WATERS NETWORK NEWS

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Summer 2010 (Final Issue)

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WATERS Network MREFC Planning Comes to a Close

NSF Continues WATERS Network Vision With New Cross-Directorate Water Sustainability and Climate Solicitation

WATERS Network planning projects to pursue National Science Foundation (NSF) Major Research Equipment and Facilities Construction (MREFC) funding have ended. The five-year major research initiative brought together top thinkers from engineering, geosciences, biosciences, and social, behavioral, and economic sciences (SBE) to address the nation's current and future water issues. "WATERS Network created a vision that showed how much water science can be advanced by working together across the disciplines," said Barbara Minsker, principal investigator (PI) for the initial WATERS Network cooperative agreement and co-principal investigator for phase II.

In a letter to the WATERS Network PIs, NSF noted that the decision not to proceed as an MREFC project was based on the recommendations of the NRC committee that reviewed the WATERS Network science plan. The NRC committee recommended that "it is probably more sensible to build the network incrementally and let the questions and experiments evolve in an adaptive framework. This approach, which is not constrained by MREFC timelines for design and construction phases, could take better advantage of advances in technology over time, such as for sensors and components of the cyberinfrastructure."

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Upcoming Events

***WATERS Network News* Final Issue**
Closure of the WATERS Network Planning Office will conclude publication of *WATERS Network News*.

For More Information

WATERS Network
http://www.watersnet.org

CUAHSI
www.cuahsi.org

NSF
www.nsf.gov

Past Issues

To view previous issues of *WATERS Network News* (*WNN*) and *CLEANER Quarterly Update* (*CQU*), please visit the links below:

WNN April 2009

WNN September 2008

WNN January 2008

WNN October 2007

WNN May 2007

CQU September 2006

CQU March 2006

CQU November 2005

While no longer an MREFC project, the work of WATERS Network has contributed to the justification for the release of a $16-million Climate Research Investment solicitation for fiscal year 2010 by NSF, with the expectation of a five-year continuing program, pending programmatic considerations and availability of funds. The new solicitation, Water Sustainability and Climate (10-524) (WSC), requires cross-directorate integration and aims to understand and predict the interaction of hydrologic systems with not only climate change, but also land use, the built environment, and ecosystem function, reflecting the WATERS Network vision and many of its goals (outlined in the WATERS Network Science Plan). “A solicitation that involves four directorates--not just geosciences and engineering, but bioscience and SBE, too--is really great,” said Jeff Dozier, principal investigator for the phase II WATERS Network planning. Proposals can include projects spanning up to five years.

“In my 14 years of working with NSF, they’ve never had a major, cross-cutting solicitation on water like this,” added Minsker. “The solicitation is exactly the type of prototyping we requested for WATERS Network.”

While the solicitation strongly encourages sites to publish their data through existing data centers and portals, such as the CUASHI Hydrologic Information System (HIS), Minsker is hopeful that the solicitation may eventually lead to an initiative focused on building infrastructure necessary for coordination across all projects and sites “to make sure that all data are accessible, compatible, and comparable.”

With the new solicitation, sites and infrastructure for a nationwide network will be built incrementally rather than simultaneously as was described for the proposed MREFC project. “WATERS Network had the idea of trying to cover the nation’s 12 human-impacted water environment classes as defined in a paper in review by Hutchinson, Haynes, and Schnoor and as described in the science plan,” said Dozier. “We’ll have to see what shakes out of the solicitation proposals and awards to see what sort of coverage we have of the various water environments.”

The planning team will continue to engage with NSF about possibilities for future community infrastructure as the new program unfolds and the benefits of cross-directorate water science observatories are demonstrated in the place-based and synthesis projects proposed. “We need to look at how you learn from studying similar processes simultaneously in different kinds of places to make the whole bigger than the sum of its parts,” said Dozier.

While NSF has decided to pursue an alternate route for building a nationwide network to study water systems and issues, it has, nonetheless, decided to pursue the interdisciplinary research future envisioned by the WATERS Network planning team. “WATERS Network built bridges among some of the best minds in the country from diverse disciplines,” said Minsker. “We have given NSF and other agencies a better understanding of the scope and complexity of the water issues we face and the opportunities we have to solve them by working together.”

