IN THE BALANCE

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By John DeVilbiss

WE NEED OUR WATER TO BE JUST RIGHT. WE DEPEND UPON THIS TO KEEP EVERYTHING ELSE IN BALANCE. JUST RIGHT IN SUITABILITY, TEMPERATURE, FLOW, AND AMOUNT. THE QUESTION THAT UTAH STATE UNIVERSITY WATER RESEARCHERS SEEM TO BE GRAPPLING WITH NOW MORE THAN EVER IS HOW TO ADJUST AND MITIGATE WHEN OUR WATER IS NOT JUST RIGHT?

Take water-choking algae, for example. Seriously, take it, says Ron Sims, and figure out how to turn it into a commodity. That is the challenge he has issued eight of his capstone students working at Utah lakes and reservoirs. Or, in Michael Johnson's case, take on an urgent challenge from desperate water officials in California to determine just how much more water can safely flow through a damaged spillway; and be aware that your conclusion impacts hundreds of thousands of lives and billions of dollars in agriculture.

Take eight summers of your life if you are Bethany Neilson wading through Arctic waters taking flow measurements and water temperatures. Or take it one day at a time, if you are Julie Kelso, determining the water quality of Utah streams. All of these researchers are looking at water through a different lens and seeing things in new ways. Literally for Mac McKee and Alfonso Torres-Rua with the help of sensors attached to AggieAir drones. McKee is the director of the Utah Water Research Laboratory (UWRL) and Torres-Rua, is an assistant professor in water resources at the UWRL and in USU's Civil and Environmental Engineering Department.

PRECISION WATERING

For the past four years, UWRL's drones have been flying over the vineyards of central California to capture images that ultimately help growers to increase water efficiency and crop productivity. Their data is so detailed they can geo-locate every grape row and vine. They can take that data and build three-dimensional models of vineyards, trees, roads, and

A blue-sky day, perfect for hunting blue-green algae. Students spent 12 hours in early October on Utah Lake in hopes of harvesting cyanobacteria through a vacuum filter they engineered. Their goal is to harvest enough algae to produce methane gas and bio-oil. Photo by Donna Barry.

An exact replica of the Oroville Dam built at the Utah Water Research Laboratory earlier this year is a model example of the UWRL's water research relevancy. With a damaged spillway on the country's tallest dam, California water officials turned to USU's water research laboratory for help. Photo by Matt Jensen.

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everything else, so growers can virtually walk up and down the rows from their computers.

"We can identify where every vine is and tell them where every dead one is and how many there are," McKee says. "We can tell them precisely where each vine is within inches of its actual location on the ground."

Their advanced remote imaging allows them to pinpoint the amount of water each plant is absorbing from the soil and how much replenishment the plant needs through irrigation. With global weather swings on the increase, being able to manage water accurately in time of drought and flood requires a new level of sophistication that UWRL's remote sensing and big data provides. The timing is critical. This year California saw both record rainfall and heat, exacerbating fire conditions in Sonoma County where deadly blazes approached within five miles of UWRL-monitored vineyards.

Torres-Rua, a native of Peru, chose USU specifically for its groundbreaking expertise in irrigation engineering, and that led him to remote sensing science. He not only wanted to understand more fully the spatial differences between one farm field and another, but also every square foot within the same field. As a young boy, he says he used to wonder why the real world was not composed of cubes and squares like the worlds depicted in video games. As it happens, in remote sensing, that is exactly how the real world is defined. He is living in that world every time he combs through the cubed pixels of data of post-flight images.

A PUZZLING HYDROLOGY

It is more like ice cubes that dominate Bethany Neilson's world. She is the assistant director of UWRL and an associate professor in USU's Civil and Environmental Engineering Department. From childhood, she has always been fixated on wanting to know how things worked and why. She was so persistent, at times, that some considered her a difficult child. "I guess things needed to make sense to me," she says.

