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Perspective Piece

The Golden Age of Water (1964-2025)

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Six decades ago, the golden age of water began in the United States when President Lyndon Baines Johnson signed the Water Resources Research Act (WRRA) of 1964. This led to the founding of the National Institutes for Water Resources (NIWR) and Universities Council on Water Resources (UCOWR). Sixty years ago, these two water organizations formed to represent the 54 water research institutes at land grant universities (NIWR) authorized by the WRRA and the over 60 water research institutions of higher learning in North America (UCOWR). This paper traces the 60-year evolution of these associations that conduct water research locally, regionally, and nationally in United States, from the Great Society of the 1960s, the Clean Water Act years of the 1970s and 80s, and the watershed movement of the 1990s into the 21st century.

Overview

The year 1964 was pivital in American history. It was the year of escalation in the Vietnam War and the year of the British Invasion on American airwaves. It was also the year of the Great Society, President Johnson's sweeping vision for social justice policies, based on his predecessor, President John Fitzgerald Kennedy's legacy. On July 2, 1964, he signed the Civil Rights Act, after Congress passed it by 2 1/2 to 1 in the House and 3 to 1 in the Senate. The Act prohibited discrimination based on race, color, religion, sex, and national origin in the workplace and in schools.

In 1964, science and environmental protection were popular with Americans. It developed from the quest for science and a college education with the GI bill, when veterans returned home from World War II. It followed President Dwight David Eisenhower's 1956 push to build the interstate highway system that linked America from coast to coast—America's biggest public works project ever. It followed the space race in 1958 and the Sputnik moment when the Americans and Soviets raced to the moon and President Eisenhower pushed for a change in the way that kids were educated in America in math and science. And it followed the publication of *Silent Spring* in 1962, when marine biologist Rachel Carson wrote a best selling book about the dangers of chemicals in society. President Kennedy, himself a former naval officer with a deep appreciation for the ocean, publicly supported Carson's work and became interested in cleaning up our nation's waters. He followed up on a 1959 report from Senator Mike Mansfield (D-MT) that said water scarcity was the biggest problem in the American West, a 1961 report he commissioned by the National Academy of Sciences recommending more water research and jobs training by our nation's universities, and a 1963 article in the journal *Science* that recommended strengthening our nation's colleges to train more engineers and scientists (Revelle 1963).

Building on President Kennedy's water initiative, on July 17, 1964 President Johnson signed the WRRA that established a network of "water resources research and technology institutes

