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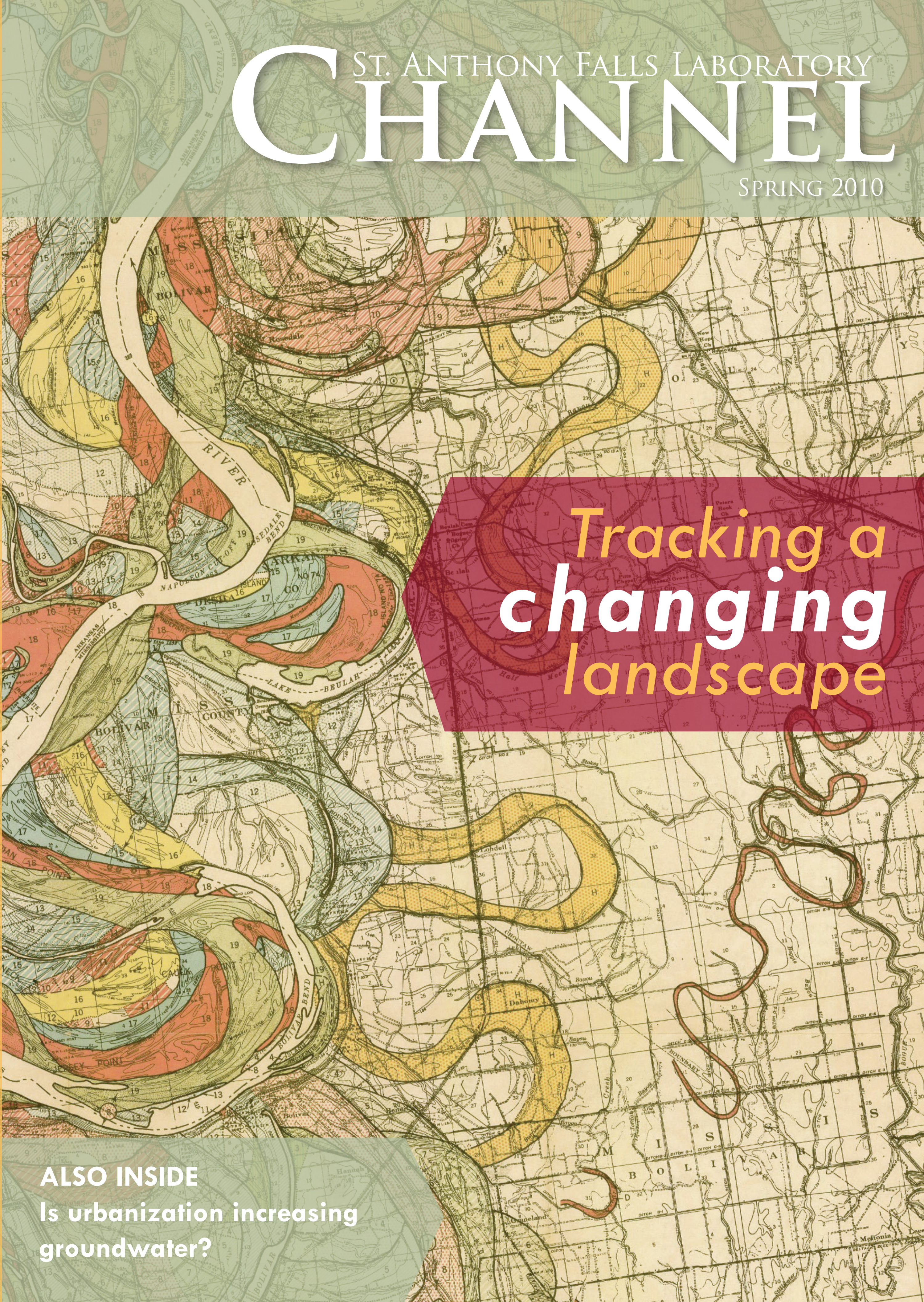
St. Anthony Falls Laboratory Channel

Spring 2010



Tracking a *changing* landscape

ALSO INSIDE

Is urbanization increasing groundwater?

spring 2010

SAFL CHANNEL

departments

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The St. Anthony Falls Laboratory is a research unit of the University of Minnesota's Institute of Technology in the Department of Civil Engineering. The laboratory is also closely affiliated with the Department of Geology and Geophysics, and the Department of Ecology, Evolution, and Behavior.

Cover: *Evolution of the lower Mississippi River by Harold Fisk, 1944*

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THE DIRECTOR'S PERSPECTIVE

In this issue you will read about exciting new advances in our ability to track the changing landscape of rivers; using three-dimensional automated instrumentation developed by SAFL engineers, researchers can now map the minute elements that define a riverine system from the scale of milliseconds to the stratigraphic scale of millennia.

Being able to accurately measure landscape evolution across scales is central to our development of science-based methods for restoring deltas and waterways, sustainable watershed management, and understanding climate change impacts. I am certain that after reading the main article of this issue you will agree we have come a long way from the beautiful hand-drawn maps seen on the cover to the high-resolution images produced by the cutting-edge instrumentation developed by our engineers.