Closure of the WATERS Network Planning Office will conclude publication of *WATERS Network News*. CUAHSI will continue to maintain the WATERS Network archives and to work with all of the disciplines involved in the WSC solicitation to advance the WATERS Network vision.

Links to More Information

Water Sustainability and Climate (WSC) Program Solicitation

NRC Review of WATERS Network Science Plan

WATERS Network Science Plan

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NRC Report Applauds WATERS Network's Multidisciplinary Vision to Address Water Issues

While Report Asserts Likeliness of Network's Transformative Science, it Questions MREFC as an Appropriate Funding Program

The National Research Council (NRC) in its *Review of the WATERS Network Science Plan* concludes that the science plan "succeeds in communicating a high-level vision for transforming water science and engineering research through the establishment of an observatory network." The plan describes a cyberinfrastructure that would not only integrate natural, social, and built environments, but would also share infrastructure and data with existing agencies and organizations.

In a preceding letter report, issued by the NRC in July 2009, the review committee expressed that a major strength of the WATERS Network is its multidisciplinary effort and funding. "This would be the first MREFC [Major Research Equipment and Facilities Construction] project to span natural sciences, social sciences, and engineering," noted the letter, "and, thus WATERS would become a model for conducting interdisciplinary research within NSF [National Science Foundation] and the MREFC program." (For more information on the multi-directorate funding, please see "Three NSF Directorates Co-Fund Phase II WATERS Network Planning" in the April 2009 issue of *WATERS Network News*.) Recognizing that the science plan is a "broad vision" rather than a design document, the letter nevertheless emphasized that for the WATERS Network to be a contender for MREFC funding, future drafts of the science plan must make a more convincing case for "why the simultaneous construction of the entire infrastructure is essential to answer the science questions, as opposed to phased construction of a few observatories at a time."

While in its final report the NRC continues to question whether the MREFC program is the best funding mechanism for the WATERS Network, the NRC also asserts that the network "will likely lead to strong, transformative science in its individual pieces."

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Little Bear River Test Bed Demonstrates Value of High-Frequency Monitoring

Team Finds That Sampling at Different Times of Day Drastically Affects Annual Contaminant Load Estimates

The Bear River, located in Utah's mountainous high desert, is the longest river in the country that doesn't drain into an ocean. Unlike an ocean-based river, the Bear River is a virtually contained, small-scale, recirculating system. While this creates a unique opportunity for observatory science, it also adds to the challenge of tracking and containing contaminants. "Water quality problems don't get dispersed in the ocean; they get concentrated into the Great Salt Lake," said David Stevens, professor in the Department of Civil and Environmental Engineering at Utah State University and principal investigator for the WATERS Network Test Bed studying the Little Bear River, a tributary to the Bear River. Because the lake is flat and shallow, even a small fluctuation in its depth results in large exposure of shoreline, and shoreline dust, sometimes contaminated with mercury and other heavy metals, gets blown back into the watershed.

Springtime view of the upper Little Bear River Watershed, where much of the annual flow is generated by high-elevation snowmelt.

Further adding to water management challenges in the Little Bear Watershed are mixed and changing land use and an arid hydrology dependent on a sustained spring runoff. Most years the watershed receives little measurable precipitation from the end of June until the end of October, leaving it heavily dependent on a sustained spring snowmelt runoff. Most of the runoff supplying the Little Bear River is captured approximately mid-watershed in Hyrum Reservoir. Above the reservoir, the small amount of urban area and the pollution it contributes "is drowned out by the very strong spring snowmelt hydrograph," said Jeff Horsburgh, research assistant professor at the Utah Water Research Laboratory in the Department of Civil and Environmental Engineering at Utah State University and co-principal investigator for the test bed. Below the reservoir, however, "the hydrologic regime is completely controlled by releases from the reservoir," said Horsburgh, and during irrigation season, when most of the water is diverted out of the river, the effects of pollution from agricultural return flows and population growth are significant. "A pristine environment in the uplands of our watershed slams into a heavily polluting environment," added Stevens.