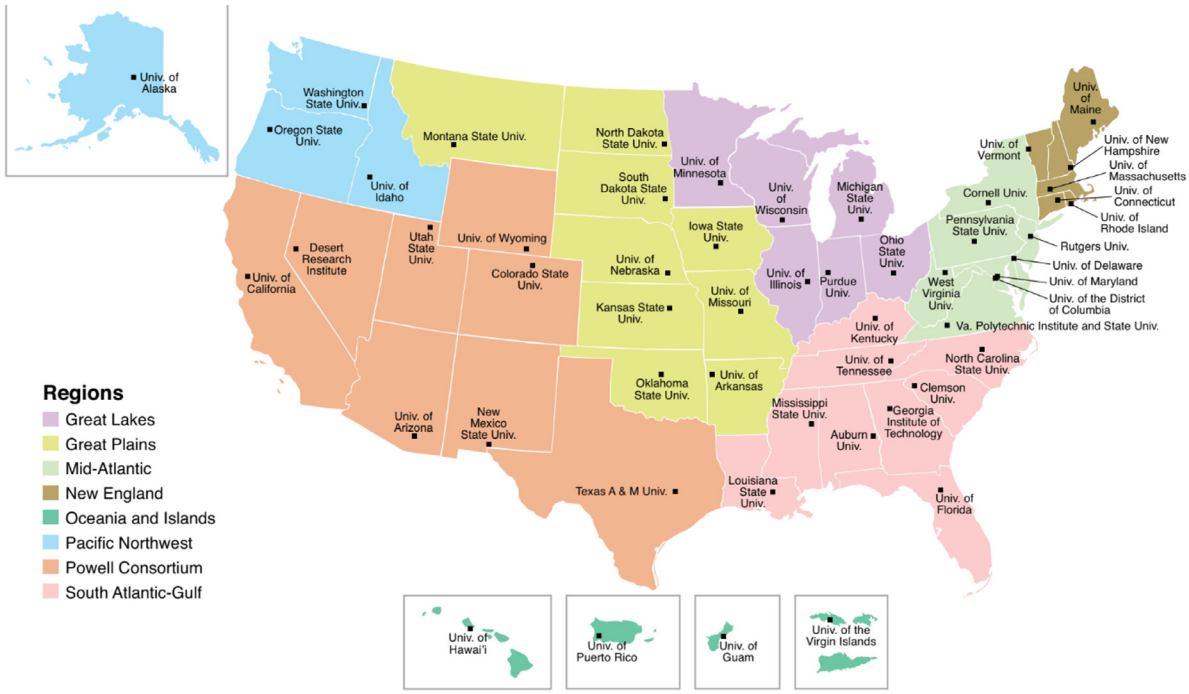

Figure 1. Network of Water Resources Research Institutes in the United States.

or centers…" at public institutions that stretch from Maine on the Atlantic to Micronesia in the Pacific (Figure 1). The 1964 WRRA was based on the 1862 Morrill Act that established land grant colleges and the 1887 Hatch Act that formed state agricultural experimental stations. It was reauthorized in 1984 and in the 2021 Bipartisan Infrastructure Law. The water research institutes are authorized by federal laws passed during the administrations of Abraham Lincoln (1862), Grover Cleveland (1887), Lyndon Johnson (1964), Ronald Reagan (1984), and Joe Biden (2021). The Congressionally chartered land grant water research institutes assist the Nation and States in augmenting their water resources science and technology to: (1) conduct research into the nation's water challenges and (2) train future scientists and engineers for water resources careers. As President Johnson signed the law he said: "abundant, good water is essential to continued economic growth and progress . . . and Congress has found that we have entered a period in which acute water shortages are hampering our industries, our agriculture, our recreation, and our individual health and happiness."

The 1964 WRRA appropriation administered by U.S. Geological Survey (USGS), a science bureau within the Department of the Interior, has been successful over the last six decades. One of the first WRRA research students supported was University of California Los Angeles graduate student Elinor Ostrom who researched regional planning and water wars in Southern California and, after moving to Indiana University, was awarded the Nobel Prize in economics for game theory. The WRRA invests in water resources and river basins that support a trillion dollars of economic activity in the U.S. such as outdoor recreation, agriculture, drinking water, and water-related jobs. (Donohue, Greene, and Lerner 2021). Clean water supports fishing ($42 billion), hunting ($23 billion), and bird watching ($46 billion) and outdoor recreation totaling $140 billion nationally for boating, paddling, and sailing. The Delaware River Basin supports $22 billion in economic activity and 600,000 jobs. The Chesapeake Bay, as the nation's largest estuary, supports a trillion dollar tourism, fishery, and agriculture economy. The Colorado River supplies drinking water for 40 million Americans, a $1.4 trillion economy, 16 million jobs, and 12% of U.S. Gross Domestic Product. The 54 WRRA institutes at our nation's colleges, with over 10 million alumni, supported

over 25,000 student water research projects that work to protect the health, safety, and welfare of the American public.

Water research in the U.S. is a national priority. The drought in the East continues into 2025 after six months with little precipitation, a record stretching back to the first National Weather Bureau rain gauges in 1894. Unprecedented flooding from Hurricane Ida in September 2021, Hurricanes Helena and Milton in 2024, and the Ohio River Basin floods in Spring 2025 drove Americans away from their homes in Delaware, Pennsylvania, Florida, North Carolina, and Kentucky. The West saw the worst drought in 400 years, since the Indigenous people and the Spanish lived on the land, and then atmospheric rivers flowed from the Pacific and flooded San Francisco and Seattle. A snow drought continues in the Sierra Nevada in the "water towers of the west." And in the winter of 2025, micro-drought driven wildfires consumed the canyons in Los Angeles along the Pacific.