The landscape outside the lab also continues to reshape, as the Mississippi River roared to life with the early signs of spring. We are gearing up for a busy summer season in the Outdoor StreamLab where a major national project aimed at developing design guidelines for in-stream structures will soon be underway. New basins are also being constructed in the OSL as I write this; they'll be used for erosion studies and for cultivating algal populations as part of SAFL's biodiesel research project.

Just a few miles away, at UMore Park in Rosemount, the preliminary environmental studies required for developing our new wind energy research facility are well under way. As part of the SAFL-led University of Minnesota wind consortium sponsored by the Department of Energy, we will be erecting a 2.5MW Clipper Liberty wind turbine there to be used for research and education.

We are delighted to extend a warm welcome to several new faces at the lab: Jessica Kozarek as the new Outdoor StreamLab manager; Leonardo Chamorro in his new position as research associate and coordinator of our wind energy and hydrokinetics experimental research; and Dan Mielke as an associate engineer for the wind consortium project. As we celebrate these new faces, we are deeply saddened by the loss of a familiar one, and share memories of beloved alumni Nels Nelson. Nels lived a notable life and inspired all of us with his ethos and leadership skills. He will be missed but never forgotten.

—Fotis Sotiropoulos
Professor and Director, SAFL

awards & honors

Professor Emeritus **Charles Song** was awarded ASCE's Hydraulic Structures Medal at the EWRI Congress May 16–20, 2010 in Providence, RI.

Professor **John Gulliver** gave a keynote lecture "Gas Transfer from Bubble Swarms" at the 6th International Symposium on Gas Transfer at Water Surfaces, May 16–21, 2010 in Kyoto, Japan.

Computational research by SAFL director **Fotis Sotiropoulos** and postdoc **Iman Borazjani** establishing links between fish evolution and the hydrodynamics of swimming was featured in Inside JEB, which highlights key scientific developments published in the *Journal of Experimental Biology* (January 2010).

Professor **John Gulliver** received a grant of $404,000 from the U.S. EPA's 319 funding, through the Minnesota Pollution Control Agency, to do research on "Enhanced Filter Media for Removal of Dissolved Contaminants from Stormwater."

Professor **John Gulliver** and Professor John Nieber (Bioproducts/Biosystems Engineering) received a grant of $312,000 from the Minnesota Local Road Research Board to do research on "Assessing and Improving Pollution Prevention by Swales."

Graduate student **Corey Markfort** was awarded the NASA Earth and Space Science Fellowship for his submission, "Including Tall Canopy Wake Effects in Biosphere-Atmosphere Flux Parameterization for Atmospheric Boundary Layer Models." The goal of this fellowship is to ensure continued training of interdisciplinary scientists to support the study of the Earth as a system.

Graduate student **Bereket Tewoldebrhan** has received the 2010 Silberman Fellowship Award, which rewards academically outstanding students who perform their research at SAFL.

Graduate students **Anwar Chengala** and **Arvind Singh** are recipients of 2010 Tsai Travel Awards. Chengala used his award to attend the National Algae Association conference this February in Las Vegas, NV, and Singh used his award to attend the May EGU conference in Vienna, Austria.

Graduate student **Arvind Singh** has been awarded a 2010-11 University of Minnesota Doctoral Dissertation Fellowship.

The 41st Straub Award was presented by Civil Engineering department head Roberto Ballarini to Dr. Karan Venayagamoorthy on April 7, 2010. Venayagamoorthy received his PhD at Stanford University under the advisorship of Professor Oliver Fringer, and presented his research "Probing the physics of internal waves on a shelf break using numerical simulations" as part of the award ceremony.

The 2010 Anderson Award was presented by Professor Roger Arndt to graduate student **Yi Fan** on April 21. The award is made annually to a student pursuing studies in hydraulic engineering and/or water resources.

other news

>>Research fellow **Andrew Erickson** received travel grants from the Department of Civil Engineering and the Center for Transportation Studies to attend conferences in Auckland, New Zealand (Asia and Pacific Division of IAHR, February 2010) and Washington DC (Transportation Research Board annual meeting, January 2010).

>>Prof. **John Gulliver** weighed in on the Gulf oil spill for Fox9 News (May 3) and MinnPost (May 4).

>>The new student group "Innovative Engineers" seeks to work with SAFL on bringing wind energy to developing countries. Read the story in the March 24 *Minnesota Daily*.

>>The research of SAFL director **Fotis Sotiropoulos** and postdoc **Iman Borazjani** on the role of water movements in molding fish bodies and swimming styles was featured on the University's homepage in February.

>>Prof. **Heinz Stefan** and SAFL graduate **Andrew Sander** (MS '09) talked to *Earth Magazine* in November about the effects of road salt.

SAFL IS NOW ON FACEBOOK!