To get a better, more detailed picture of these processes driving water quality in the Little Bear River, the test bed team set out to develop an expansive, low-cost, high-frequency monitoring network. "We're interested in bracketing, at a very high frequency, the nutrient loads generated by human activity and their impact on downstream water that includes everything from drinking water to a mixed-use reservoir that supports fisheries, canoeing and boating, bird and other wildlife refuges, and a wetland that is in transition from production agriculture to shopping malls, houses, and 'hobby farms,'" said Stevens.

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Because phosphorus, nitrogen, and sediment—contaminants of interest—require lab analysis, the test bed team implemented a sensor network to track surrogate measures, such as turbidity, temperature, pH, and dissolved oxygen, in real time. From these measurements the team then attempted real-time predictions of relevant contaminants. As it turned out, turbidity could be used to predict phosphorus and sediment levels, which they predicted at 30-minute intervals over the course of two years.

As they anticipated, the increased volume of data provided a much more detailed picture of contaminant behavior in the watershed. “We all came into this with a conceptual model of how we thought the Little Bear River behaved in terms of where the water’s coming from, where it’s going, and what processes affect its quality,” said Horsburgh. “What we found was that there were a lot of signals in the high-frequency data that we didn’t anticipate and that we didn’t necessarily have a good explanation for,” said Horsburgh.

Perhaps more significant, however, was the discovery that current data collection programs are likely yielding inaccurate estimates of nutrient loads. Using the 30-minute data as their “gold standard,” the team generated random monthly, weekly, and daily subsamples. They discovered that not only monitoring frequency but even the time of day samples were taken, according to Horsburgh, drastically affected annual load estimates of contaminants.

“Many management decisions are made at the level of annual loads,” said Horsburgh. Like many other impaired waters across the country, the Little Bear River is regulated using Total Maximum Daily Loads (TMDLs), or specific amounts of pollutants determined by the state that the river can receive and still meet water quality standards (for more information on TMDLs, please see the Environmental Protection Agency site). In many cases, TMDLs are set using annual load estimates, which are based on periodic sampling for contaminants. “Conventional data collection programs collect monthly samples if you’re lucky and weekly samples if you’re really lucky,” said Horsburgh. “If you’re making estimates of the annual load based on monthly samples, you’re in trouble.”

With the real-time, virtually continuous monitoring of surrogate samples, however, “you can have whatever frequency estimate that you want for these loads,” said Stevens. “That’s the beauty of this observatory infrastructure that we’ve built.”

Not only is the test bed team convinced of the value of high-frequency monitoring, but now so are others, including the city of Logan who shoulders a good deal of the nutrient management responsibility for Utah’s Cutler Reservoir (where the Little Bear River drains). The city has contracted with test bed team members to add continuous monitoring stations to four more reservoir tributaries so they can better understand “how the reservoir works in response to river inputs to make better management decisions for their own pollution sources and to promote the idea that we also need to regulate non-point sources,” said Stevens.

While the test bed team did succeed at establishing the network, it wasn’t without the usual complications that come with inserting manmade equipment into a rough, unpredictable environment. “During high-flow, a boulder the size of a Volkswagen rolled on top of a sensor pipe, and it took us days to get it freed up and recalibrated,” said Stevens. And in a landscape covered with both mountains and canyons, signals relaying data were often thwarted. Future research plans to address these issues.

Continuous measurements in the Little Bear River are combined with lower-frequency automated and grab samples to create high-frequency estimates of water quality constituent concentrations.

Next steps for the observatory team also include developing the software and intellectual infrastructure for an adaptive monitoring system. A model would “listen” to the data on turbidity, discharge, and weather and then trigger samplers to automatically adjust monitoring frequencies during storm events and particularly high- and low-flow times, which have been tough to capture, according to Horsburgh.

“We’ve convinced ourselves and some local stakeholders that high-frequency monitoring is a good idea,” said Stevens. “It should be part of long-term planning for water quality in the watershed.”

Links to More Information

Little Bear River WATERS Network Test Bed site

TMDL document for the Little Bear River Watershed

For another example of a test bed using surrogate measures for real-time prediction of water quality, check out the WATERS Network Clear Creek Test Bed, which we profiled in April 2009 (http://www.watersnet.org/WNNApril2009.html#article3).

