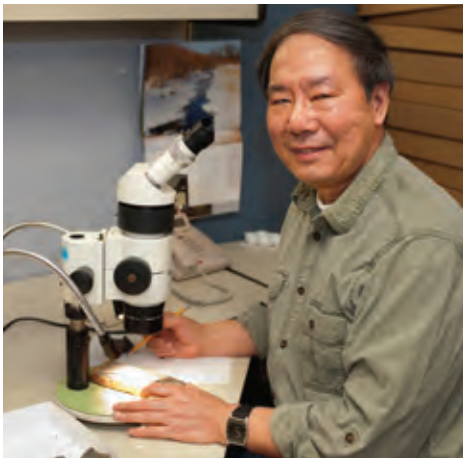
A New Window

What made the Decorah crater such a good environment for fossil preservation? During the Middle Ordovician period, Liu says, shallow saltwater covered much of what is now the Midwest. The area around Decorah was near the coast, where the water was less salty. Thus, distinctive organisms evolved to exist in the conditions there. After the meteorite struck the Earth, the water near the crater's seafloor became very still, brackish, and low in oxygen. Organisms in the water died and fell to the seabed, where they laid undisturbed.

"This opens a new window to tell us what Ordovician life was like," Liu says. There's much more work to be done, he adds. Liu and his colleagues can't wait to get on with it.

Facing page: *Pentecopterus* was named for an ancient Greek warship, which featured long sleek lines, similar to the six-foot sea scorpion. Illustration by Patrick Lynch/Yale University

This page: (Top) H. Paul Liu studies a fossil under the microscope. (Bottom) Researchers temporarily diverted the Upper Iowa River to excavate the only outcrop of the shale.



Solving the Puzzle

Clean Water + Sanitation = A Lifetime of Better Health

it's 5:30 in the morning, and Kelly Baker is already at work. While her husband and 2-year-old son sleep, she's answering emails from the other side of the world, where the U.S. workday is just ending. Baker is an assistant professor in the Department of Occupational and Environmental Health at the University of Iowa, with a second appointment in epidemiology. She's also an assistant research scientist at IIHR—Hydroscience & Engineering. She's in Kisumu, Kenya, studying how lack of access to sanitation facilities affects the health of mothers and their children by spreading fecally-transmitted pathogens across the environment, creating disease risks in the community.

A Day in the Life

By 7 a.m., she's ready to join her field team for a visit to Kisumu's urban slums. On this particular day, the babysitter fell through, so she's taking son Cameron with her in a carrier on her back.

The team, which includes community health students from the Great Lakes University, starts early to minimize time in the blistering sun. The students are invaluable team members, Baker says. "If I came in with a goofy idea about an intervention, they would be more than happy or able to shake their heads and tell me that it would never work and why."

Baker believes that sanitation is a key component in maternal/child health. Her research explores how inadequate access to sanitation facilities affects the community. If women defecate outside rather than in a designated toilet, they are twice as likely

(Above) Kelly Baker led a team of researchers gathering samples in the slums of Kisumu, Kenya. (Right) Children in the Kisumu slums often play near open channels of sewage and waste. Photos this spread by Jeremy Susskind

to have an adverse pregnancy outcome, such as miscarriage, premature delivery, or low birth weight. She believes these adverse outcomes often cascade through life, causing health problems for years to come. Baker and her colleagues would like to track how poor water, sanitation, and hygiene affect women and their offspring over time. “What we want to know is, what happens to those children?” Baker says.

GEMS

Baker was also involved in another study, the Global Enteric Multi-center Study (GEMS), which was funded by the Gates Foundation to explore the causes of diarrhea in children under the age of 5 in India and several other countries. Baker’s role was to study whether children with poor access to clean water and sanitation facilities were at higher risk of diarrhea and acquired infection faster than children with better access to sanitation.

Baker joined GEMS at the urging of her PhD advisor Myron Levine at the University of Maryland-Baltimore; Levine is PI of the GEMS study. It was Baker’s introduction to global health. In the process, Baker says, she learned something important about herself. “I’m really a bootstrap, shoe-leather kind of epidemiologist. I like fieldwork.”

The Mean Streets of Kisumu

Back in Kenya, Baker and her team are visiting randomly selected sites in each of the three Kisumu slums. Over the course of the study, they will collect samples at 60 locations in each neighborhood — water, soil, etc.

Kisumu is the third largest city in Kenya and the capital of the Nyanza Province. Set on Lake Victoria, Kisumu is a major trade center, but many residents live in desperate poverty. The neighborhoods Baker visited are beyond destitute. Latrines, where they exist, are grim. Child feces are commonly dumped on the ground, and animals roam free. Open channels carry waste and raw sewage, and children run barefoot through the streets.

As Baker and her team move through the neighborhoods, taking samples as they go, someone almost always asks what they’re doing. Sometimes residents are suspicious, Baker says; others are just curious. She plans to return once the results are compiled to share the conclusions at community forums.

The Sanitation Fingerprint

Baker and her team are using an innovative new tool to quickly identify 23 pathogens in DNA and RNA extracted from the environmental samples. The Microfluidic Taqman array card dramatically reduces the time needed to identify pathogens in a sample. The data provide what Baker calls a “sanitation fingerprint” for each site. Baker’s IIHR colleague Ananya Sen Gupta is the co-PI and will analyze the complex data. “We have pieces of the puzzle,” Baker says. “We’re seeking funding to try to fill in some of the gaps.”

Monsoon Harvest

Saving water for a not-so-rainy day

whenever farmers meet, they talk about the weather. How much will it rain, and when? Will it come at the crucial time?

Here in the United States, farmers in drier climates sometimes install expensive irrigation systems. In older cultures such as India, however, ancient rainwater harvesting systems blend into the landscape, making it hard to distinguish the manmade from the natural. "They've been there so long, they're an integral part of the hydrology," says IIHR Research Engineer Eric Tate.

Adapting to Climate

Tate and his colleagues are exploring the function and sustainability of rainwater harvesting systems in semi-arid regions of South India, where precipitation falls mostly during the monsoon season. Rainfall can vary widely from year to year. "People have had to survive in these areas for millennia," Tate says.

For the past 2,000 years, Indian farmers have adapted to rainfall variability by capturing rainwater during the monsoon season

(Clockwise from top) Eric Tate (left) traveled to India to study the country's ancient rainwater harvesting systems. India's system of small earthen reservoirs is not so different from IIHR's current efforts to develop farm ponds, wetlands, and other hydraulic structures in Iowa to slow floodwaters and filter out nutrients. (Right) Water "tanks" in India provide water for crops and livestock. (Above) Researchers talk with farmers and others in India to understand the system of reservoirs.
Photos this spread by Patrick Bitterman.

in “tanks” or small reservoirs set in natural depressions on the landscape. The water collects behind an earthen dam and is later gravity-fed onto farm fields through sluices that can be opened and closed to control flow. The tanks also provide water for livestock, and sometimes offer a place to raise fish or ducks. “They can increase financial stability and diversify livelihoods,” Tate explains.

The study is called “Monsoon Harvests: Understanding the Role of Ancient Tank Irrigation Systems in Increasing Climate Change Adaptability in Rapidly Changing Landscapes.” The researchers are exploring the social, economic, and environmental impact of agricultural rainwater harvesting tanks, as well as the viability of these systems in the face of climate change and population growth. It’s an exploratory grant funded by the National Science Foundation; Tate, who is also an assistant professor of geography, says they plan to apply for a follow-up grant to continue the work.

India is home to some 160,000 of these rainwater harvesting systems. “It’s a sort of hydrologic network that’s a combination of human and natural composition,” Tate explains.

Maintenance of the tanks requires a huge group effort. “This is a collective,” he says. “The whole village participates.” Many small farmers cooperate to make repairs and excavate silt in the off-season. Often they have to clear vegetation from the feeder channels, including invasive species.

Challenges

The Indian government introduced *Prosopsis juliflora* in the late 1960s to provide wood for fuel. However, the aggressive shrub is quickly taking over the landscape. Juliflora berries are poisonous to livestock, and the plant grows long, vicious thorns that can rip through a leather boot. Once juliflora invades a tank, it creates a huge problem. With its deep roots, juliflora can out-compete almost anything, using up water farmers need to grow rice, millet, or chili peppers.

Another complication has grown out of rural electrification in India. Farmers who can afford to are now drilling deep wells straight to the aquifer. “This has been a game-changer over the last 50 years,” Tate says. Groundwater levels are decreasing, creating a have/have-not scenario with regard to water, Tate explains. Wealthy landowners with wells also feel little need to contribute to tank maintenance efforts. “What was really collective action is now less so,” Tate says.

He and his colleagues (including former IIHR researcher Nandita Basu) are working with the DHAN Foundation, an NGO that is working to reduce poverty. Tate and his colleagues recently traveled to India for a research workshop, and afterward they visited tanks in the field and talked with farmers and villagers.