Today things still do need to make sense, and although the focus of her questions has changed since childhood, she still needs to know why things work the way they do. Stream temperature dynamics, for example, have kept her puzzling for years. She started her studies in the desert of southern Utah and then extended it to the deserts of the Arctic. She learned how groundwater interfaces with the landscape in warm regions and wanted to know how it behaves in cold ones. That led her to a lonely field station in the Arctic — an arduous nine-hour drive from Fairbanks, Alaska.

"I was just going to go up there and figure it out," she says. That was in 2009, and she's still trying.

It turns out that Arctic hydrology is a lot more complicated than what she first thought. Yes, everything is frozen solid as you would expect in the winter, but in spring when things begin to warm up, "Kaboom, everything runs off." But not like a pipe. No river is. The water actually flows in and out of the sediments and, in the process, interacts with frozen soils below that creates a cold boundary condition hidden from the 24-hour Arctic sun.

Despite the low streamflow during dry summer periods and the constant sunlight, the rivers are buffered, meaning you don't have these huge daily fluctuations of temperatures that you would expect. This buffering effect helps to keep river temperatures down to safe levels for fish and other aquatic life. As the planet continues to warm, this unique cooling system used by rivers may help prevent fish die-off. At least for now.

"The system is pretty resilient," she says. "But I don't know how long it will last."

PROCEED WITH CONFIDENCE

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While the dam itself was never under threat, the failure of the spillway was serious, says Michael Johnson. He is a research professor at the UWRL and in USU's Civil and Environmental Engineering Department. The partial loss of the flood control outlet spillway compromised an important safety valve, and right in the middle of one of California's wettest years on record, including nearly 13 inches of rain that dropped in Oroville's Feather River Basin the first week in February. With March, April, and May still looming, the California Department of Water Resources needed to know just how much more water their damaged spillway could handle if the flooding continued.

"Surprises are only good on birthdays and at Christmas," Johnson says. "We engineers are averse to risk, that's for sure."

So engineers in California turned to Johnson and other UWRL researchers for help. They knew that physical modeling is still the gold standard in projects such as these and that the UWRL had the necessary expertise. They needed the laboratory to build a replica of the failed condition of the spillway "to help them get from where they were to where they wanted to be," Johnson says.

Although the model is 50 times smaller than the actual spillway, it still takes up a lot of space in the hydraulic structures modeling building west of the UWRL. Built in just 40 days, the model is 100 feet long and about two-stories high. Walk on the model and you feel like a giant looking down on the actual spillway, including the 300-foot crater the water eroded away when it escaped the crumbling chute in February.

"Those little blocks you see at the bottom of the chute are actually 23 feet tall," Johnson says. "Under large flow releases, the water is leaping off those things and landing 500 feet away, and it's 100 feet in the air. Wouldn't you love to stand near that?"

Johnson is still capable of wonder, but not so much regarding the Oroville Dam spillway. His replica has removed all of the guesswork. That's a good thing because, unlike computer and mathematical modeling, physical modeling accounts for variables such as turbulent flow that can't be replicated exactly through numerical means. "It's just somebody's best estimate," he says.

Thanks to the UWRL, engineers and officials at Oroville can proceed with confidence as they shore up the dam over the next two years. Johnson said that even if the state sees a repeat of last year's record precipitation, he will sleep well at night, and California should too. He has run the numbers — and the water — to prove it.

UTILIZING POLLUTION

Ron Sims and students are running water too — through a vacuum filter that his students engineered to harvest blue-green algae. Sims is the director of the Huntsman Environmental Research Center and professor in USU's Biological Engineering Department. If this pans out, it is definitely good news for Utah, and the world, as it tries to deal with a recent phenomena, a steady increase of toxic algae on our waterways.

The problem is that excess nutrients are getting into water supplies from wastewater treatment plants and from non-point sources such as agriculture and runoff from over-fertilized lawns. All of these excess nutrients are flowing into large bodies of water, such as Utah Lake, and accumulating.