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Like the other WATERS Network Test Beds, the Little Bear River Test Bed used the Consortium of Universities for the Advancement of Hydrologic Sciences (CUAHSI) Hydrologic Information System (HIS) to archive and publish their data. For more discussion of the CUAHSI-HIS, please see the text box in the April 2009 Clear Creek Test Bed article in *WATERS Network News*. They also developed additional tools specific to their test bed (available at littlebearriver.usu.edu).

To learn more about the other WATERS Network Test Beds, please visit the website.

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Florida's Santa Fe Basin Healthy, but Vulnerable

Test Bed Team Attempts to Capture and Predict Flashy Karst System's Response to Population, Climate, and Land-Use Changes

Unlike any of the other WATERS Network Test Beds, the Santa Fe Basin Test Bed in north central Florida is a karst system, creating an exceptionally diverse—and challenging—hydrogeology across the watershed. In the upper half of the watershed, a clay layer separates and protects the underlying Floridan Aquifer. About midway in the watershed, however, the clay erodes in a transitional area known as the Cody Escarpment, leaving the limestone aquifer in the lower half of the watershed exposed to surface contamination. "It's a pretty dramatic transition between surface-dominated processes and groundwater-dominated processes," explained test bed principal investigator Wendy Graham, Carl S. Swisher Chair in Water Resources in the Department of Agricultural and Biological Engineering and Director of the Water Institute at the University of Florida. "The Santa Fe River is completely captured by a sinkhole at the transition, where it goes underground for about six kilometers before emerging as a spring further downstream."

According to the US Geological Survey (USGS), nearly 40 per cent of groundwater drinking supplies in the US come from karst aquifers, "so understanding their behavior, characteristics, and controls on water quality and quantity is really a quite important undertaking," said Jonathan Martin, professor of geological sciences at the University of Florida and co-principal investigator for the test bed.

Students Lauren Smith and Brooke Sprouse sample water chemistry at the Santa Fe River Sink where surface water enters the aquifer.

The Floridan Aquifer underlies the entire state of Florida and parts of Alabama, Georgia and South Carolina. According to Graham, " the Floridan Aquifer is one of the most prolific aquifers in the world," supplying most of central and northern Florida's potable water—an average of more than four billion gallons of water per day were withdrawn from the aquifer in 2005, according to the USGS data. Due in part to the protective clay layer and sparse population in the region, the water quality in the Santa Fe Basin and its parent Suwannee Watershed is relatively good. In 1999 the Environmental Protection Agency named the Suwannee a National Showcase Watershed.

But like nearly every other watershed around the country, the Santa Fe and Suwannee Watersheds are threatened. Much of the rest of the state, especially the heavily populated south, is not so well off when it comes to clean and ample water. One solution proposed both by a group of developers ("Florida Unprepared for Looming Water Crisis," *The New York Times*, June 19, 2007) and the Corps of Engineers ("Draining Supply," *The Gainesville Sun*, May 19 2003), is interbasin transfers, and the plentiful supply of the Santa Fe's parent Suwannee River Watershed is a good target. More recently concern has arisen that pumping in the Jacksonville area is reducing groundwater levels and spring flows in the Suwannee River Basin ("Will Jacksonville guzzle our water?" *The Gainesville Sun*, September 21, 2009).

Furthermore, below the Cody Escarpment, the groundwater in the two watersheds is particularly vulnerable to contamination. "Most contaminants come from land use, and if there is much exchange between surface water and groundwater, contaminants can easily infiltrate the aquifer," explained Martin. "Precipitation and runoff flow directly into the aquifer where it is unconfined." Changes in the watershed can already be seen due to increased urbanization and contamination. "There's been a fairly large ecological shift in the spring runs from a macrophyte-dominated system to one that's algally dominated," which is believed to be the result of reduced flow rates and increased nitrogen concentrations in the water, among other problems, according to Martin.