Looking Ahead

In the next stages of research, the Monsoon Harvests team hopes to quantify and understand the water balance created by the tanks—how much water is there, and how much is moving into the groundwater? How much is lost to evaporation? Tate says they also hope to construct a water sustainability indicator for the tanks. Are they sustainable? Can we measure that? Can we assess why some tanks in some areas are more sustainable than others?

There is a lot of work to be done, but the outlook is promising, Tate says. “It’s a small, human-scale effort that involves social and environmental issues rather than just gross efficiency for large systems,” Tate says. Rather than conquering nature, the tanks work within natural systems.

Tate says these distributed, smaller systems with social and environmental benefits may offer a good solution. “Maybe it’s a better way to adapt to climate change—who knows?” Tate says. He and his colleagues intend to find out.

Hidden Treasure

Managing Iowa's Groundwater

Mike Gannon (left) and Jason Vogelgesang take water samples in Clear Creek in Coralville.

When 2012 was declared the hottest year on record, it came as no surprise to Iowans. Spring had started ahead of schedule, causing trees to bloom in March. By July, the state was drying up. With virtually no rain and record high temperatures (107 degrees on July 23 at three locations), Iowans were in the midst of the worst drought since 1936.

In Northwest Iowa near the city of Rock Valley, the drought created anxious moments for livestock producers. The region is home to many large-scale animal

feeding operations. Managers feared that soon they wouldn't have enough well water for their animals. The potential for catastrophic livestock deaths was clear.

Who You Gonna Call?

In the midst of that hot, dry summer, Rock Valley Rural Water contacted the Iowa Geological Survey's Mike Gannon and Jason Vogelgesang for help. "The severity of the situation required an emergency response," Gannon says. Today, Gannon, Vogelgesang, and Antonio Arenas Amado make up IIHR's new Water Resources Management (WRM) team. Many Iowa cities, industries, and livestock producers are turning to Gannon and his team for expertise on modeling and management of water resources.

At Rock Valley, they were able to implement a short-term solution by pumping water about a mile from the Big Sioux River to a nearby abandoned gravel quarry, which served as a groundwater recharge basin for water storage. Groundwater levels rose immediately. The project was so successful, it turned into a more permanent solution involving a nearby intermittent stream.

A Vital Resource

Although Iowa has excellent groundwater resources, demands from growing urban areas, ethanol production, large-scale livestock feeding operations, and industry have intensified. In some parts of Iowa, groundwater is being pumped out of the aquifer faster than it can recharge. "You can't keep increasing aquifer withdrawals forever," Gannon says.

In addition, new state regulations to protect and sustain the Jordan aquifer limit how much groundwater can be extracted. As a result, many cities and industries are looking for new sources of water.

The WRM team conducts predictive local-scale groundwater modeling, which can be used for drought assessments, aquifer storage assessments and recovery, water sustainability studies, and water-quality assessments. IGS researchers have developed groundwater flow models for four of Iowa's bedrock aquifers. The models are good predictive tools that can be used to look at various pumping rates, future well locations, the effects of climate fluctuations on water resources, and future water-quality impacts. They can also function at the local scale. "You can start to zoom in and see how people are affected," Vogelgesang says.

The WRM team can help Iowans cope with the intensifying flood-to-drought cycle by enhancing groundwater storage. "What we try to do is capture and store as much water (both surface water and groundwater) as we can during the flood cycle so it can be used during the drought cycle," Gannon says. They achieve this through a combination of strategies, including recharge basins, constructed wetlands, and low-head dams on rivers and streams. Water captured behind these structures provides both surface water and groundwater storage.

For Rock Valley, they diverted an intermittent stream to the former quarry/recharge basin, holding water in place to increase infiltration. "Water levels in some of these wells rose about 17 feet," Vogelgesang says. Even when the creek stops flowing during a drought, water storage in the basin and surrounding groundwater allows the rural water system to continue providing water to customers.

A Thirsty World

Elsewhere, these issues often affect municipal drinking water supplies. "Drinking water issues affect the economy tremendously," Vogelgesang says. And as communities grow, water managers realize they can't continue to increase pumping rates from their deep Jordan aquifer wells. They need secondary water sources, such as a shallow bedrock aquifer or the sand and gravel aquifers adjacent to major rivers and streams. Vogelgesang uses geophysical tools such as electrical resistivity to develop a 3D image of what's beneath the ground to find the best potential shallow water sources. This data can also feed into the local-scale groundwater models to make them better predictive tools.

The WRM team is also studying the ways these strategies can affect water quality, impact wildlife and sedimentation, and potentially cause nitrate levels to increase.

Assistant Research Scientist Antonio Arenas Amado is focusing on these water-quality issues. He recently worked with the city of Ottumwa, where officials were concerned about nitrates in the river that provides the city's drinking water. The city currently collects and stores river water during low-nitrate periods for later use, and is considering investing in a nitrate removal facility. "They are at the mercy of whatever happens upstream," Arenas explains. He looked at 30 years of historical data in the Des Moines River and analyzed the trends. He found weather patterns were becoming more extreme, along with increasing trends in the number of days with high nitrate concentrations and nitrate concentration variability.

Water for the Future

Should Iowans be concerned about declining aquifers? "I think it's more of a management issue," Gannon says. Vogelgesang agrees. "People want answers," he says. "They want to know what will happen in the future."

He adds, "It's all dependent on using good science and sound engineering so our water resources are sustained for future generations." Fortunately, the WRM team is well-equipped and ready to provide these services.

> "You can't keep increasing aquifer withdrawals forever."
>
> MIKE GANNON

Iowa Flood Center

BY SHIANNE FISHER

IFC EXPERTS TAKE FLOOD RESEARCH TO THE NEXT NATIONAL, INTERNATIONAL LEVEL

marian

Muste had a dream. In this dream, the Iowa Flood Center (IFC) spanned the entire globe, making available the flood research and outreach that has benefited Iowa since the center's inception after the flood of 2008. He dreamed that IFC resources such as stream-stage sensors, community and statewide flood mapping projects, and watershed initiatives were the norm in every state, every nation, and every corner of the world.

Today, Muste, a research engineer at IIHR—Hydroscience & Engineering, says that his dream is beginning to become a reality.

In the past year alone, the center's network of stream-stage sensors has grown to about 250. Researchers have also mapped more flood-prone communities and launched a new crowdsourcing flood information tool (see story page 3).

But behind the scenes, a global initiative is in the works.

(Top) Marian Muste won the first Strategic Global Initiative Award from the UI Office of the Vice President for Research and Economic Development for his efforts to expand the Iowa Flood Center's work globally. Photo by Jim Heemstra (Bottom) IIHR Director Larry Weber (fourth from right) signed a memorandum of understanding with the China Institute of Water Resources and Hydropower Research to work together on flood-related projects.

A Strategic Global Initiative

For years, Muste has been collaborating with IFC Director Witold Krajewski and others to make the IFC more visible. In 2015, Muste received the first Strategic Global Initiative (SGI) Award sponsored by the University of Iowa Office of the Vice President for Research and Economic Development's Internal Funding Initiatives. His research, titled "Capacity Building for the Creation of the SGI: Decision-support Systems for Flood Mitigation and Resilience," will facilitate cross-institutional and -continental collaboration.

"It's about triggering new research, yes," Muste says, "but the request is to end up with a comprehensive toolset that can be sold to decision-makers, which is very difficult."

Dreams Big

"It's not a one-institution type of job. This needs global-scale collaboration. Our plan is to create a robust international partnership."

MARIAN MUSTE

But not insurmountable, says IIHR Director Larry Weber. While the institute has a major focus on fundamental research, it also has a strong tradition of applied research and the development of information systems. Commercial ventures are new territory, but also a welcome challenge, Weber adds. He says they will begin by scouting out available technologies in other countries.

The initiative is a two-part, long-term project, focused on creating a core group of global research institutions to launch a commercial product: a flood informatics system that will transfer flood science and research products and technologies into a decision-support system. The core partners are the Flood and Drought Disaster Reduction Center of China Institute for Hydropower and Water Resources; Ocean College, Zhejiang University, China; and the Danish Hydraulics Institute Inc., Denmark.

"This needs global-scale collaboration," Muste says. "Our plan is to create a robust international partnership."

The end product would build on the Iowa Flood Information System (IFIS). Through this online, map-based application, users can pinpoint their community and view live data on stream stage, precipitation levels, and more. The application also allows for flood prediction in flood-prone Iowa communities; with the slide of a scale, areas of likely inundation appear.

This system and other IFC initiatives have proven useful in the short-term for businesses and emergency management coordinators, as well as for individuals across the state. However, Muste stresses the need for more long-term flood-mitigation strategies, as well as efficient and timely warnings.

Increasing Velocity

In October 2014, Louis W. Uccellini, director of the National Weather Service (NWS), called for a more "weather-ready nation" during a visit to the UI campus. His visit was just one example of the National Oceanic and Atmospheric Administration's outreach to experienced public research institutions with the goal of establishing the new Integrated Water Resources Science and Services (IWRSS) partnership—a strategic plan to improve forecasting, adapt to climate change, and support healthy communities and ecosystems.