In 1965, by resolution of the Governor and Delaware General Assembly, the Board of Trustees established the University of Delaware Water Resources Center (UDWRC) on campus with three directors over the years: Dr. Robert Varrin, Chair of the Department of Civil and Environmental Engineering (1965-1995), Dr. Thomas Sims, Dean of the College of Agriculture and Natural Resources (1995-2015), and Dr. Gerald Joseph McAdams Kauffman, Jr., Associate Professor, Biden School of Public Policy & Administration (2015-2025). In 2024, we celebrated the 60th anniversary of the WRRA and in 2025 we commemorate the 60th anniversary of the UDWRC. With federal, state, local, and philanthropic cost sharing, UDWRC supports Delaware, Delaware State University, and Delaware Tech students in water research concerning PFAS (per- and polyfluoroalkyl substances), and lead in drinking water, coastal and riverine flooding, harmful algal blooms, and water economics, all important issues in Delaware and the Delaware and Chesapeake Bay watersheds.

Universities Council on Water Resources (UCOWR)

The 1950's space race turned to an emphasis on math and science here on Earth, but in the 1960's there was little emphasis on hydrology as a science (Scott 1988). In August 1962, Professors David Todd (University of California Berkeley) and Warren Hall (University of California Los Angeles) invited 20 scientists including V. T. Chow (University of Illinois), R. K. Linsley (Stanford University), and M. G. Wolman (Johns Hopkins University) to an intercollegiate symposium to discuss the state of hydrology at Lake Arrowhead, California. The 19 universities at this first conference defined hydrology as "the science that treats the waters of the Earth, their occurrence, circulation and distribution, their chemical and physical properties, and their reaction with the environment, including their relation to living things . . ." On November 26, 1962, 16 universities met to form the Universities Council on Hydrology (UCOH) with membership from Caltech, Iowa, University of California Los Angeles, Idaho, University of Southern California, Washington, Wisconsin, Utah State, Illinois, Colorado State, Cornell, Arizona, Georgia Tech, Stanford, Johns Hopkins, and Michigan State. In 1964, the UCOH reformed as UCOWR to recognize "the interdisciplinary nature of the field."

The mission of UCOWR is to address water resources challenges through sharing expertise, fostering leadership, and developing interdisciplinary collaborations (UCOWR 2025). The Board of Directors is supported by staff at Southern Illinois University in Carbondale, Illinois. UCOWR connects member institutions through conferences and webinars, recognizes water resources scholarship, teaching, and outreach through annual awards, and publishing the *Journal of Contemporary Water Research and Education (JCWRE)*. Over 60 institutions with a water education and research mission in North America are UCOWR members. UCOWR and NIWR cosponsor annual forums such as the Joint 60th Anniversary Conference with AWRA on September 30, 2024 in St. Louis and annual conferences in June 2025 at the University of Minnesota and June 2026 in San Antonio, TX. At the annual conference, the UCOWR Board presents national water awards such as the Warren A. Hall Medal, Friends of UCOWR, Ph.D. Dissertation Awards, Education/Public Service Award, and *JCWRE* Paper of the Year.

National Institutes for Water Resources (NIWR)

Federal action on water resources research goes back to the 1950s and the Eisenhower administration. In 1957, Sol Resnick formed the University of Arizona Institute of Water Utilization and served as director until 1964 when the Arizona Water Resources Research Center was established (AWRRC 2014). In 1959, Senator Mike Mansfield (D-MT) informed the Western Democratic Senators conference that water was the greatest resource problem facing not just the West, but the entire nation. Senators Murray, Mansfield, and Anderson then introduced Senate Resolution 48, recommending water research legislation to the Interior Committee chaired by Senator R. Kerr (D-OK) and Senator T. Kuchel (R-CA).

In January 1961, just before President John F. Kennedy's inauguration, President Eisenhower's Bureau of Budget sent a bill to Congress to establish river basin planning commissions. On February 23, 1961, in a message to Congress, President Kennedy directed the National Academy of Sciences to review federal programs to strengthen their water research capabilities. In 1961, Professors Castle, Burgess, Krygier, and Warren petitioned the Oregon Board of Higher Education to authorize the Water Resources Research Institute at Oregon State University as one of the first water institutes in the nation (Jarvis 2019). In 1962, the WRRA was drafted based on the January 1961 Report of the Select Senate Committee on Water Resources chaired by Senators Kerr and Kuchel (Caulfield 1987). Revelle (1963) wrote in the journal *Science* about a shortage of qualified water research scientists and recommended that Congress and the White House pass new water legislation to strengthen university based water research.

