FEATURE

The Utah Water Research Laboratory: Empowering Water and Environmental Research in Utah and Around the World

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Utah Water Research Laboratory, Logan, Utah (Photo credit: Jessica Griffiths, UWRL)

When the first water flow experiments took place in 1957 along the Logan River at the future site of the Utah Water Research Laboratory (UWRL) at Utah State University (USU), who could have guessed that within 50 years, UWRL researchers would be flying computers in the sky, improving the design and function of dams around the world through physical and computer models, and developing hydrologic information systems to help manage and interpret huge volumes of data from a variety of sensors in a range of formats collected by and shared among a nationwide community of hydrologic researchers?

Yet those types of research and many more are precisely what have made the Utah Water Research Laboratory a leader in water and environmental research and one of the most respected facilities of its kind. This article illustrates some of the history and research accomplishments at the UWRL addressing water problems in Utah and around the world and demonstrating the value of cross-disciplinary collaboration, as is promoted by the AWRA. Institutions such as the UWRL are an important part of the nation's research infrastructure and are critical to generating the knowledge needed to solve those water problems.

History

The Utah legislature authorized the establishment of a water research laboratory at USU in 1959. The 80,000 ft^2 UWRL building was started in 1963 and dedicated in 1965, making it one of the oldest and largest university-based facilities in the United States, developed to research better ways to measure, monitor, model, understand and manage water resources. An environmental quality wing built in 1980 broadened the disciplinary capabilities of the lab to add chemistry, microbiology, and analytical instrumentation to the hydraulics and water resources facilities already present. The hydraulic modeling and testing facilities were expanded in 2009 with the addition of a new 11,000 ft^2 recirculating flow hydraulic modeling building.

Hydraulic Modeling

The UWRL uses numerical and scaled physical models to evaluate hydraulic structure design and performance (e.g., spillways, bottom outlets, pump stations), as well as identify and solve hydraulic deficiencies. State, national, and international projects have utilized the UWRL hydraulic structures modeling services to ensure proper function and public safety. Located adjacent to the Logan River, the UWRL hydraulics laboratory can divert flows of up to 250 cfs (cubic feet per second) through the lab for detailed large-scale models of dams and spillways, along with other hydraulic testing.

Figure 1.(a) 1:45 scale model of Lake Isabella labyrinth spillway (Photo credit: UWRL, Blake Tullis)

Figure 1.(b) 1:50 scale model of the damaged Oroville Dam spillway (Photo credit: USU, Matt Jensen)

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Water Resources Management

Collaborative and interdisciplinary research at the UWRL over many years, including early work on severe sustained drought in the Colorado River basin, snowmelt modeling, and Utah waterways, has laid the foundation for projects that are still advancing the study of water resources management in many key areas.

Colorado River: A new project led by Jack Schmidt in the USU Watershed Sciences department, including UWRL contributions in modeling components for water temperature, water resources systems, and hydrology, is building on decades of previous work in the basin.

Bear River: This interstate basin (WY, ID, UT) has inspired numerous UWRL studies, with recent efforts on synergistically managing water and vegetation to improve habitat for birds at the Bear River Migratory Bird Refuge and improve aquatic, floodplain, and impounded wetland habitat throughout the lower Bear River. Another project is helping local and state managers plan for and manage future droughts by providing monthly streamflow reconstructions from regional tree ring chronologies and climate indicators that date back to the 1400s.

The Great Salt Lake: Multi-disciplinary work over many years has increased understanding of this closed basin lake that is iconic for Utah and a barometer for the condition of water resources in the state. The amount of water in the lake fluctuates dramatically, driven by streamflow, precipitation and evaporation. Salinity, critical for the brine shrimp and salt harvesting industries varies with level too. Of particular concern is the effect of increased consumptive water use in the basins draining to the lake, and UWRL computer models for lake level, salinity, and flows through the causeway that partitions the lake are key parts of multi-disciplinary work to predict future fluctuations and their impact on the lake ecosystem, economy and environment.

Snowmelt: The Utah Energy Balance (UEB) snowmelt model, a parsimonious physically based model, was developed to simulate snow accumulation and melt accounting for variability in topography and vegetation. It has been applied widely, and as far away as Nepal, where it was used to simulate glacier melt.

Instream Flows for Ecosystems: The UWRL is working with state and local water and environmental managers and legislators to examine water laws and policies that traditionally only incentivized agricultural and municipal water supply, hydropower generation, mining, and navigation and make changes to allow these stakeholders to manage and allocate instream flow in ways that also benefit ecological needs.

Measurements and Sensing

Long-time UWRL Director Mac McKee often stated the axiom "If you don't measure it, you can't manage it."

Figure 2. One of AggieAir's fixed-wing UAVs. (Photo credit: Jessica Griffiths, UWRL)

Applications using high-frequency data collection systems, sensor networks, satellite data, and multispectral sensors aboard unmanned aerial vehicles (UAVs) are just a few ways UWRL researchers are harnessing the power of direct measurement and remote sensing.

AggieAir: The UWRL developed the AggieAir unmanned remote sensing platform in 2006 to respond to the needs of water, environmental, and civil applications for high-resolution, multispectral scientific imagery (Figure 2). It has become an exceptionally capable, scientific-quality, small, unmanned aerial data collection system in support of precision data collection (Figure 3).