"We are visible at a national level," says Muste, noting also the IFC's recent participation in the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) National Flood Interoperability Experiment. Funded by the National Science Foundation, just eight institutions were invited to attend. The goal of the seven-week "camp" at the new National Water Center at the University of Alabama-Tuscaloosa was to establish partnerships among members of the academic community and to build a new high-resolution, near real-time hydrologic simulation and forecasting model for the United States.

"At this point, a comprehensive, long- and short-term planning, warning, and mitigating product does not exist," says Muste. He explains that this is because researchers use different tools to solve short- versus long-term problems. However, he would like to help create one tool that could serve both time scales.

So would many others, Weber notes. "In this area of flood management systems and flood information systems, there is competition out there," he says. One example is the National Weather Service. "We would like to see them as our partner," he adds. "But the challenge for us is to continue to see what our role is in these partnerships. We want to make sure that there's some value added and gained by everybody."

Perfectly Prepared to Lead

Weber has also been named chair of the International Association for Hydro-Environment Engineering and Research's new Flood Risk Management Committee, officially launched during the 2015 IAHR World Congress.

"Usually it takes a long, tiered process to get a technical committee started and established," Weber notes. "The outgoing president of IAHR saw that flood management was such a key scientific and technical issue around the world that he just moved things right up top. In doing so, he saw no better leadership than IIHR."

One of the committee's responsibilities will be to serve as the primary contact for other institutions interested in flood risk management. "We have the intellectual and academic recognition and credibility to be able to take on an initiative that brings people from around the world together on a topic like this," says Weber. "I think it's a perfect place for us to be."

Fighting for Breath

Improving life for people with asthma and COPD

Most of us rarely think about breathing—we simply do it. But for people with severe asthma or chronic obstructive pulmonary disease (COPD), every breath can be a struggle.

What does it feel like to have COPD? "Have you ever seen a fish out of water, how it flops around and gulps air?" writes an anonymous poster on the COPD Foundation website. "It tries to breathe any way it can; it's afraid that every breath is its last breath. That's me on most days. I fight with every power I have in me to make it through another day."

The new research extends the study from an individual to a large population using data gathered from multiple NIH-funded centers, including CT images of 260 asthmatic human lungs acquired at two different lung volumes.

Understanding the Human Lung

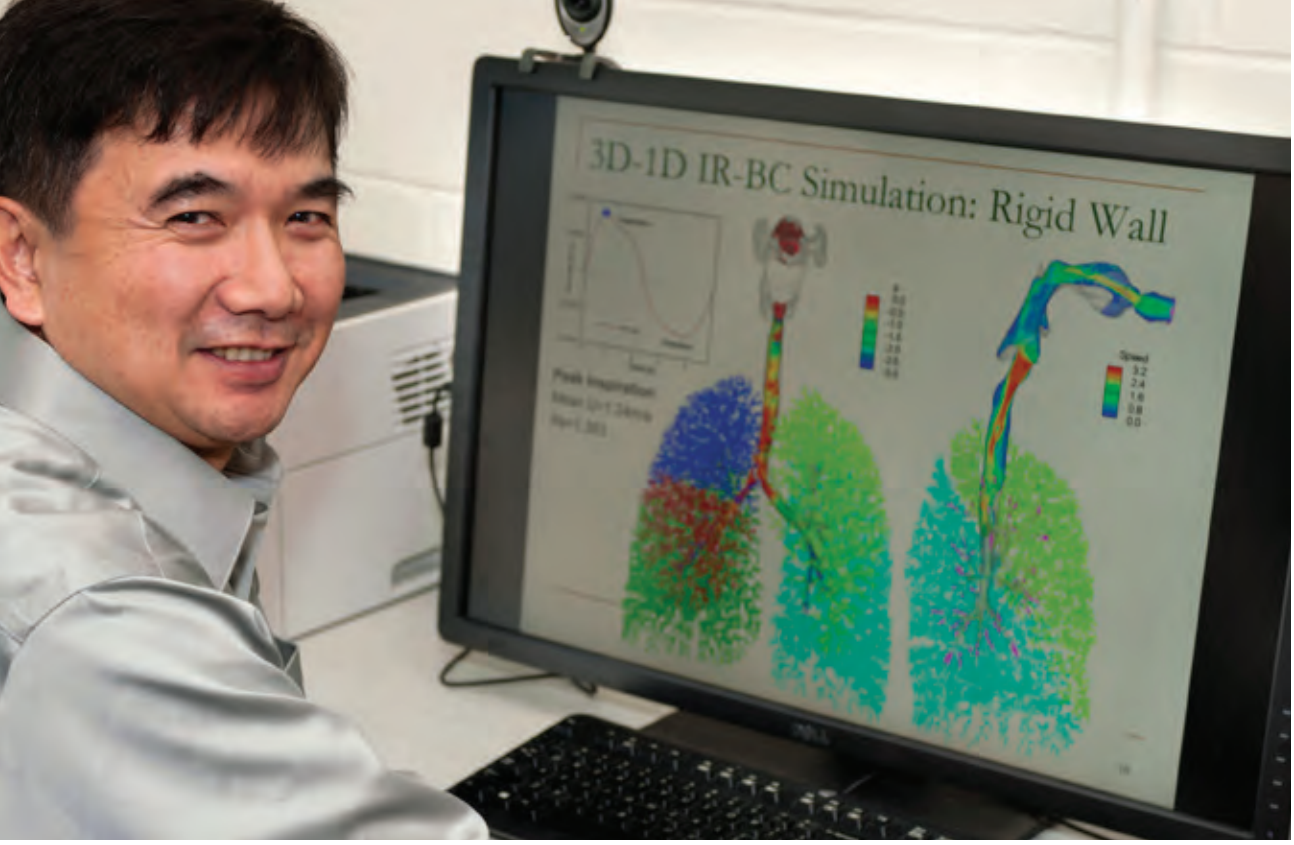
Ongoing research at the University of Iowa and a number of other centers is focused on improving our understanding of lung function and structure, with the ultimate goal of making a difference for COPD and asthma patients. IIHR Research Engineer Ching-Long Lin is part of this large multi-center research project, which builds on more than a decade of study focused on the human lung—research that is already making important progress that could potentially improve patient care.

Phase I of Lin's National Institutes of Health–funded lung research began in 2005 with a study of air flow, gas transport, and aerosol particle deposition in the subject-specific multi-scale lung models. Lin, a professor of mechanical and industrial engineering, used his computational fluid dynamics (CFD) modeling expertise to develop a digital model of the human lung from the trachea to the smallest airways.

In Phase II, researchers added a thermodynamics model and a model of the epithelial or skin cells in the lung to study the interactions between pulmonary airflow, lung mechanics, and cell response. This research allowed them to better understand the airway defense system by predicting the depth of the liquid layer lining the airway wall. Tiny hair-like structures known as cilia in this layer propel inhaled irritants or particles trapped on the mucus layer toward the head, where the subject can expel them by coughing.

Data Magic

The current research, which is Phase III of the study, expands the scope from one individual and one organ to a large population.



How is this possible? "It's all about data," Lin says. The original study gathered patient data through computed tomography (CT) scans of the lungs of a few human subjects. The new research extends the study from an individual to a large population using data gathered from multiple NIH-funded centers, including CT images of 260 asthmatic human lungs acquired at two different lung volumes.

Using huge datasets that also include airway wall thickness, airway branching angle, angle rotation, and more, Lin and his team perform cluster statistical analysis to extract the most important variables. This analysis makes it possible for them to reduce the thousands of variables in the data to just a few. Using these imaging-based variables, Lin and his colleagues can identify clinically useful "clusters" of patients grouped together based on similar characteristics, such as disease severity, gender, age, BMI, and more. The results of the statistical analysis also showed that one of the severe asthma clusters was primarily female — a new finding. Using the key variables, physicians can quickly gather key information from a new patient to differentiate which cluster he or she fits into best.

"No one knew there was a connection between imaging-based and clinical variables," Lin says. "This finding is actually quite encouraging to everyone." In addition, it's a non-invasive approach that requires only the scan without potentially expensive and uncomfortable collection procedures for the patient.

Improving Patient Care

One of Lin's longtime research partners is Dr. Eric Hoffman, a UI professor of radiology. It's not easy to impress doctors, Lin says, but the new findings have done just that. The new relationship between CT imaging-based and clinical variables is, in fact, very useful to physicians. Lin says it is one of the most important findings to come out of the multi-center study.

The complexity of the project means there's always more for researchers to learn. Lin also hopes to develop a smartphone app to collect additional patient data and correlate everything together. "It's very interesting research," he says. "I like collaboration. I'm very lucky to work with so many talented people."