Tracking a changing landscape

Advances in SAFL instrumentation

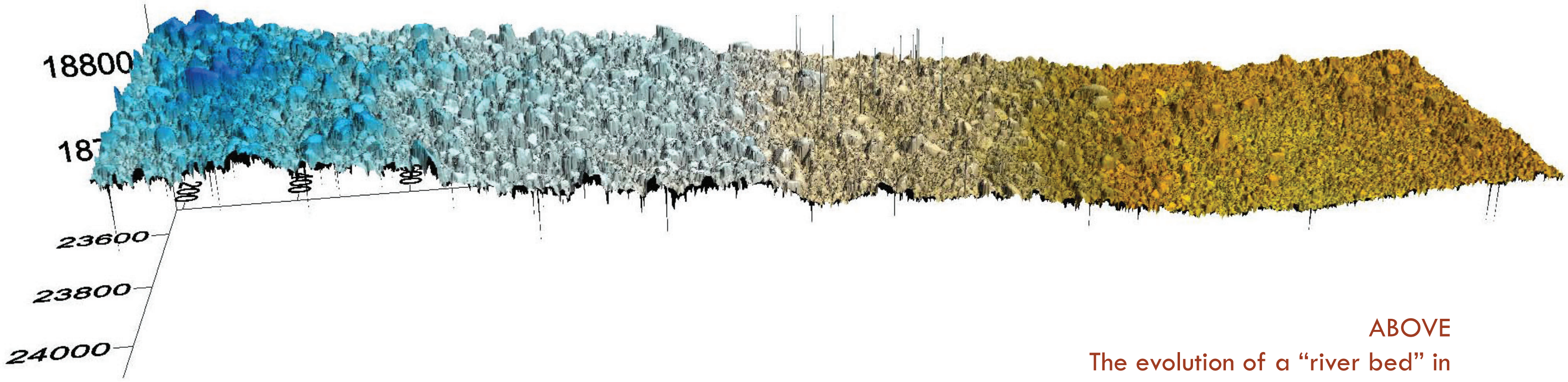
THIS PAGE
The evolution of the lower Mississippi River, as mapped by Professor Harold N. Fisk, 1944.

IN 1944 A GEOLOGY PROFESSOR NAMED HAROLD FISK presented to the Army Corps of Engineers a stunning series of hand-made maps depicting the historical traces of the lower Mississippi River. From southern Illinois to southern Louisiana, Fisk's masterpiece provided a three-dimensional pattern of sediments in the alluvial valley and deltaic plain. Painstakingly piecing together nearly 20 years worth of aerial photographs, topographic maps, and soil samples, he tracked the changing landscape and documented it with a rare artistic eye. A tribute to Fisk in *Engineering Geology* states that, "[his report] marked a great leap forward in understanding the alluvial and sedimentological processes of the Mississippi Valley, and the fundamental value of these insights to river engineering strategies and techniques."

Researchers at SAFL continue the practice of tracking these changing landscapes, now focusing on movements across milliseconds rather than decades. Using 3-dimensional automated positioning and measurement platforms (fondly dubbed "Magic Carts"), SAFL scientists are currently able to map—in the lab and in the field—underwater topography, water surface and wave height, subaerial topography, 3-D water velocities, photographic mosaics, and more.

Over the last few decades, these types of computer-based measurement systems have made high-speed data acquisition both affordable and accessible. Automated, highly accurate positioning abilities have evolved dramatically as well, largely due to the development of cheap microprocessor-based control systems. The marriage of these measurement and control systems allows extremely precise data to be acquired at unprecedented temporal and spatial scales. SAFL senior research associate Chris Ellis and senior engineer Jim Mullin have developed and built numerous variations of the Magic Cart, and working models are now also used at UC Berkeley/Stillwater Sciences, UIUC Hydrosystems Laboratory, Bucknell, Cal Tech, Tulane, and UT Austin. The largest carriage (at 8m) is currently under construction for Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil.

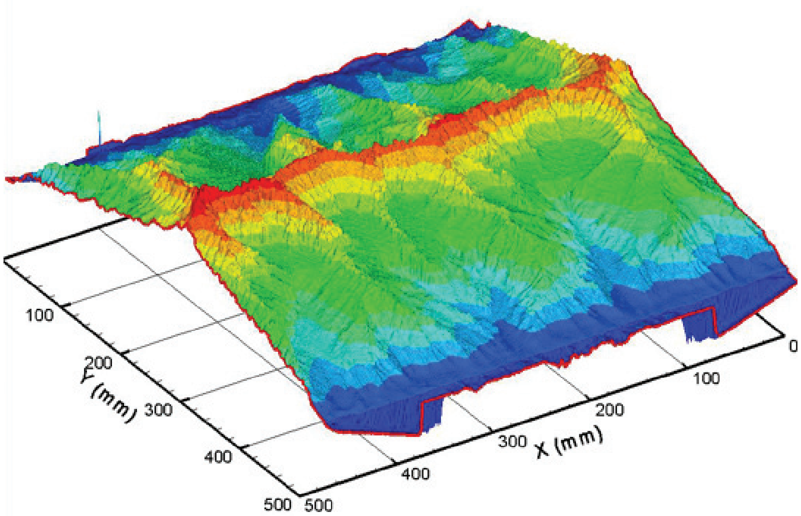
There are six variations of the Magic Cart that have been developed to provide data specific to research at SAFL. The one used in the lab's main channel is perhaps the best example of high-speed coordinated measurement and control. This cart is capable of positioning an instrumentation package anywhere within a 1.8m high x 2.75m wide x 55m long space, and is able to measure accurately at 10μm, 100 μm, and 1mm, respectively. The platform's maximum speed in either horizontal direction is 2 m/sec, with maximum data rates of 100



ABOVE
The evolution of a “river bed” in SAFL’s main channel, as mapped using the Magic Cart (1mm x 1mm resolution).

measurements/sec (water surface), 120 measurements/sec (sonar), and 2000 measurements/sec (laser topography and other miscellaneous analog measurements). A topographic scan at 1mm x 1mm grid spacing over a 1m square domain (1,000,000 points) takes about 30 minutes.