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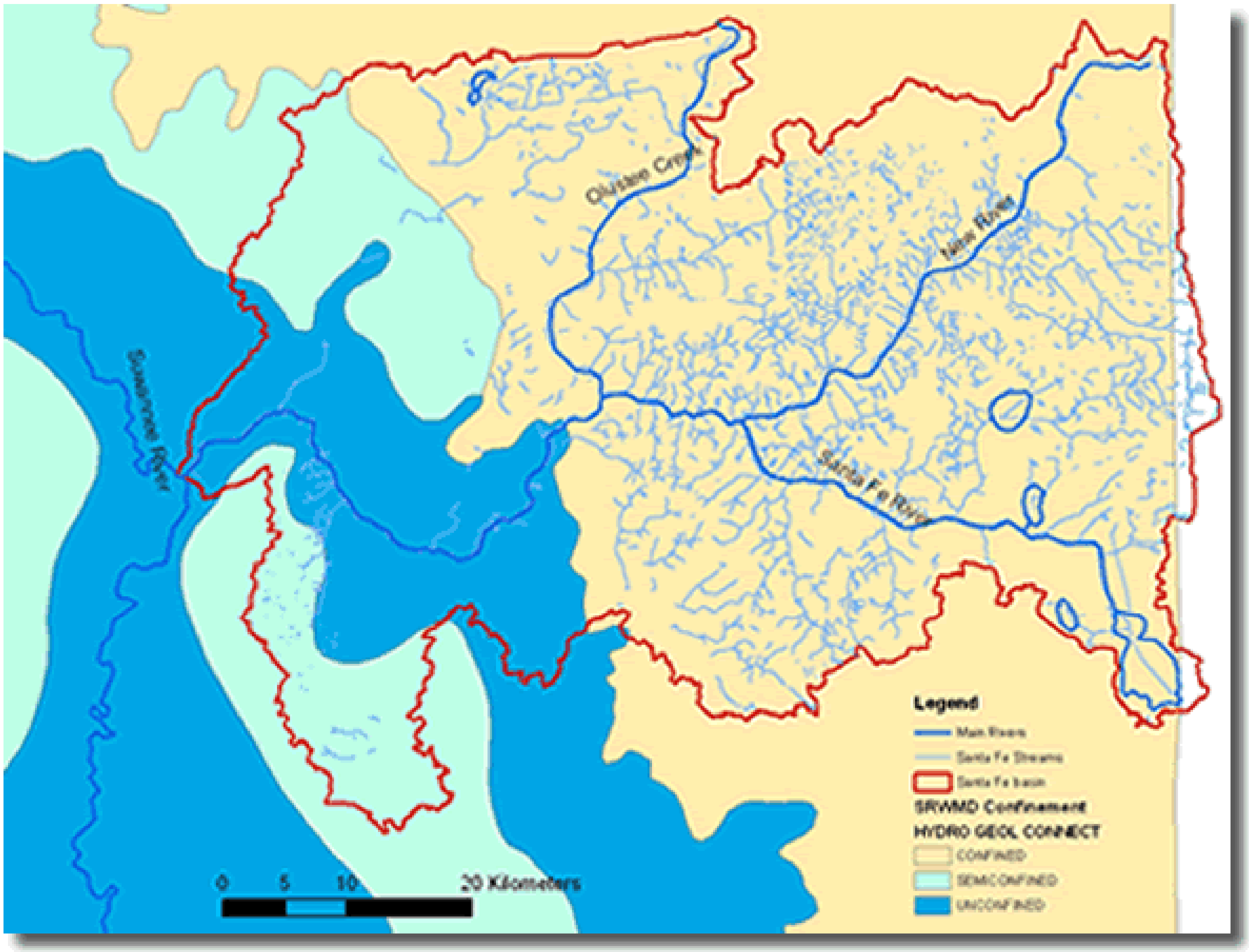

The hydrogeological features of the smaller-scale Santa Fe Basin mimic that of the larger Suwannee River Basin.

To try to prevent this shift in the ecosystem, the Santa Fe Basin WATERS Network Test Bed is developing a distributed sensor array to observe and predict water flow and nitrate flux in the Santa Fe Basin in response to climate and land use. Ultimately, they want to model the effect of land use changes on surface water quality, the optimum configuration of land use, and the effectiveness of improved farming practices "to inform decisions about how to best manage land use," said Martin.