(Top) Ching-Long Lin shows off a graphic simulation of the human lung. (Bottom) This image shows a three- and one-dimensional coupled airway tree. The lung is color-coded by lobe (red, left upper lobe; blue, left lower lobe; light blue, right upper lobe; pink, right middle lobe; green, right lower lobe). The surface of the trachea is color-coded by pressure.

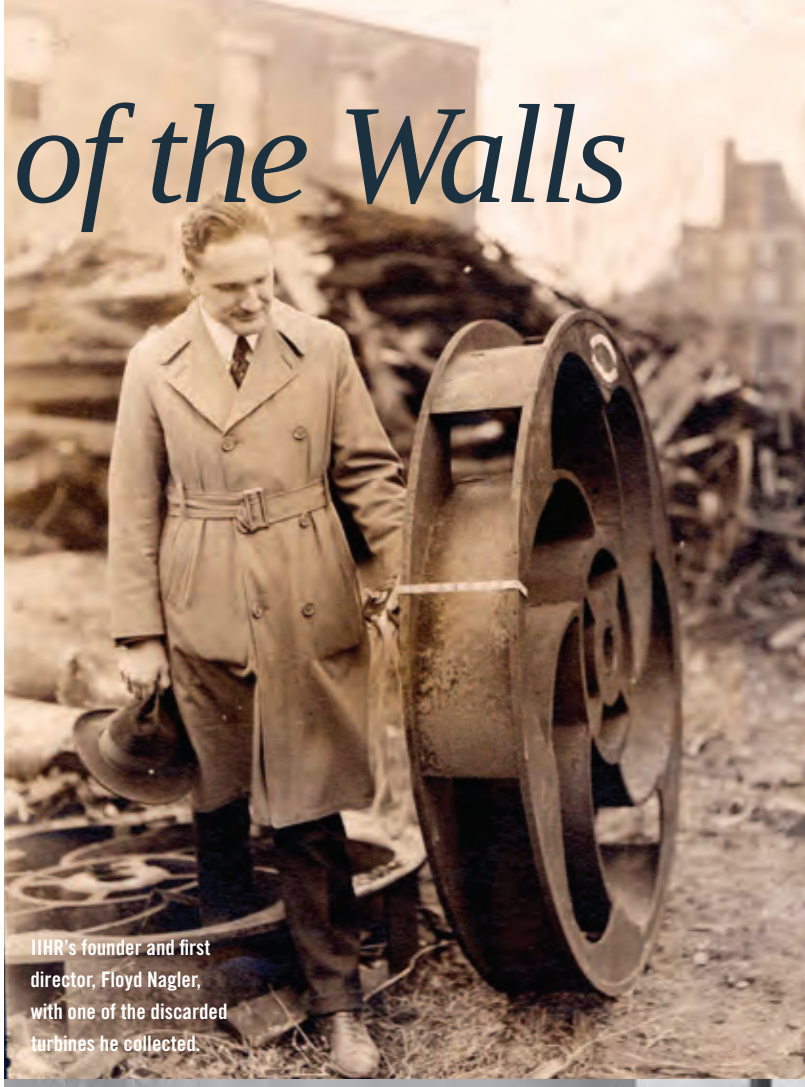
The Whispers of the Walls

BY CONNIE MUTEL

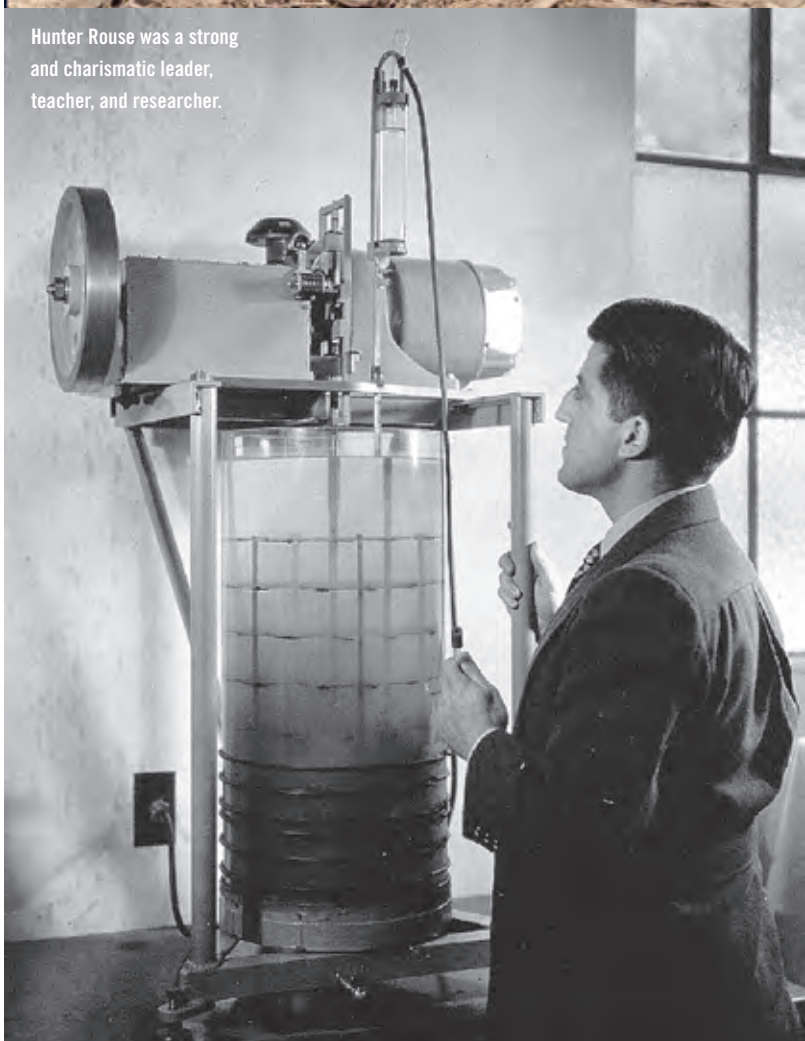
Connie Mutel established IIHR's archives and wrote the book Flowing Through Time, the 20th-century history of IIHR *(available through IIHR). Here she reminiscences about her experiences with these efforts.*

In the mid-1990s, before the Hydraulics Laboratory was modernized, I wandered the lab's basement storage rooms seeking stashes of papers left by earlier researchers and administrators, pulling these from rusting filing cabinets, collapsing cardboard boxes, and dank cubbyholes in the laboratory's walls. Finding an interesting pile of yellowing papers, I would sit on a nearby stool (or, if necessary, on the floor) and start to read.

While skimming these papers by the light of a single swaying lightbulb, with the sounds and smells of running water permeating the air, I sometimes felt as if the building's very walls were whispering their secrets to me—how flourishing times had alternated with challenges that threatened to sweep away successes, for life is never totally safe or predictable, not even here within a solid structure perched on bedrock next to the rippling Iowa River.



IIHR's founder and first director, Floyd Nagler, with one of the discarded turbines he collected.



Hunter Rouse was a strong and charismatic leader, teacher, and researcher.

Built on Bedrock

During those times, I came to know IIHR's prior directors, a diverse set of productive men with high standards and a passion for their work. Each of them had shaped the lab to fit his own unique vision. Floyd Nagler (founding director, 1920–33) was an optimistic, expansive thinker; he built today's massive building with floors and walls so thick, the lab could remain standing even if filled with water, or so he liked to brag. He then brought in research projects robust enough to finance the lab through the Great Depression, when many other hydraulics labs were closing.

Francis Dawson (director, 1936–44) added another major research project that likewise sustained the lab through the difficult 1930s—the testing of plumbing equipment. These efforts catapulted the lab into the flush defense-related funding of World War II, when Hunter Rouse took over as director (from 1944–66). Intense, driven Rouse had a singular focus on integrating fundamental fluid mechanics into hydraulic engineering. He accomplished this feat through his teaching, writing, worldwide travels, and research—but his vision might have gone nowhere if not funded through the open-ended federal grants available immediately after the war.

(Top left) Francis Dawson (right) kept the institute going through the Great Depression. (Top right) Jack Kennedy's visionary leadership reinvigorated the institute in the 1960s and '70s. (Lower left) Hunter Rouse focused on fundamental fluid mechanics. (Center) Construction in the early 1930s expanded the laboratory facility. (Right) Testing of plumbing equipment brought essential funding to the institute during the 1930s.

Rouse's Singular Vision

Rouse, like his IIHR predecessors, was perfectly situated to succeed. I asked myself, how did this repeatedly happen? How did one director cede to the next at just the right moment, allowing each leader's vision to simultaneously rejuvenate the lab and pour benefits into the larger world? Nagler's modeling projects validated a nine-foot-deep navigation channel in the Upper Mississippi River. Dawson's work transformed indoor plumbing fixtures into devices that improved (rather than degraded) public health. Rouse intellectually reshaped the theoretical capabilities of hydraulic engineering so they could better serve the planet's needs. Each director seemed to perform an intricate, perfectly timed dance with history. Were their visions carried forward on the wings of their imagination, I wondered? Or were those in charge of the lab listening to the whispers of its walls and following some predetermined course?