In addition to these Magic Carts, SAFL engineers have developed in situ measurement devices, an example of which measures spatially and temporally varying bedload. (Variations of this device have been built for UC Berkeley/Stillwater Sciences, and for the Agriculture



ABOVE
Three-dimensional measurements of a mountain landscape model project run by former visiting researcher Liam Reinhardt. +WEB EXTRA

Research Station in Oxford, Mississippi.) Also measured are the unsteady water and fine sediment flux levels in the many landscape evolution experiments throughout the lab, such as the model used by former visiting researcher Liam Reinhardt to map evolving landscapes (below).

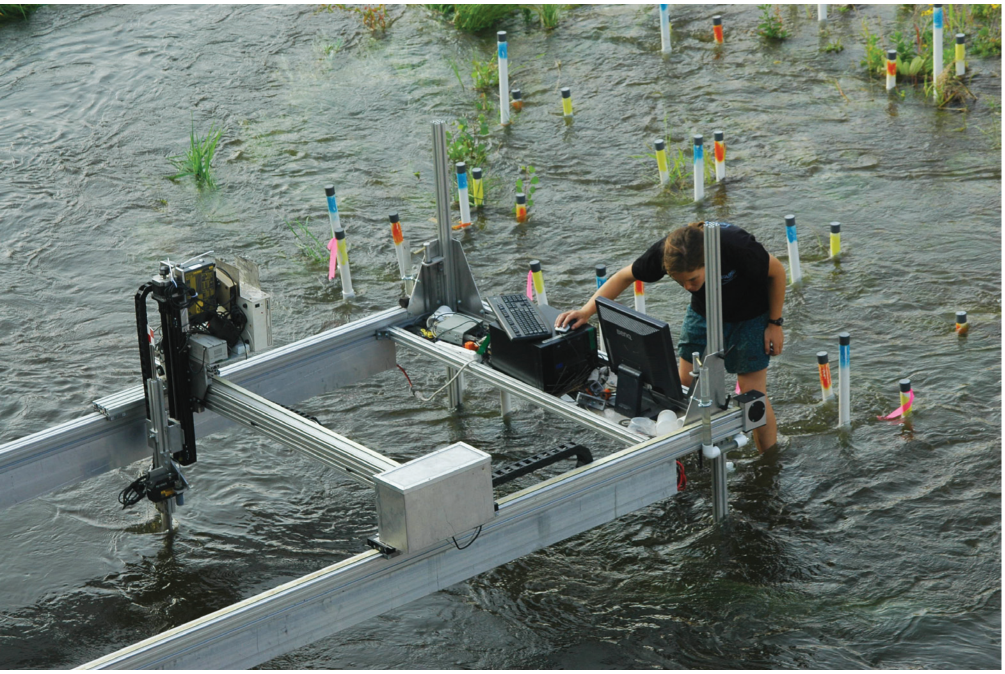
Field measurements in water resources have also benefitted greatly from advances in digital and networking technologies. More efficient remote data logging and real-time radio and internet-based networked systems are allowing new possibilities in the area of field-based measurement, control, and water resource decision making. Two illustrative examples are a joint project between SAFL and the Mississippi Watershed Management Organization, and in the Outdoor StreamLab.

The Mississippi Watershed Management Organization (MWMO) is charged with overseeing and assessing the water quality of the Mississippi River as it passes through the city of Minneapolis. Their stormwater monitoring program includes tracking both inflow rate and a number of water quality parameters (e.g., chemical constituents, sediment, etc.) at six different locations. In order to improve the reliability, accessibility, and accuracy of this program, SAFL engineers designed and implemented a wireless, real-time data acquisition network. The improved system provides internet-based remote access to MWMO’s field sites, and real-time updates to their measurement database. The wireless network is radio-based, which requires (near) “line of sight” connectivity between stations. To accomplish this, a radio repeater located on the 19-story tall Moos Tower is used to relay data from the SAFL base station to the MWMO monitoring sites. After making significant radio optimization improvements, reliable real time data connectivity was achieved for all six MWMO sites by the end of 2009. Data from these sites is downloaded every five minutes and integrated into a main database available via a website. In addition to their work on the networking system itself, SAFL engineers also advised MWMO on the best methods for monitoring on-site installation and construction procedures to optimize data acquisition.