The Santa Fe Basin is an ideal test bed site because its hydrogeological features mimic that of the larger Suwannee River Basin, only on a smaller scale, which makes it easier to manage the observation and measurement logistics, according to Martin. The basin is also already well-instrumented by the USGS and has a rich history of monitoring, including flow, groundwater level, and rainfall measurements, with some discharge data dating back to the 1800s.

Water quality measurements, however, "tend to be available only as snapshots, which are fairly sparse for research purposes and for trying to put together accurate chemical and water budgets," said Graham. The test bed team, therefore, wants to "augment the existing data with chemistry measurements of the same intensity and frequency to improve the conceptual model of how water is moving through the watershed," continued Graham.

What's more, it's particularly difficult in a karst system to make observations at a high enough spatial and temporal resolution to capture its "flashiness." In aquifers made up of porous media, subsurface water tends to seep through to the aquifer very slowly, but in a karst system "embedded caves or conduits act like pipes, creating very rapid flow," said Martin. "The characteristics of both flow and water chemistry can change rapidly over relatively small spatial areas and through time." For example, a river may lose water to a sinkhole and a little ways downstream gain water from a spring, but it may not be the same water. "Along 40 kilometers or so of the lower Santa Fe, the river has multiple sinks and springs exchanging water between the aquifer and river," said Martin. The water's chemistry must be measured at frequent enough points along the river to identify whether the water is the same and, if not, where different water enters the system and where it's coming from.

Though still in the design and development stage, test bed data have already led to new discoveries. "For example, it's long been thought that recharge of the aquifer occurs by point-source allogenic recharge, such as when water flows off the confined unit and coalesces into streams and rivers until it comes to fractures or sinkholes and flows into the aquifer," said Martin. But when the test bed team compared allogenic recharge to diffuse recharge (by rain falling across the land and slowly infiltrating into the aquifer, for example), it turns out they're nearly equal where the aquifer is semi-confined. "In fact there's actually a little bit more diffuse recharge into the aquifer," said Martin. Data also point to a new hypothesis for cave formation. "Caves have been thought to form from the upstream end where allogenic water enters the aquifer," but

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test bed data show that they may actually form when flooding causes springs to reverse flow. River water, highly undersaturated with calcite, flows back into aquifer, dissolves the limestone, and builds the caves. “In this case the caves would form from the downstream end, which is completely antithetical to previous models of cave formation,” said Martin.

Two projects have been funded expanding on test bed work. One will develop physical and Bayes network modeling for prediting water and chemical fluxes throughout the basin, and the other is looking at nitrogen cycling and calcite dissolution, which contribute to erosion of the limestone and are critical for determining best management practices for a karst system. Water extraction and water quality both “depend on where that dissolution is taking place and creating conduits,” said Martin. A contaminant spill or harmful land use practice is much more damaging near these conduits. Furthermore, because “there is more than 1000 times more carbon in carbonate rocks than all other global carbon reservoirs combined, understanding the dissolution and precipitation of carbonate minerals is important for carbon cycle and climate change,” added Martin.

The team hopes to share information and lessons learned regarding sensor performance and reliability, data acquisition and management, and modeling with the other test beds “to show that new science questions can be addressed by having this data consistently across a gradient of watersheds versus always intensively studying one,” said Graham.

And locally, test bed data are already being put to use by the Springs Task Force, a state-organized group made up of residents, decision makers, and agriculturalists to protect the springs from contamination. Overall Martin expects the test bed data “to have a major impact.”

Links to More Information

Santa Fe Basin Test Bed

Suwannee River Hydrologic Observatory

Suwannee River Water Management District

January 2002, *U.S. Water News Online* article, “Florida drought over, but water shortage still critical,” which discusses Florida’s impending water crisis and its potential impact on the Floridan Aquifer.

To learn more about karst systems, please visit http://water.usgs.gov/ogw/karst/pages/whatiskarst.

Like the other test beds, the Santa Fe team used the Consortium of Universities for the Advancement of Hydrologic Sciences (CUAHSI) Hydrologic Information System (HIS) to archive and publish their data. For more discussion of the CUAHSI-HIS, please see the text box in the April 2009 Clear Creek Test Bed article in *WATERS Network News*.

WATERS Network Test Beds

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This issue, Summer 2010, concludes publication of *WATERS Network News*.