Strong directors continued to follow, one after the other—exceptional leaders, each with his own visions and priorities. Jack Kennedy took over the lab in the mid-1960s, when stagnating student and staff numbers and shrinking grant funding had started to dissipate the lab's mission. Immediately, Kennedy began to intertwine IIHR's theoretical emphasis with practical, applied projects, pronouncing that the two would feed off each other—as indeed they did. By the 1970s, the lab was bustling with burgeoning environmental research. Newly-installed computers that collected and processed data eased the completion of many projects, such as examinations of power-plant pollution, ice flows, fish-bypass systems, and the ability of concrete vanes to halt riverbank erosion.

Modernization

Then, in 1991, without warning, cancer took Kennedy's life. Rob Ettema (interim director, 1991–94) stepped to the fore and helped the lab transition to its next director, while also starting to revitalize the lab's structure and infrastructure. V.C. Patel (director, 1994–2004) amplified that focus by modernizing the Hydraulics Lab, procuring IIHR's first supercomputers, and building the Lucille A. Carver Mississippi Riverside Environmental Research Station (LACMRERS). He also oversaw IIHR's fiscal reform and educational innovation, encouraged the adoption of computational fluid dynamics, and shepherded in a diversification and multiplication of research projects.

Today IIHR continues to grow and thrive. To what end, I ask myself? What is the current guiding vision? Larry Weber, director since 2004, might answer with the words "excellence shaped by relevance"—relevance to the problems of the times. And how could it be otherwise, with the planetary challenges we now face? A soaring human population thirsts for pure water, even as our water sources shrivel and degrade. Healthy ecosystem processes depend on the earth's biodiversity, which is in major decline. And complex societies count on predictable, dependable atmospheric processes, even as the climate's steadily rising temperatures reshape the hydrological cycle.

A World of Challenges

Relevance—it applies to each of these crises and their many spin-offs, and IIHR responds. Under Weber's leadership, the institute has begun many important new initiatives, including: Iowa Flood Center, Iowa Watersheds Project, Water Sustainability Initiative, Iowa Nutrient Research Center, and the Iowa Water-Quality Information System (see story page 8). These efforts seek to address current crises, as do researchers' teaching and writing efforts on climate change and examinations of river and upland hydrological restoration. These projects and others continue to push IIHR's interests beyond the riverbed so they can comprehensively address entire watersheds.

In these ways, IIHR moves onward as one small piece of a world that seems to grow ever more complex, demanding, and difficult to navigate. And what of the future? Will the lab continue to address the functions and flows of water, the universal fluid, in a meaningful way? Will IIHR continue to nurture the creativity of researchers and students, even as their work takes our planet in a slightly new direction?

This I do not doubt. I only wonder how. What specific visions will chart IIHR's future paths? What have the walls yet to whisper?

New Blood

BY SHIANNE FISHER

When one thinks of a toothbrush, engineering is probably not the first thing that comes to mind. But each bristle, each grip is created with a specific purpose in mind—to "engineer healthier smiles" as Oral-B likes to put it.

Can a toothbrush inspire one to become an engineer? For Matthew Pontarelli, the answer, in a way, is yes.

Pontarelli, a graduate researcher in computational fluid dynamics (CFD) at IIHR—Hydroscience & Engineering, remembers fondly the days of his childhood spent working with his uncle, an engineer for Oral-B. "He was always building stuff and working on stuff, and he let me work with him," Pontarelli says.

As a young boy, this passion for tinkering turned into a love of cars, and in high school he spent countless hours working on his own vehicles. While he's put a lot of thought into choosing a car (his first was a 1965 Chevrolet Impala; his most recent is a 1991 BMW), Pontarelli admits that a submarine was never on the list of potential projects.

From Toothbrushes to Submarines

Today, however, Pontarelli is part of a research group using CFD to validate submarine experiments in the Netherlands. Funded by the Office of Naval Research, the research is just one of IIHR Research Engineer Pablo Carrica's many projects in naval hydrodynamics. While it's admittedly less hands-on then the mechanical work he is used to, Pontarelli says it's an incredible learning opportunity. "I'm very much the new blood in the group," he says.

Carrica's team consists mostly of postdocs and research scientists. Pontarelli is the only graduate researcher without an advanced degree and the least knowledgeable in CFD, he says. He admits to feeling a bit humbled and has quickly realized that the implications and applications of CFD are far-reaching. Currently, he's helping to write the CFD curriculum for undergraduate classes that will be part of the new ship hydrodynamics certificate at the University of Iowa. "It's cool to be working in an industry that's going to reach levels that I can't even fathom."

Carrica's team is trying to reach those levels through its partnership with the Maritime Research Institute Netherlands (MARIN), a leading institute in hydrodynamic research and maritime technology. The team will use Carrica's CFD code—REX, a spon-off of sorts of the famous CFDShip-Iowa—to validate experimental fluid dynamics (EFD) of deep submarine simulations conducted by MARIN.

Since neither real-life experiments nor coded simulations can provide 100 percent accurate results, Pontarelli explains that similar margins of error would achieve that validation. "It's a two-way comparison," he adds. "If our data are similar to theirs, then it confirms that we probably both have good data. Then we, as a code-developing group, know that the code we've written does its job and simulates real-life situations well."

An Infatuation with Fluids … and Formula One

If it had been his choice, Pontarelli says he would have taken only fluids classes as an undergraduate in mechanical engineering at Iowa. "My advisor insisted that I diversify a bit to be a more well-rounded engineer when I graduate," he says. A difficult request of someone whose mind had been turned on to fluids dynamics through—what else?—Formula One racing.

"As far as engineering goes, it's probably the most high-strung development program in the world," he says. "Teams are spending millions and millions of dollars to maybe shave off a couple thousandths of a second in a lap time. The fluid dynamics, the aerodynamics, part of it is really cool."

How cool? An F1 car can theoretically drive upside down because of all the downforce it creates at speeds of up to 220 miles per hour. "I didn't know much about fluid mechanics, but that small fact just kind of blew my mind. How can a car do that? I guess that kind of fueled my passion."

After Pontarelli graduated last May, he jumped at the chance to attend his first F1 race in Montreal, Canada. While automotive design is more of a hobby now, he still dreams of being part of an F1 race team—perhaps for his favorite driver, Nico Hulkenberg.

Doing Something Important

BY SHIANNE FISHER

Many students rush home to their high school bedrooms after their first year at college. Katelyn Harms, a sophomore chemical engineering student at the University of Iowa, spent the summer after her freshman year cooped up in a laboratory studying Chicago's air quality.

Harms, an Iowa native, has loved science since she was a little girl. A Project Lead the Way (PLTW) class at Alden High School gave her the push she needed to become an engineer. Her ambition was to somehow make the world a better place, even if only in a very small way. "I feel like with chemical engineering as a whole, you can find a way," Harms says. She's considering pursuing the pharmaceutical elective focus area so she can potentially help develop life-saving drugs.

For now, however, Harms is helping to make areas of Iowa and Chicago better living environments as a laboratory technician in Keri Hornbuckle's research group. Hornbuckle, an IIHR research engineer and professor of civil and environmental engineering, studies the sources of airborne PCBs (polychlorinated biphenyls) and the consequences of exposure through the Iowa Superfund Basic Research Program. Hornbuckle also holds the Bently Professorship in Engineering.

Her team collects air samples by sending out polyurethane foam—called PUF—to see where the PCBs are. "They're kind of everywhere—in the air, water, and soil," Harms says.

PCBs Everywhere

Hornbuckle's research group has discovered that drying sewage sludge, contaminated soils, and architectural paints are the main sources of emissions in the Chicago area. PCB-11, one of the most volatile forms of the chemical, was found in 60 percent of 85 women tested in East Chicago, Ind., and Columbus Junction, Iowa.

Harms says the goal of the research is to prove the presence of PCBs in the environment. "There isn't really a lot of research on how exactly bad they are," Harms explains. "Do PCBs in air really cause cancer? No one really knows. We just want to show where there are more of them [and] then try to clean up those areas and make them safe."

Harms is part of a newer project focused on a specific type of PCBs called OH (hydroxylated)-PCBs in schools. She says the organic chemical compound was generally regarded as a metabolized form of PCBs, but their findings show there may be additional sources from "who knows where"—a question that Hornbuckle's team is trying to solve.

Go With Your Gut

Coming to the University of Iowa wasn't necessarily an easy decision, but Harms says that in the end she went with her gut feeling. "Iowa City just felt more like home," she says. Now, it's the College of Engineering that feels like home. "I love how I'll walk into my engineering classes and automatically know people. We have a really tight-knit community."

Harms is an ambassador for Women in Science and Engineering (WISE) and loves to help with K-12 STEM—science, technology, engineering, and math—outreach. Her favorite event? An "engineering extravaganza" where she helped 6th grade girls create gumdrop domes. "We put them in groups, and they had to see how many textbooks they could get their gumdrop to hold." The record was four.