For SAFL's Outdoor StreamLab (OSL), a portable Magic Cart was designed and built similar to the carriages made for the indoor flumes and basins, performing high resolution topography, mosaic photography, 3-D velocities, etc. Capable of scanning a 3.5m x 1.5m area at millimeter resolution, this portable version is mounted on four adjustable legs that allow regular leveling and "straddling" of the stream, enabling measurement and monitoring of the water and bed. Using this system, high-resolution bathymetry measurements of the OSL are then used as input to the Virtual StreamLab (VSL), providing instantaneous velocity fields at both the water surface and bed. The VSL, developed by SAFL graduate student Seokkoo Kang and SAFL director Fotis Sotiropoulos, demonstrates the physics of natural water flows at an unprecedented level of detail and employs sophisticated numerical algorithms that can handle the arbitrarily complex geometry of natural waterways.

The ability to simulate water flow over topography with this degree of realism can be used to improve sustainable stream restoration strategies, helping to fight erosion, prevent flooding, and restore aquatic habitats in degraded waterways.

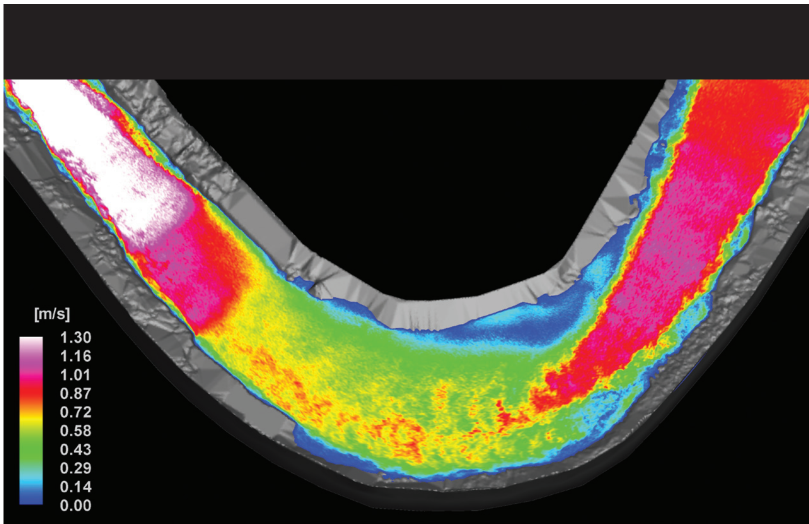
Much like Fisk's original river illustrations of the last century, SAFL engineers map the movement of rivers and floodplains, but the process has progressed with the help of major technical advancements such as these. Our researchers are now making their mark in the field with instrumentation that is fast becoming this century's hallmark in river engineering techniques.



LEFT
OSL intern Kristin Sweeney uses the Magic Cart to take measurements during a flood stage.

BOTTOM LEFT
An overhead view of the Outdoor StreamLab, showing the protective tent that sits over the instrumentation.

BOTTOM RIGHT
A computational simulation of the Outdoor StreamLab showing instantaneous velocity fields at the water surface.
+ WEB EXTRA



MAGIC CART DRAWS VISITING RESEARCHERS

“Quite a Sisyphean activity isn’t it?” asked NCED PI Peter Wilcock after describing PhD student Chuck Podolak’s current experimental work at SAFL. It was a question asked with good reason. By early March, Podolak, with help from the lab’s staff and researchers, will have spent several days removing sediment from the bottom of the main channel (an indoor 9 ft x 250 ft x 6 ft flume), shoveling tons (literally) of it back into the flume, collecting it at the flume’s mouth, and adding it to the channel again. Far from futile however, the activity will help Podolak investigate what happens to the topography of a gravel-bedded river when a lot of sand and gravel are added.

Podolak has been studying the question since 2007, when the Marmot Dam was removed from the Sandy River in Oregon. The removal released 750,000 cubic meters of sand and gravel that had accumulated behind the dam, in effect adding the sediment to the downstream river. At the time, the breach represented the greatest release of sediment from any U.S. dam removal. The question is how all that sediment will affect the river bottom.

To answer that question, Podolak, in typical NCED fashion, is combining knowledge gained from numerical modeling work, field studies of the Sandy River, and his current experiment in SAFL’s main channel.

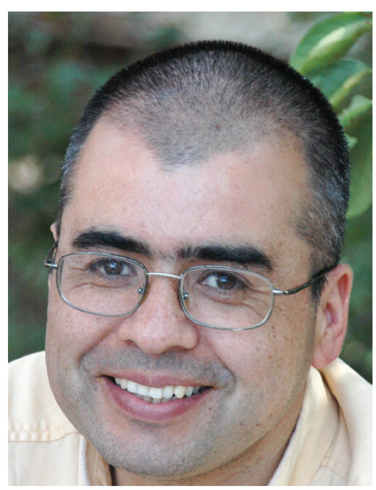
The Magic Cart installed over SAFL’s main channel.

Podolak’s work will help predict how bed topography in mountain rivers like the Sandy will respond to dam removal, or how large-scale gravel additions that are occasionally employed downstream of dams for management purposes will affect bed forms that are beneficial for fish spawning and habitat. In his current experimental work, Chuck Podolak is using one of SAFL’s Magic Carts to take laser scans and make centimeter-scale maps of the flume bottom. The measurements will give him an extremely detailed look at the flume bed, revealing whether the bed’s pools fill, the bars grow taller, longer, or wider, or if they increase in number. After the experiment’s conclusion, Podolak will combine its revelations with data gathered from field studies to run computer experiments that will shed new light on bed topography dynamics in gravel-bedded rivers.