In early 1964, Senator Anderson drafted a WRRA bill (Strong 1964) supported by Dr. J. Fisher (Resources for the Future), Dr. J. Geyer (Johns Hopkins), and Stephen Dedijer, a Russian scientist and emigree who wrote in the *Journal of Atomic Scientists* that scientist knowledge shared by all citizens—not just the elite—is essential to democracy (Caulfield 1987). In Spring 1964, the WRRA was redrafted with Title I water research grants to land grant universities and Title II grants of $1 million to centers of excellence at non land grants, foundations, and public agencies. Hawaii Representative Thomas Gill expressed his concern about depleted water tables, water pollution, and water supplies that make knowledge of water critical to this life source. Interior Committee chair Senator C. Anderson modeled the WRRA after the 1887 Hatch Act that created land grant agricultural experimental stations popular with conservative rural legislators like Representative Compton White of Idaho (Sowards and Lacabanne 2017). Speaking at New Mexico State University, Senator Anderson maintained federal water research was underfunded at 0.7% of budget compared to oil and gas industry research and development at 3%, chemical industry at 6%, and auto industry at 12.5% (Caulfield 1987). Representatives. C. Brown (R-OH), W. Aspinall (D-CO), J. Saylor (R-PA), and O. Teague (R-TX) thought the WRRA would better coordinate federal water research to prevent duplication and hailed universities for diverse expertise with ''an ideal setting for water resources research.'' In June 1964, the WRRA (HPL 88-379) was supported by Colorado State University President Dr. William Morgan, the Association of Land Grant Colleges and State Universities, Harvard, John Hopkins, Georgia, and Stanford, and Council of State Governments (Caulfield 1987) and Cal Tech professor and UCOH chair Dr. D. Todd (UCOWR 1964) who wrote to the Secretary of Interior and endorsed the WRRA, as it "provided the opportunity to significantly increase . . . research in water resources at universities throughout the United States."

On July 16, 1964 President Johnson signed the WRRA to assist the Nation and States in augmenting their water resources science and technology to: (1) assure supplies of water sufficient in quantity and quality, (2) discover practical solutions to the Nation's water resources problems, (3) assure protection of environmental and social values…with water resources management, (4) promote more effective coordination of the Nation's water resources research program, and (5) promote the development of a cadre of trained research scientists, engineers, and technicians for future water resources problems. President Johnson stated: "The Water Resources Research Act of 1964, which I have approved today, fills

a vital need. Abundant, good water is essential to continued economic growth and progress. The Congress has found that we have entered a period in which acute water shortages are hampering our industries, our agriculture, our recreation, and our individual health and happiness…by the year 2000 there will not be enough usable water to meet the water requirements . . . of . . . Arizona, California, Colorado, Delaware, Idaho, Illinois, Indiana, Iowa, Kansas, Louisiana, Michigan, Minnesota, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Texas, Utah, Wisconsin and Wyoming. . . . It will create local centers of water research. It will enlist the intellectual power of universities and research institutes in a nationwide effort to conserve and utilize our water resources for the common benefit. The new centers will be concerned with municipal and regional as well as with national water problems." In 1964 and 1965, state water resources research institutes were established at most of the land grant university campuses in the U.S.

In 1971, the Water Resources Task Force of the Department of the Interior concluded: "interregional institutional research will strengthen the overall research effort in water resources evaluation and provide a protective umbrella for projects that might be regarded as too controversial for a specific investigator of an institution to undertake." In the 1970s, the WRRA was amended to: (1) add technology development as a water research purpose, (2) form the Office of Water Research and Technology (OWRT), (3) develop technology transfer methodologies "to make information gained from water research generally available," (4) encourage regional consortiums to increase effectiveness of a nationwide network of institutes, and (5) "cooperate closely with other colleges and universities . . . in developing a statewide program to resolving state and regional water problems."

By 1983, amendments to the 1964 WRRA broadened the charter to 54 institutes in the 50 states, District of Columbia, Puerto Rico, U.S. Virgin Islands, and Guam to: (1) oversee competent research that addresses water problems or expands the understanding of water phenomena and (2) aid the entry of new research scientists into water resources fields, helping to train future water scientists and engineers, and transferring results of sponsored research to water managers and the public.