Helping out with STEM activities makes Harms remember why she pursued engineering in the first place: her PLTW class in high school, and a special teacher, Lisa Digman.

"I really believe that STEM education is important to the future of Iowa, and the success and stability of our students—especially our female students," says Digman, now the director of STEM and PLTW at Northeast Iowa Community College. "They come out of class with a clear understanding of what engineering is. But I think most important, they learn that they can do more than they ever knew they could."

Harms never thought her love for science would lead her to the type of research she's doing now, and she thanks Digman for inspiring her. "It's great to be able to go into the lab and feel like I'm actually doing something."

Why did you choose to come to IIHR?

KARL BRAUER, WAUSAU, WIS.
Research Area: Hydrology, watershed modeling

"I came on a tour and I was very impressed by the lab and the opportunities, but more importantly, the people were incredibly welcoming. Everyone was excited about their work and excited to share it with me."

KATHERINE GREENSTEIN, SACRAMENTO, CALIF.
Research Area: Synthesis and application of nanomaterials for water treatment

"This has been a persistent theme throughout my time here at IIHR—everyone is incredibly nice and helpful! It's the culture, and it definitely makes IIHR feel like home."

DANIEL VICENTE HORNA MUÑOZ, LIMA, PERU
Research Area: Computational fluid dynamics, flood modeling

"In South America, people are usually very warm and welcoming. When I joined IIHR, I was expecting a colder environment, but I was pleasantly surprised. People here are very friendly and made me feel like I was back at home."

ANTHONY VECCHI, DULUTH, MINN.
Research Area: Hydrologic modeling

"The sense of community and the emphasis on collaborative work makes IIHR feel like home to me."

ANDRE DELLA LIBERA ZANCHETTA, SÃO PAULO, LEME, BRAZIL
Research Area: Hydroinformatics

"Despite the fact that I am the only Brazilian here, the multicultural feature of the group, together with the mutual respect, make it even more interesting … bringing the feeling that 'the world is my home' when I am here."

KATIE GOFF, BETTENDORF, IOWA
Research Area: Quaternary sediment analysis, weathering profiles, soil and water interactions

"I chose to come here so that I can put my knowledge and energy into something I truly care about—improving our understanding and input on the overall landscape of our home."

KATHY PETER, SHAKER HEIGHTS, OHIO
Research Area: Development of nanomaterial-based technologies for drinking water treatment

"I chose to come to the UI because of the research opportunities and a 'gut feeling' that it was the right fit—and because I wanted to stay in the Midwest while I am in school!"

Reboot!

Who else on the University of Iowa campus can make the claim that they get their computer support from royalty? Here at IIHR we can, because our own Brian Miller is the self-proclaimed Burrito King.

But more on that later.

Rebooting Fixes Most Things

Senior Systems Administrator Brian Miller loves his job. Since he took an AP computer class as a senior in high school, he has had one ambition — to work on computers. "I found something that was interesting and just kind of kept going with it," Miller says. He studied computer science at the University of Iowa and started working at IIHR in 1996 as a sophomore. He liked the work and accepted a full-time position at the institute after graduation.

And even though Miller liked programming, he knew he wasn't cut out to be a full-time programmer. "I didn't want to sit behind a desk all day long, just coding," he says. "I was a people person. I like to interact with people and troubleshoot."

After 15 years working in his field, Miller hasn't lost any of his enthusiasm. He particularly likes supporting research computing. "This job changes all the time," Miller says. "The job itself motivates me because it's fun. Figuring it out is the best part.

"It's also fun to deal with the user support side of things," Miller says. "Although rebooting usually fixes most things."

Flood 2008

In his 15 years at IIHR, Miller has seen a lot, including the historic floods that devastated Iowa in 2008. Miller was on vacation in June 2008 when floodwaters were rising in Iowa City. He came home from his fishing trip at Lake Rathbun early because it was raining every day. He came into work that Thursday and learned that everyone had to evacuate the building the next day by 5 o'clock. Miller set to work with the rest of the team, working steadily through the day to get the computer equipment ready to move. Friday morning, they learned that everyone had to leave immediately.

"It was crazy," Miller says. "I remember just powering stuff off and pulling cables and unscrewing things. I was handing servers out the door with no idea where they were going." Almost the entire IIHR staff relocated to the Seamans Center until the C. Maxwell Stanley Hydraulics Lab (SHL) could be dried out and cleaned.

Although the flood left almost $1B in damages to the University of Iowa campus, it also brought out the best in people. "There was an outpouring of compassion," Miller says. "In Iowa, everybody helped — they took care."

The Burrito King

Brian Miller loves burritos, and often boasted that he could eat three in a single sitting. His friends scoffed, but Miller knew he could do it. So when a friend entered him in Panchero's first annual Burrito Eating Contest, he was thrilled. His wife was less enthusiastic. When he called her with the news, she replied, "You are not doing that. I have to go. Goodbye."

On July 4, 2007, Miller gathered with about 25 other competitors at Morrison Park in Coralville. It was a sweltering 90-degree day, and he was nervous. His hands shook as he launched into his first burrito, but it went down quickly and he dived into burritos number two and three. The crowd cheered him on, yelling, "Go Bears!" because Miller was wearing his Chicago Bears hat. With three burritos successfully down, Miller was faltering. But victory was in sight, so he kept on eating. As he popped the last bite of burrito number four into his mouth and swallowed, Miller was declared the burrito-eating champ! He had eaten four burritos in six minutes.

"By no means am I competitive eater," Miller says. "But I did like Panchero's and I knew I could eat." He won three free burritos a week for a year, and every bite was sweet. "I did it, and I won, and it was awesome," Miller says.

Perhaps because he likes to eat, Miller also loves to cook. Mostly he cooks for his family: wife Kelly and three sons, Blake (14), Luke (12), and Reid (6). "I have kids to feed. If I get too crazy, then I'm the only one who ends up eating it," Miller explains.

He also loves coaching his sons' sports teams, everything from soccer to T-ball to basketball. "I don't know if I could tell you what I'd rather be doing than that," Miller says.

Science and Poetry

Connie Mutel takes a deep breath and slowly exhales. Standing at the water's edge, she closes her eyes and stills her thoughts. Her mind takes her to another time, hundreds of years ago, before human beings had systematically transformed the Iowa landscape. She can see in her mind's eye the hundreds of thousands of waterfowl and songbirds that migrated through Iowa a scant 200 years ago—flocks so large they blackened the sky. She can hear their call and response, thousands of birds talking all at once. She can imagine, too, the native prairie and woodland plants and the animals, the flow of the water—a whole, intact system of integrity and beauty.

Mutel has a gift for deeply, intuitively understanding the function and structure of a natural system, for placing herself in that world and completely assimilating it. "I've always had a passion for learning about the natural world," she says. "I've always felt a real dedication to working toward its health and preservation. That's what challenges my mind and nourishes my spirit."

After careful research, Mutel synthesizes the often complex science with her understanding of the system. The result is poetic prose combined with a clearheaded scientific lesson.

Ecologist and Poet

Mutel, who is senior science writer and archivist at IIHR, has been part of the institute since 1990. She created and maintains the institute's archives while writing books that include *Land of the Fragile Giants* (1994), an examination and celebration of Iowa's Loess Hills; *Flowing Through Time* (1998), a history of IIHR; and *Hans Albert Einstein: His Life as a Pioneering Engineer* (2014), about the noted hydraulician and son of Albert Einstein. As editor, Mutel masterminded *A Watershed Year* (2010), comprised of 25 essays on the 2008 Iowa floods. She also gave dozens of public talks and participated in many flood-related forums. Her latest book is *A Sugar Creek Chronicle: Observing Climate Change from a Midwestern Woodland*, which interweaves the science of climate change with her nature journal and memoir; it will be released in March 2016.

But Mutel considers *The Emerald Horizon* (2008) her best book, and also the most complex to write. The book is a recreation of Iowa's natural environment as it once was. Mutel says her goal was to honor the integrity of Iowa's native prairie system, now nearly completely gone, without trashing the destroyers—the Iowa settlers who plowed up the prairie, drained the wetlands, and straightened the streams. "Because you and I would have probably done the same thing," Mutel says.

Combining poetry with science without compromising either is not easy to do, but it is rewarding, Mutel says. "I love, love, love going into a new field. Learning about it and then portraying it in compelling words." She compares her research and writing process to diving into a lake and coming up with a crystalized cup of pure water.

PHOTO BY ROLLIE HENKES

Making Beauty

Mutel grew up in Madison, Wis., the child of two creative people. Her mother baked, sewed, and wove rugs, creating beauty for her family. Mutel's father was a research scientist and woodworker. Shortly before he died, Mutel's father advised her to weave creativity into her daily life. She took his words to heart and poured them into her writing, creating "visions of beauty." She compares the flow of writing to the rhythm of music.