>>See **www.nced.umn.edu** for more.
+ WEB EXTRA

congrats grads

Mike Weiss (MS ‘10) with advisor Heinz Stefan



Leonardo Chamorro (PhD ‘10) (Advisor Fernando Porté-Agel.)

Dan Mielke (MS ‘10) (Advisors Vaughan Voller and Miki Hondzo.)

Congratulations also to Michal Tal (PhD ‘08) and Bruno Lashermes (SAFL postdoc ‘06), and to Andrew Sander (MS ‘09) and Leslie DellAngelo (MS ‘07) on their nuptials!

Alumni Spotlight:

Alwin Young

SAFL graduation year: 1975

Degrees: Ph.D. (Civil Engineering, UMN)

Advisors: Charles Song and Alvin Anderson

Thesis title: "Cavitating flow over a step in an open channel with transverse gravity effects"

In what ways did each of your advisors influence you?
Both of them influenced me greatly as personal role models. Dr. Anderson guided me through to the candidacy and was the chairman of my committee. Whenever I encountered any difficulties, I could go to him and he would listen to me kindly and help me solve them. I remember him as always having a gentle smile on his face. As a foreign student, I especially appreciated and enjoyed the regular invitations to holiday dinners with the Anderson family, and to a play at the Guthrie Theater. While giving a workshop about sedimentation in Taichung, Taiwan, Dr. Anderson took time to visit my family at Chushan, and took a picture of my mother at my father's tomb. The picture still moves me deeply, as I wasn't able to go home for my father's funeral.

Dr. Song was suggested by Dr. Anderson as my dissertation advisor, once the subject was determined. Dr. Song guided me in developing a mathematical model and steps to find the numerical solutions that were physically meaningful. I appreciated his gentle and patient guidance.

What was your role at the National Weather Service?
I was a senior hydrological forecaster. Besides the operational duties, I worked mostly on assigned river hydraulic projects. I recently retired after twenty eight years and ten months of service.

What was a typical day like for you?
Routine operations involved monitoring river conditions and making adjustments to the model, issues that were required to make routine forecasts. This process began by evaluating what had happened the previous night and checking the inputs for the operational forecast model, which included precipitation and temperature conditions and river stage data. We also watched for developing weather conditions, both short and long term, which might affect the forecast category. Contingency forecasts were issued if a large quantitative precipitation event was expected.

What were your operational duties?
The operational forecast duties involved running a continuous mathematical model (we used the Sacramento River Forecast model) which creates a simulated river hydrograph. Based on the simulated hydrographs, forecasts were issued for specific forecast points each morning. Operational duties during the rest of the day included monitoring how well the model is doing compared to the data coming in, adjusting the model to minimize discrepancies between the observed and simulated hydrograph, and then merging the two together. The rate of change in river surface elevation and rate of attenuation in flood wave propagation were also important. Mostly it was fine-tuning the model to simulate a flow hydrograph that is in good agreement with the observed data. Since a storm event usually is not uniform across a basin, the conditions that deviate from the model (such as storm direction, rainfall intensity distribution, seasonal ground surface condition, river cross sectional change from the flow change, etc.) make it necessary to make adjustments based on the observed data.

In addition to the basic set of forecast points issued every morning, a smaller set of forecasts are updated every evening. During a flood event, the number of forecasts increases as the number of points (expected or actual) above flood stage increases. The office was typically open two shifts every day, but during moderate to severe flooding a third shift was added to monitor conditions during the night. During severe flooding, forecasts could also be updated throughout the day as conditions changed or specific updates were requested by our user community.

What kinds of river hydraulic projects were you assigned?
It changed over the years. During the 1993 flood (the largest during my tenure), my assigned primary basin was roughly from the upper lock and dam at the St. Anthony Falls, all the way to Lock and Dam #19 at Keokuk, Iowa. The flood lasted 80 days;

the line of storms kept falling in the same place, resulting in a broad-crested flood. I worked mostly on the main stem of the Mississippi, but I also worked on the other basins, switching off with coworkers. During the mid-90s we changed the forecast model we were using, which meant that the Sacramento River model was calibrated over a period of two to three years for all of the river basins that were our responsibility. I then also became involved with development/adaptation of a dynamic wave model for a number of river segments that were assigned to me.

What part did you enjoy most about your job?
I enjoyed the chance to use my training and my background. When the group was working together (and when I was still learning), they would show me what to do, but not necessarily why we were doing it. I could find the correlation or characteristics, but not necessarily know the reason. First you observe, then you find relationships, and then you find an explanation. Observing the correlations is very important—you don't necessarily learn that in school, you learn through your accumulated experiences over time. You apply all hydraulic principles in estimating the order of magnitude of change for a given hydraulic condition, or reverse estimate of a condition. I learned to monitor the changes in rates of attenuation in flood wave propagation that were due to changes in the physical conditions of the reach. Over time, I started to build a set of rules to feel what's happening on that stretch of river, but it required a while to adjust.