In 1984, during the Reagan Administration, the Secretary of the Interior, James Watt, and Office of Management and Budget (OMB) Director, David Stockman questioned federal water programs such as the 1978 Water Research and Development Act and 1965 U.S. Water Resources Council Act following the trickle-down economics theory to defund federal Agriculture and Interior programs they thought were state issues. Opposing the Administration, Congress voted to reauthorize the Water Resources Research Act of 1984 (P.L. 98-242) following Senator Abdnor's subcommittee legislation and Congressman McNulty's House leadership. Overriding President Ronald Reagan's veto, Congress passed the 1984 WRRA amendments and the Secretary of the Interior delegated oversight of the WRRA to the USGS.

At the 1987 National Water Institute Directors meetings in Arlington, Virginia, Colorado State University political scientist Dr. H. P. Caulfield (1987) looked back to 1984 and observed the 54 water institutes should support WRRA reauthorizations without regard for political ideology as the Enlightenment valued science and "scientific thinking dominates much modern intellectual thought" and "this honorific role of science gives water research a strong presumption of public worth." Dr. Caulfield continued: "It is essential, as I see it, that the whole water research community find a consensus for the water research program it wants to see reauthorized. . . . different interests within the community will need to bargain . . . to arrive at a consensus that all feel makes good sense and is capable of being sold to the political community. Finally, the water research community needs to stand solidly together in the . . . political process. . . . The 54 state institutes provide a widespread base for distributive politics that not all very worthwhile federal programs are fortunate enough to possess."

On December 4, 1989, Dr. Paul Godfrey (Massachusetts Water Research Center), Dr. Patrick Brezonik (Minnesota Water Resources Center), and Dr. Paul Zelinsky (Clemson Water Research Institute) signed articles of incorporation

by the Commonwealth of Massachusetts that established the National Association of Water Institute Directors, NAWID (later NIWR), that provided representation for state water research institutes to implement the WRRA of 1984.

In FY99 the federal WRRA appropriation to the 54 NIWR institutes was $4 million, institutes provided local matching funds of $71 million (38:1 local match), and USGS funded 800 research projects averaging $54,000/project (NIWR 2000). In August 2007, the Water Institute Directors Panel (2007) at the Western States Water Council in Bozeman, MT discussed the western institutes such as Arizona, Idaho, and Montana which preceded the 1964 WRRA. They also pointed out that NIWR institutes collectively supported $120 million in water research between 1964 and 2007, the largest water education program in the Nation, that supported 1000 students, 1000 publications, and 280 conferences with 150,000 participants. John H. Marburger of the White House Office of Science and Technology Policy (OSTP) formed a Subcommittee on Water Availability/Quality co-chaired by Robert Hirsch (US Geological Survey) and Rochelle Araujo (Environmental Protection Agency Office of Research and Development) and requested Federal agencies "develop a coordinated, multi-year plan to improve research to . . . control water availability and quality and . . . to ensure an adequate water supply for the Nation's future."

Table 1. Board of Directors of the National Institutes for Water Resources.

Position	2015	2019	2024
President	Sharon Megdal, Arizona	Alexander "Sam" Fernald, New Mexico	Gerald McAdams Kauffman, Delaware
President-elect	Rick Cruse, Iowa	Daniel Devlin, Kansas	Yu-Feng Forrest Lin, Illinois
Past President	Brian E. Haggard, Arkansas	Stephen Schoenholtz, Virginia	Jeffrey Peterson, Minnesota
Executive Treasurer/Secretary	John C. Tracy, Idaho	Todd Jarvis, Oregon	India Allen, Van Scoyoc Assoc.
At-Large Representative	Doug Parker, California	Susan White, North Carolina	Linda Weavers, Ohio
New England Region	John Peckenham, Maine	Leon Thiem, Rhode Island	Michael Dietz, Connecticut
Mid-Atlantic Region	Steve Schoenholtz, Virginia	Kaye Brubaker, Maryland	Brian Rahm, New York
Southeast Region	Kirk Hatfield, Florida	Kirk Hatfield, Florida	John Schwartz, Kentucky
Great Lakes Region	John Lenhart, Ohio	John Lenhart, Ohio	Keith Cherkauer, Purdue
Great Plains Region	Daniel Devlin, Kansas	Daniel Devlin, Kansas	Stephanie Ewing, Montana
Pacific Northwest Region	Todd Jarvis, Oregon	William E. Schnabel, Alaska	Nicole Misarti, Alaska
Powell Consortium	Alexander "Sam" Fernald, New Mexico	Alexander "Sam" Fernald, New Mexico	Karen Schlatter, Colorado
Islands and Oceana Region	S. Khosrowpanah, Guam	Darren Lerner, Hawaii	Tao Yan, Hawaii
USGS			
USGS Office of Planning	Jerad Bales, Reston, VA	Robert Joseph, Austin, TX	Robert Joseph, Austin, TX
Director, WRRA Program	Kimberly Dove, Reston, VA	Earl Greene, Baltimore, MD	Christian Schmidt, State College, PA
Chief Office Acquisition/Grants	Sherri Bredesen, Reston, VA	Sherri Bredesen, Reston, VA	
Grant Specialist Grants	Kimberly Dove, Reston, VA	Kimberly Dove, Reston, VA	