Mutel also followed her father into the sciences. Mutel double-majored in biology and music at Oberlin and pursued graduate studies in ecology at the University of Colorado-Boulder. She met Robert Mutel at Colorado, too, an astronomer who became her husband of 45 years. They live on an 18-acre woodland, which they manage for native biodiversity. They have three sons (Chris, Andy, and Matt) and six grandchildren.

Life at the Lab

Mutel says her 25 years at IIHR have been a privilege and a blessing. "There hasn't been a single day when I have not been happy—not just content—but happy to come in here and do my day's work," Mutel says. "I love the place for its people, I love the place for its vision and for the energy and passion that people put into the work here."

Although Mutel says she will soon retire from IIHR, she expects to continue doing what she loves best. "I don't think I'll ever stop writing," she says.

Rivermaster

In the 1960s, S.K. Nanda was one of 18 graduate students in former IIHR Director Hunter Rouse's fluid mechanics class. "Professor Rouse was tough," Nanda says. Rouse would prowl the classroom, shuffling a deck of 18 cards, each with a student's name. Suddenly, he would stop and direct a question to the person whose name was on the top card. If he or she was caught without an answer, Rouse would say something like, "Well, say something, even if it's wrong! At least I'll know your brain is working!"

"Everybody was scared of Professor Rouse," Nanda says. "But we had a lot of fun!" Nanda went on to work at the U.S. Army Corps of Engineers (USACE) in Rock Island, Ill., for 42 years, rising to the position of chief of the Hydrology and Hydraulics Branch. "It was my job to oversee almost every drop of water that came to the five states of Iowa, Illinois, Wisconsin, Missouri, and Minnesota," Nanda says.

Indian Roots

Although Nanda now considers himself an Iowan through and through ("We are Hawkeyes all the way!" he says), he grew up thousands of miles away in an Indian village so small it didn't even have a library. Nevertheless, Nanda graduated from the elite Indian Institute of Technology (IIT). "I don't know how I even competed," he admits.

When Nanda expressed an interest in hydraulics to his IIT advisor Gerhard Rouvé, his mentor told him there was only one place to go: the Iowa Institute of Hydraulic Research. "I thought he was going to say MIT or Stanford or Caltech or something," Nanda says. Iowa? "I had absolutely no idea," he says. But Nanda received a research fellowship, and so off he went to IIHR. Iowa's charms soon grew on Nanda, and he has made his home here ever since. "Iowa is such a beautiful state," he says. "People are so nice in Iowa. You just can't move away from here!"

A Flood of Memories

As an IIHR student, Nanda worked on the famous IIHR hotwire anemometer, a device that measures the velocity of flow, pioneered by Professor Philip Hubbard. Nanda has many fond reminiscences of his time at the institute. He and two other students rode along to a conference in Colorado with Jack Kennedy, IIHR's new director at the time. Later on, Kennedy and Nanda would be colleagues and friends. "What a wonderful man," Nanda says. At the conference, Nanda also met and chatted with Hans Albert Einstein, son of the famous physicist Albert Einstein and a leading expert in sediment deposition. "That was one of the most exciting things I have ever done," Nanda says.

In 1968, Nanda was curious about the lock and dam system in the Quad Cities, and on the spur of the moment, he stopped by the USACE offices in Rock Island. Although Nanda had not yet completed his thesis, the USACE chief engineer offered him a job on the spot. Nanda hesitated, but with a wife and a young son to consider, Nanda accepted the job and finished his thesis while working at USACE.

Nanda quickly climbed the ladder to became chief of the hydraulic branch,

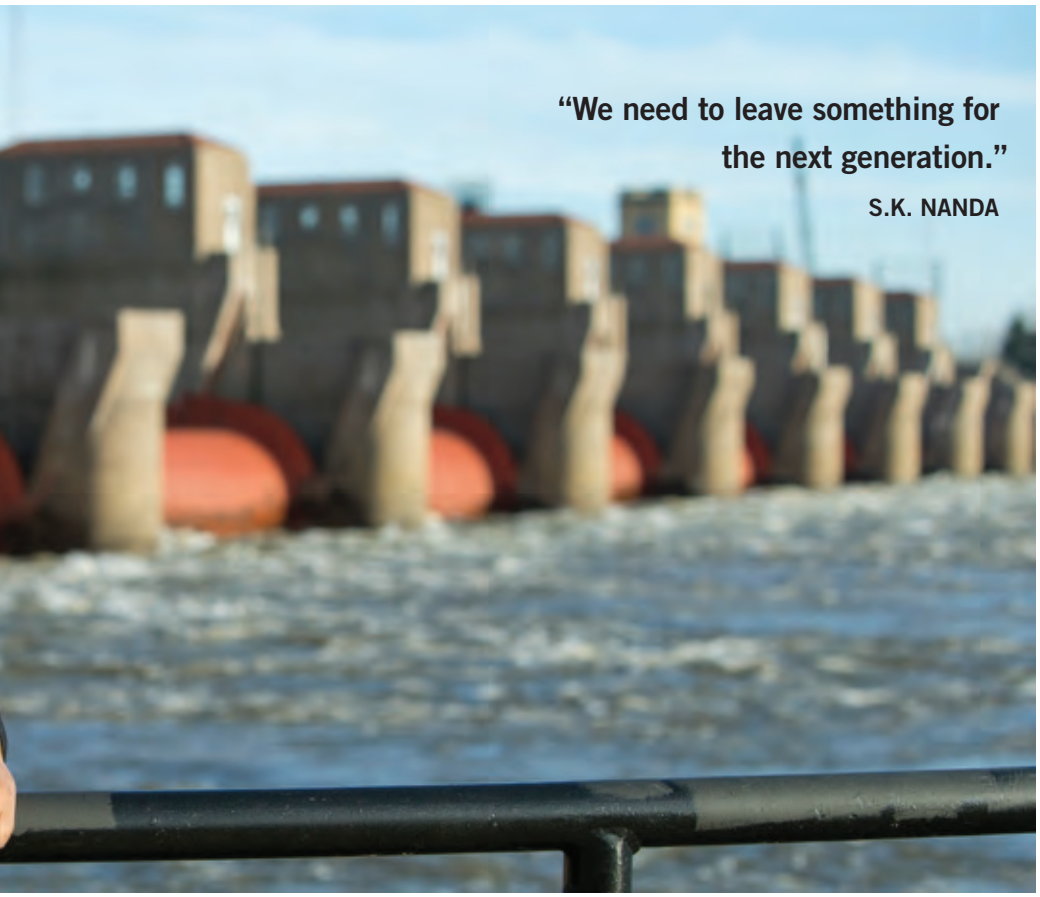
PHOTO BY GREGORY BOLL

where he was in charge of the lock and dam systems on the Mississippi and Illinois rivers. When Nanda started in 1968, engineers still physically checked gauges every morning and phoned in the results to headquarters, where someone would use a slide rule to compute the daily instructions to keep the pool levels at a consistent height. This task had to be done by 9 a.m. every day. Iowa's reservoirs, too, came under his supervision. "It was a pretty challenging job," Nanda says.

From the beginning, Nanda dreamed of technology that could make the job easier. He led research efforts to develop satellite-based remote sensors that would relay data to a computer at USACE every few minutes. "I was really delighted to push this edge of technology to make use of it in water management," Nanda says.

Nanda also led efforts to develop cutting-edge technology that included advanced one-, two-, and three-dimensional modeling. "It's been so exciting in my life to go from slide rule technology to satellite and high-speed computers," Nanda says. "That's what kept me going."

He especially enjoyed sharing these new technologies with engineers in countries around the world. "If the rest of the world doesn't enjoy the benefit, what is the fun of doing all this? That was my goal—to share our technology with developing countries," Nanda says.



"We need to leave something for the next generation."

S.K. NANDA

Paying It Forward

After the flood of 1993, Nanda was appointed to the inter-agency White House Scientific Assessment and Strategy Team, led by Vice President Al Gore. Nanda spent six months in Sioux Falls, S.D., where the LANDSAT satellite is headquartered. For a man who lives for the latest technology, it was a dream job. The team used satellite technology to study the Mississippi/Missouri river systems and to develop a plan to help Midwesterners be ready for the next major flood.

Nanda retired from the corps in 2010, after a long and celebrated career. His awards and honors are too numerous to list; he is particularly proud of the de Fleury Medal from the U.S. Army Engineer Association for his contributions to army engineering. Another great honor was his induction into the Distinguished Alumni Academy at the University of Iowa College of Engineering.

Nanda is still active in Rotary and the Lions Club, and he was a founding member of the American Academy of Water Resources Engineers. More than anything, he says, he wants to give back to society. With his fondness for IIHR in mind, Nanda established a scholarship fund to provide support for a deserving graduate student at the institute. He hopes to continue giving to the fund to create a meaningful scholarship fund. "We need to leave something for the next generation," Nanda says.