Did you collaborate with and/or utilize the USGS data?
We utilized both real-time and historical data from the USGS, and were dependent on their field observations of flow elevation and flood measurements. We also cooperated closely with the Army Corps of Engineers using their river data and their data on lock and dam regulations. Similarly, they used our initial forecasts to make decisions in regulating the dams.

How did you use their data on lock and dam regulations?
The purpose of a lock and dam is to maintain a consistent river depth for navigational purposes, so they regulate it by changing the gate opening to maintain a target water level. We used their three day (or more) flow forecast as input for our model. There are 26 locks and dams along the Mississippi River and 8 locks and dams on the Illinois River. The North Central River Forecast Center is the only river forecast center that has to deal with locks and dams in this manner. If river levels become high enough, and the Corps can't control them using the locks and dams, they open everything up and it becomes an "open" river. This would mean one less thing for us to worry about, so we were as happy as the fish in the (open) river!

Do you think there is greater cooperation among different organizations now?
Yes, definitely. There are a series of coordination meetings every spring as all the agencies prepare for the melt season. The USGS often had teams of observers in the field to monitor conditions and keep equipment operating. If we needed to know the field conditions during specific events, we contacted the USGS and the Corps about any changes. We developed a close working relationship through the years, especially with the Rock Island Corps of Engineers. They would occasionally ask me about an engineering problem, and I would process a contingency run of the model for them. We now also work with the University of North Dakota on the Red River inundation map on their website.

How have you seen this field change over the years?
We used to run models in batch mode on the main frame computer using punched tape or cards, but now we can run them in an interactive mode on a work station at our desk. There were also a number of operational changes. Initially our routine forecasts were for only three days in advance for a very limited number of points, and the forecasts were issued only once per day. The forecast period increased from three to five days, then to seven days in advance. An additional shift was added in the evening. More recently contingency forecasting began, giving us the capability for issuing forecasts 30 to 60 days in advance, using historical climatological data. Other major changes include communications with the satellite system, management of information using database systems, etc. I think that the forecasters are now able to provide much better forecasts with these new tools and improved weather forecast systems. And the recent big floods have sparked an interest in the general public and the media for forecast services.

What are your plans for retirement?
I plan on learning Chinese medicine, especially acupressure and *tui-na*, which is a form of therapeutic massage based on acupressure points. My grandfather, father, and two brothers all practiced medicine, so I guess it runs in the family! I'll also be making more frequent visits to Taiwan, Indonesia, Japan, and Europe.

Remembering Nels Nelson

A MEMBER OF BARR ENGINEERING FOR MORE THAN 30 YEARS, Nels Nelson (MS ’80) was well-respected by regulators, consultants, and the academic community for his work on water management and environmental review projects. He was a man of many talents, but to his friends and colleagues, it was his broad knowledge and his gentle leadership that they admired most about him.

Nelson, 59, died this January from a brain tumor. His sudden death cut short a flourishing career in water resources management at Barr, one that impacted all corners of the state, and beyond.

After receiving a B.A. in history from Carleton College in 1972, Nelson came to the University of Minnesota where he obtained a B.S. degree in civil engineering, and later an M.S. degree in civil engineering through St. Anthony Falls Laboratory. “In a field full of very intelligent people, he was exceptional, a true polymath,” remembers James Cardle (PhD ’84), who attended SAFL with Nelson as a graduate student.

Nelson and Cardle established a lasting friendship while working long hours running programs in the basement of the Electrical Engineering building. Listening to jazz and trouble-shooting the temperamental old punch-card computer, the two would often stay until the early hours of the morning, working to get their projects done in “the bullpen” before the undergraduates took over the machine during the day. Through their long hours spent together, Cardle gained an appreciation for Nelson’s intellect, vision, and perceptiveness—qualities that he believes made Nelson a leader in the water resources field.

During his graduate years, Nelson was advised by Professor C. Edward Bowers, and was awarded the lab’s Anderson Award in 1979. His interest in connecting the worlds of consulting and research began during his time at SAFL.

“I remember him as an especially sensitive person. He cared about the welfare of every individual with whom he had a relationship. In later years, he was especially concerned about Professor Bowers and looked upon him as his mentor,” said Professor Emeritus Ed Silberman.

Nelson began working at Barr straight out of graduate school, and became involved in a leadership role shortly after, eventually becoming head of the water resources business unit and the chair of the board of directors.

“Nels helped us develop our leadership team and put the plan and philosophies in place that have allowed us to prosper. He really valued the people he worked with and took pride in their successes and development,” said Barr president Doug Connell.

“Nels was an amazing guy. He could talk to you about eighteenth-century Russian politics, or Latin American dictatorships and the revolutions they inspired; or he could quote from Machiavelli, or the poetry of Goethe; he could tell you about Lao Tsu, or he could tell you about Italian opera. And he was also an incredible resource engineering-wise. He knew about direct ore reduction, and rotary hearth kilns up on the Iron Range. He could tell you about the intricacies of the hydrodynamics of meromictic lakes. He had a remarkable memory for detail; he could tell you about the projects he had worked on, and the people he had dealt with, from years and years ago. It made him just a tremendous resource for all of us at Barr,” said co-worker Charles (Chico) Hathaway (MS ’92).