As the algae grows and dies, it sinks to the bottom, and all those nutrients remain there until the next year. When the temperature of the lake water begins to even out, usually in the spring and fall, it becomes easier for those bottom-lying nutrients to be whipped up by wind and rise to the surface and grow as algae. While green algae may not be anything you want to swim in, at least it is harmless. It is the blue-green, or cyanobacteria, that is dangerous because it can produce toxins harmful to nerves, kidneys, and livers that are capable of killing people and animals if ingested.

While global warming appears to be a link, what exactly triggers these dangerous algal blooms is still being studied. But for Sims and his students, they are on a search and recovery mission. With help from AggieAir flyovers, they hope to be able to quickly target patches of blue-green algal blooms on Scofield Reservoir. Sims challenged his students to come up with a way to extract algae on a large scale from reservoirs and lakes in Utah that they can then run through a bioreactor to produce methane gas and bio-oil, while detoxifying the toxins.

"Pollution is a resource out of place," Sims says. "We are looking at this as a resource and are asking ourselves, 'How can we harness it instead of running away from it? Instead of trying to destroy this resource, how do we get energy and products out of it? How can we utilize it?'"

In early October, his students spent 12 hours at Utah Lake attempting to put this thinly disguised resource in its place. They were there to try out their new harvester attached to a stubby pontoon boat. After several attempts and many hours of wading through cold water, they had to scrub the mission, but Sims says it is only temporary. They plan to go back again, before month's end, after the students fix a few things. He is confident they will ultimately succeed. "Persistence is the best indicator of success when you are working with bright and motivated students."

COMMUNICATION FLOW

Julie Kelso looks at algal blooms from another perspective. She is a graduate student who works with iUTAH (innovative Urban Transitions and Aridregion Hydro-sustainability). When a lake has these blooms, and they are not being harvested to make fuel, what do we want to do about them? Do officials just want to know when they are occurring so they can tell people to stay away? That is a first step, but just articulating that message to the right people who make that decision involves many channels of communication. How well are researchers communicating their findings and what impact is it having on people in terms of valuing water?

After years of monitoring water quality on the rivers of Logan, Provo, Red Butte, and Jordan, Kelso says she now finds herself trying to communicate it to others in a meaningful way. It has been both eye-opening and a bit maddening.

"I think that's where I get frustrated with research because, at the end of the day, it may not matter how much research you do, or answer scientific questions, if people's values fundamentally are driving the policy-making decisions."

So how do you communicate research to influence public values and subsequently public policy?

It is a new frontier for Kelso. She is already honing her communication skills as a science reporter for Utah Public Radio. Anything to help start the conversation and bring people together. She is convinced that collaboration across universities and communities is essential if we hope to manage water more wisely. She thinks the biggest impact of her research with iUTAH was the way so many people came together to look at the question of water sustainability for Utah's future.

It was not just research and social scientists; they managed to get people of all labels across the state, in all different disciplines, and not just involving USU, but all three primary research institutions in the state.

"We're trying to get away from scientists in ivy towers working by themselves, which I think will be extremely hard to overcome," she says.

Sims, who comes from an industrial background, says the trick is to change the educational paradigm to encourage more collaboration on the academic side with faculty and students working together from multiple departments across several disciplines, and then take it a step further by collaborating with industry.

"We have got to be more innovative and that is why we are world leaders in innovation," he says. "Innovation means 'come on, let's sit down and talk about ways to do both.'"

That means putting aside labels, he says. Industry is not the enemy and those who work for the environment are not on the "other side." It is a balance thing – not too much and not too little, but just right.

Just a hope? Maybe. But think of all the questions and the hope for answers that have long inspired human exploration. Spend an hour with Sims and you will believe anything is possible, even a future flavor for Aggie Ice Cream.

"How about Aggie Algae Ice Cream?" he says with a laugh. Well, maybe, just maybe.

USU scientist Alfonso Torres-Rua has developed ways for farmers and growers to see water needs of individual plants right down to their roots. Remote sensing science, one of the Utah Research Water Laboratory's specialties, makes it possible to manage water accurately in time of drought and flood. Photo by Gerry McIntyre.