Let It Bee

BY SHIANNE FISHER

Lance Le marched out onto the open grassland, his white beekeeper's suit standing out amidst the purple flowered bushes, toward a cluster of handmade wooden hives teeming with honeybees. Le adjusted his suit. He felt ready to begin his first day as a beekeeper-in-training on an apiary outside Berlin.

Minutes later, bees swarmed into his head covering and stung him five times in the face. Not properly securing his suit was a rookie mistake, Le admits. "I'd never been stung before," he says. "I could've died that day." Naturally, he would later become a beekeeper himself.

Le, who recently received a PhD in civil and environmental engineering from the University of Iowa, was six weeks into a two-month stay in Germany when his honeybee mishap occurred. Le spent the summer working with Worldwide Opportunities in Organic Farms (WOOF) following his sophomore year at Rice University. "At the time I was very unsure of what I wanted to do," he says. "A friend asked me 'Do you want to go farming in Germany?' and I was like sure, why not?"

Today, Le says he is much more sure of his career goals. Becoming a professional beekeeper—although his hobby hives still thrive at Friendly Farm in Iowa City—is not one of them.

One Team

Le's true passion? Climate change.

"To say climate change is a pretty big issue is kind of an understatement," Le says. After his stay in Germany, he returned to Rice University to study aerosols and ozone as indicators of air quality in Houston while he finished his undergraduate degree in civil and environmental engineering. The social justice issues related to his research only amplified his passionate interest in climate change issues. "It's unfortunate that climate change will impact poor countries more than wealthier countries, despite the wealthy contributing to more emissions," he adds.

Once at Iowa, Le moved from air quality to water quality. He worked with a team of researchers led by IIHR Research Engineer Jerry Schnoor to produce climate change models for the Iowa-Cedar River basin. Using the U.S. Department of Agriculture's Soil and Water Assessment Tool (SWAT), the team was able to simulate 30 years of precipitation levels, temperature, and nutrient loads for the area. Le says they were able to project possible future rainfall, streamflow, and nitrates in Iowa. They also found that extreme levels seemed to be increasing in the summer months.

The project, funded by the National Science Foundation's (NSF) Dynamics of Coupled Natural and Human Systems (CNH) program, was a massive interdisciplinary effort, which Le says is the type of work he enjoys most. "I feel like climate change is one of those fields where everyone is involved," he says. "Economics, hydrology, engineering, climatology, history, politics—the list goes on."

The World is His Home

Originally from Oklahoma, Le has made his home in Iowa, Texas, and now California as a water resources control engineer with the North Coast Regional Water Quality Control Board in Santa Rosa—an opportunity that grew out of an internship in the Bay Area with the AmeriCorps Watersheds Stewards Project. He's currently working on what he calls the Climate Adaptation Strategy for the North Coast of California. The policy will help solve issues linked to sediment deposition, temperature, and timber activities in the region he currently calls home.

Le doesn't regret his nomadic existence, though. In fact, he thanks Professor Schnoor for letting him take a semester off before pursuing his graduate studies. "I went around the world, basically." He visited New York, London, Switzerland, Egypt, and Thailand. His next trip, however, will be back to Vietnam, where he was born, to visit relatives.

Perhaps he'll stop in Iowa City to check on his hives—whose inhabitants have also stung him many times. "It's part of the territory," he says. "Still hurts, though."

The 2015 IIHR Advisory Board meeting (front, l to r) Carmen Langel, Marcela Politano; (second row) Teresa Gaffey; (third row, l to r) Kevin Richards, Antonio Arenas Amado, J-C Yang; (fourth row, l to r) Troy Lyons, L.D. McMullen, Scott Hagen; (back row, l to r) Paul Dierking, Larry Weber, Craig Just, and Brennan Smith.

IIHR Advisory Board Members

Randy Beavers (2013–17), Warren Water District, Indianola, Iowa

Paul B. Dierking (2012–16), HDR Engineering Inc.

Robert Libra (2013–17), Iowa Department of Natural Resources

Harindra Joseph Fernando (2012–16), University of Notre Dame

Charles Gipp (2011–15), Iowa Department of Natural Resources

Scott C. Hagen (2014–18), Louisiana State University

L.D. McMullen (2013–17), Snyder & Associates

Kevin Richards (2011–15), U.S. Geological Survey, Iowa Water Science Center

G. Todd Ririe (2013–17), BP America Inc.

Brennan Smith (2015–19), Oak Ridge National Laboratory

Richard H. Stanley (2013–17), The Stanley Foundation

Jinn-Chuang Yang (2014–18), National Chiao Tung University

Ex Officio Members:

Alec Scranton, Dean, College of Engineering, University of Iowa

Larry J. Weber, Director, IIHR—Hydroscience & Engineering, University of Iowa

Carmen Langel, Director of Development and Communications, IIHR—Hydroscience & Engineering, University of Iowa

Our Mission

To be a leader in fluids-related fundamental and applied research; to provide interdisciplinary education for future leaders in science and engineering; and to advance knowledge in support of sustainable natural and engineered systems.

Our Vision

To be an international leader among academic institutions in hydroscience and engineering research recognized for integrating laboratory, field- and simulation-based experimentation, and participatory interdisciplinary education.

The Fiscal Year in Review

IIHR's internal and external research funding is up about 2.5 percent. External research funding has increased about 3.4 percent, but not from sources across the board. Notably, the trend continues in which some areas increase and others decrease, demonstrating how well IIHR is served by maintaining its diverse portfolio of funding sources.

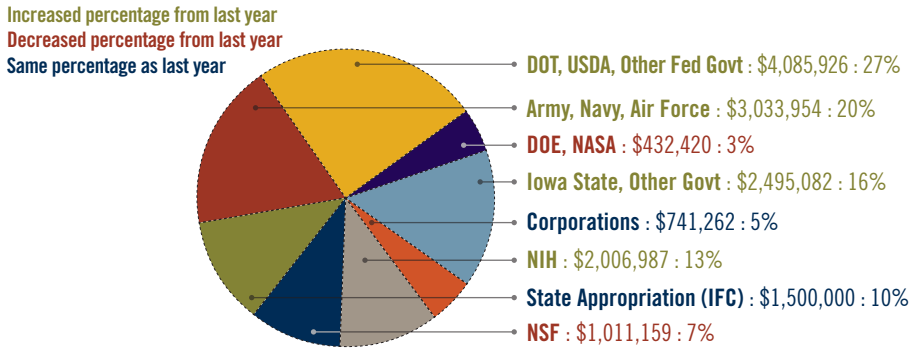
As we finish the second year of the contract with the Iowa DNR for managing the responsibilities of the Iowa Geological Survey (IGS), the IGS team is starting to bring in new contracts to fund various projects across the state. In the 2016 Iowa legislative session, we will strive to change Iowa code to make the University of Iowa directly responsible for the duties of the IGS. This would result in IGS funding coming to IIHR from the state, much as it does for the Iowa Flood Center, instead of through the Iowa Department of Natural Resources contract. We look forward to reporting on this next year.

Speaking of the future, a major new funding initiative is likely on the very near horizon for IIHR. Please stay tuned for exciting news about a potential capital campaign for a new IIHR facility!

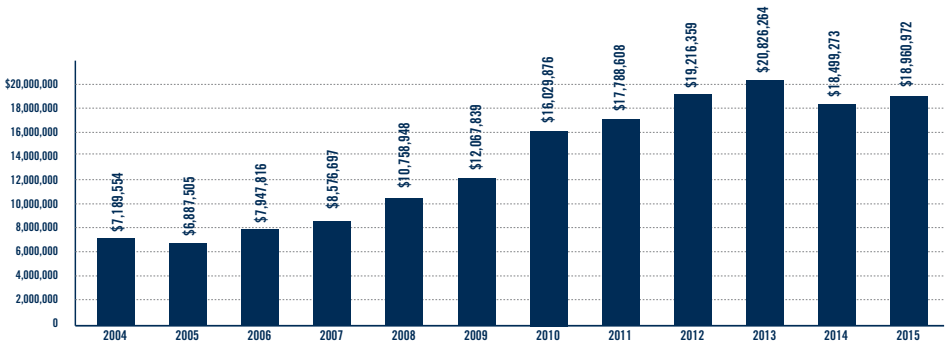
IIHR Internal Investments

	2014	2015
Graduate Students	$157,783	$129,028
Postdoctoral Associates	$23,703	$35,140
Research Engineers	$559,814	$346,963
Facilities & Equipment	$456,861	$605,430
Total IIHR Internal Investments	**$1,198,161**	**$1,116,561**

Fiscal Year 2015 External Research Funding by Sponsor ($15,306,790 Total)



Fiscal Year 2005 to 2015 External and Internal Research Funding



Shadows on Snow

Fog forms over the river as humid air moves over the cold surface of the water.

PHOTO BY TIM SCHOON/UI CREATIVE SERVICES

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The University of Iowa
College of Engineering

PHOTO BY TIM SCHOON/UI CREATIVE SERVICES