Throughout his career, Nelson promoted the ongoing association between Barr and SAFL. He compared the areas of research and industry as being similar to a meromictic lake, in that mixing the two layers requires an input of energy.

“He was a wealth of knowledge on so many topics; he was able to talk about anything,” said Omid Mohseni (PhD ’99), former associate director of SAFL’s applied research program, and recipient of the 1998 Anderson Award when Nelson was the guest speaker. Mohseni worked at Barr from 2001–2003, and remembers Nels as a sup-

Nels Nelson (right) with Professor John Gulliver at the 1998 Anderson Award ceremony, where Nels was guest speaker.

portive leader, encouraging him to investigate a variety of approaches when faced with modeling discrepancies.

"Nels was also a big help to the Department of Civil Engineering. We were engaging in a strategic planning exercise where we developed mission and vision statements and outlined goals and strategies with specific action items. I knew that Barr had undertaken a successful planning and reinvigoration of the company, and had him come over to spend an afternoon with our faculty to describe what they had done and how they went about it. He was very thoughtful and respectful of the differences between an engineering company and a university department. He was the perfect person for what we wanted to do," said Professor John Gulliver.

Nelson also served on the selection committee for SAFL's new director in 2005.

"Nels was careful to point out how grateful he was for the senior leaders who took him under their wings, and mentored him, and really helped him in his career—and he passed that on. There's any number of people at Barr who will tell you, 'I would not be where I am today if it weren't for Nels believing in me, and supporting me, and helping me along when I didn't really feel like I had two legs to stand on.' He was there. He pushed opportunities our way, and we're the better for it," said Hathaway.

"To Nels, it was always about finding the good way, finding the right path, finding the elegant solution to the really complex problem. That's the kind of thing he cared about."

Thank you donors!

SAFL gratefully acknowledges the following individuals, who have generously provided support during this past calendar year.

Mr Curtis W Bauers
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Dr Xing Fang
Ms Cuiling Gong
Thea A & James R Langseth
Drs Mary B & John M Killen
Mr Nels P Nelson
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Growth & Groundw

Is urbanization *increasing* groundwater?

COURTESY OF ERDAHL AERIAL PHOTOS

IT IS GENERALLY BELIEVED THAT URBAN DEVELOPMENT LEADS TO A REDUCTION IN GROUNDWATER VOLUME BECAUSE IMPERVIOUS SURFACES SUCH AS ROADS AND PARKING LOTS INCREASE SURFACE RUNOFF AND REDUCE INFILTRATION. A RECENT SAFL STUDY SHOWS THAT THIS MIGHT NOT ALWAYS BE THE CASE. RESEARCH FELLOW TIM ERICKSON, WORKING WITH PROFESSOR HEINZ STEFAN, HAS EXAMINED THE EFFECTS OF PROGRESSIVE URBANIZATION IN THE UPPER VERMILLION RIVER AND HAS FOUND SOME UNEXPECTED RESULTS.

LEFT
The Vermillion River watershed includes these developments in Farmington.

The Vermillion River watershed is located on the southern fringe of the Twin Cities metro area (Scott and Dakota counties). In its upper reaches the river is a naturally producing trout stream with about 80% of its annual stream flow coming from groundwater sources. That high percentage means that the river is both susceptible and responsive to urban development, making it an ideal case study for changes in groundwater recharge because the area has experienced substantial development since 1984; the watershed's population nearly doubled between 1984–2005.

Urban development alters the pathways of water by landscaping, changes in land use, and by introducing new water collection and conveyance systems. Areas available for groundwater recharge by infiltration and evapotranspiration by plants are also changed, usually by increasing the amount of impervious surfaces, compaction of the soils and reduction of surface slopes. Add to that the sewers installed for conveying stormwater directly to streams and lakes, and infiltration is reduced even further.

Yet the man-made water supply systems installed during urban development are also used extensively for irrigation of lawns during dry weather, providing additional sources of water for aquifers. If the amount of water infiltrating the soil increases, so does the potential for additional groundwater recharge, especially if the water is imported from sources outside the urban watershed. Thus "natural" groundwater recharge from precipitation is distinguished from "artificial" groundwater recharge from man-made water sources.

Erickson and Stefan recently conducted a stream flow and water budget analysis of the upper Vermillion River incorporating natural and artificial water inputs, and found the results were not what was anticipated. The researchers had projected a decrease in natural groundwater recharge of about 0.5 inches/year, but their study showed that recharge from artificial sources (such as excess lawn irrigation, leakage from water distribution networks and septic system drainage) had replaced this amount, and possibly more. Evidence of additional groundwater recharge from man-made sources, as well as improved storm water management techniques, was found in the seasonal distribution of base flow in the Vermillion River. While precipitation actually increased only during June, the researchers found that base flow in the river increased throughout all irrigation months, from June through October.

For more about this study, go to: http://troutstreamresearch.safl.umn.edu/case studies.

This article is based on the paper "Shallow groundwater recharge in an urban watershed: Effects of water distribution, sewer and stormwater management systems," submitted to the *Journal of Hydrology*.


A STORM OUTLET ON THE VERMILLION RIVER

LEFT
Detail of Fisk river image. (See inside for full story.)

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