Hydrologic Observatories: UWRL researchers have built and maintained high-frequency data collection systems leading to a better understanding of key hydrologic processes, more accurate models, and ultimately better management decisions. In 2012, the National Science Foundation funded a 5-year, multi-institution, interdisciplinary program called iUTAH (innovative Urban Transitions and Arid region HydroSustainability) that focused on water sustainability in Utah and established environmental sensor networks across the state. The Logan River sensor network has become the Logan River Observatory (LRO), with streamflow, water quality, and weather stations throughout the watershed from the headwaters through Logan City and into the Cache Valley, supporting multiple lines of research.

Environmental

Understanding and finding sustainable solutions to water challenges that result from the innumerable interactions between humans and water requires an integrated engineering and science approach. Environmental research at the UWRL emphasizes the quality of land, water, and air and combines basic and applied laboratory and field research. Research encompasses topics from the effects of copper and zinc oxide nanoparticles on wheat roots to biofiltration of Utah's drinking water, turning food waste into energy, and more.

Storm Water Management and Green Infrastructure: One UWRL research study is evaluating vegetation types that survive in bioretention areas in the Intermountain West for a low-tech, plant-based treatment approach to safely release stormwater from urban areas back to the environment free of hazardous metals and polluting nutrients in a low-cost, environmentally sustainable way.

Hydroinformatics

The increasing flood of sensor data presents both a challenge and an opportunity for researchers. The volume of data produced far outstrips our ability to use it effectively with conventional data management and analysis tools. However, UWRL researchers have been key participants and leaders for over a decade in the development of CUAHSI's (The Consortium of Universities for the Advancement of Hydrologic Sciences, Inc.) Hydrologic Information Systems, which help researchers manage and interpret the data they collect and provide technology to enhance collaboration. Key contributions follow.

The Observations Data Model: The initial CUAHSI Observations Data Model and subsequent ODM2 were developed to consistently describe, store, manage, and encode spatially discrete observational datasets for archive and transfer over the Internet, across scientific disciplines, and in the domain cyberinfrastructures within which they are stored.

HydroShare: This web-based Hydrologic Information System enables researchers to more easily share data, computer models, and research results in a variety of formats to help manage, organize, and interpret the extensive data available (https://www.hydroshare.org/). HydroShare supports the growing trend for open data that is findable, accessible, interoperable and reusable (FAIR).

Future Opportunities and Directions

The UWRL has evolved into a diverse center of excellence for generating knowledge related to water challenges. It fills an important role in the US/global community of water research facilities, with the interdisciplinary expertise to develop better ways to measure, monitor, model, understand, and manage 21st century water resources. Good water management recognizes the value of information from many disciplines—from how a single water molecule behaves to the constraints and opportunities created by state or national water laws and policies.

The increasingly collaborative nature of research generally requires a team—a community—to gather information from the many disciplines needed to advance understanding and solve problems. Building connections to other research facilities will bring the UWRL's unique capabilities to bear on future water challenges. Even with the exciting new technological advances in fields such as remote sensing, cyberinfrastructure, information management, and "big data," it has been and will continue to be the hard work and dedication of students, faculty, other professionals and the community who push the boundaries to advance the field of water resources management, in all its complexity. ■

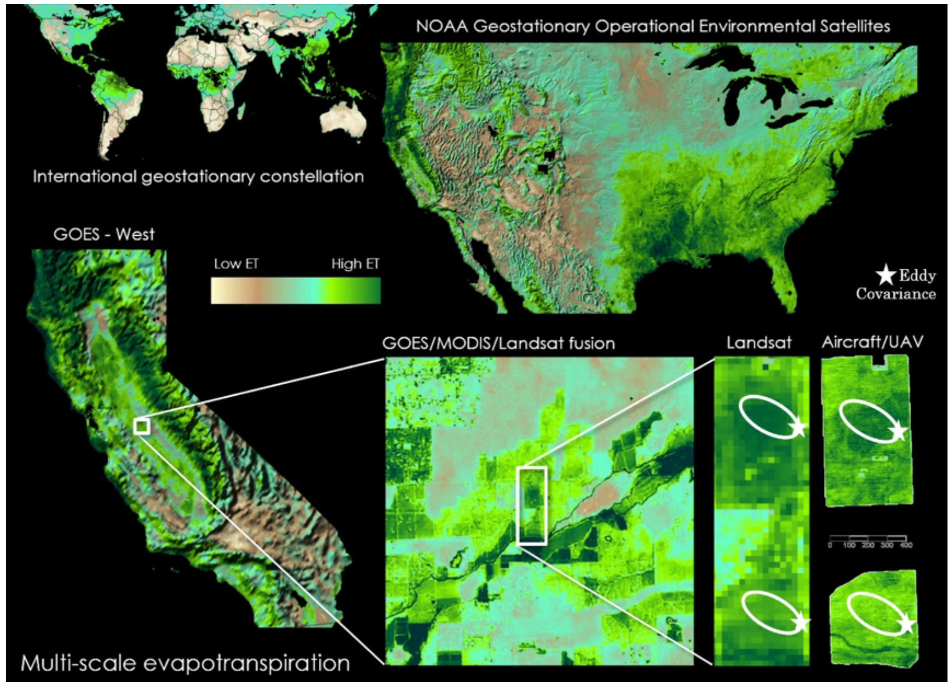

Figure 3. AggieAir collaborated with E&J Gallo Winery, USDA-ARS, and NASA on the GRAPEX, "Grape Remote sensing Atmospheric Profile & Evapotranspiration eXperiment" project, producing high-resolution imagery to improve high-value agriculture by mapping the spatial variability of crop water use and water stress.

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