(Marburger 2007).

On July 17, 2014, USGS celebrated the 50th anniversary of the WRRA, noting its federal agency partners, universities, state/local governments, and especially President Johnson who signed the WRRA. In 2014, Dr. Sharon Megdal, Director of the Arizona WRRC (2014) and president-elect of NIWR stated: "The water research partnerships fostered by the WRRA are unparalleled . . . fifty years later, the Water Resources Research Institutes, in partnership with the USGS, continue to fulfill their roles assigned by Congress in 1964. They have produced path-breaking research, developed innovative information and technology transfer programs, and provided training to more than 25,000 students in their 50-year history." On June 9, 2015, the Senate passed S. 653 sponsored by Senators Cardin and Boozman reauthorizing the WRRA program at USGS.

USGS released a 10-year strategic plan (2020-2030) for the WRRA Program setting priorities for: (1) Water Scarcity/Availability, (2) Water Hazards/Climate Variability, (3) Water Quality, (4) Water Policy, Planning, Socioeconomics, (5) Ecosystem/Drainage Basin Functions, (6) Water Technology/Innovation, and (7) Workforce Development/Water Literacy (Donahue, Greene, and Lerner 2021). In November 2021, President Biden signed the Bipartisan Infrastructure Law passed by the House (228 Yea, 206 Nay) and Senate (69 Yea, 30 Nay) that reauthorized WRRA with a 1:1 federal/state match, five-year evaluation studies, and authorized appropriations of up to $12 million for the Section 104b (base grants) and $3 million for Section 104g (special topic grants) programs in FY22-25. In FY24, Congress provided $15.5 million in WRRA funding and USGS awarded grants totaling $14.4 million in year four of a five year authorization to 54 NIWR institutes with $8.3 million in Sec. 104b and $6.1 million in Sec. 104g grants matched by $13.7 million in state/local funds for 245 water research projects (NIWR 2024) and USGS awarded six Sec. 104g Aquatic Invasive Species, nine PFAS, and seven general research grants. In 2024, the House and Senate Appropriations Committees requested $16.5 and $15.5 million, respectively, for the FY25 WRRA budget.

Over 15 years, WRRA funding by Congress doubled from $6.5 million in FY10 to $15.5 million by FY24. White House budget requests in the USGS budget were zero from FY10-14, $3.5-$6.5 million from FY15-17, zero from FY18-21, and $11-$15 million from FY22-24. Congress passed WRRA appropriations in the Interior budget at $6.5 mil (FY10), $6.49 mil (FY11), $6.49 mil (FY12), $3.27 mil (FY13), $6.5 mil (FY14), $6.5 mil (FY15), $6.5 mil (FY16), $6.5 mil (FY17), $6.5 mil (FY18), $6.5 mil (FY19), $10 mil (FY20), $11 mil (FY21), $14 mil (FY22), $15.5 mil (FY23), and $15.5 mil (FY24).

The National Institutes for Water Resources are

Figure 2. Past Presidents of NIWR and UCOWR organizations at the 60th anniversary conference in St. Louis, MO, September 30, 2024.

Figure 3. On February 23-26, 2025, over 80 Directors, Delegates, and staff met at the annual National Institutes for Water Resources annual meeting in Washington, D.C.

governed by Bylaws through a Board of Directors from eight regions and an Executive Committee who serve three-year terms as President-elect, President, and Past President (Table 1). During 2013-2026, NIWR Presidents were 2013-14 Brian Haggard (Arkansas), 2014-15 Sharon Megdal (Arizona), 2015-16 Rick Cruse (Iowa), 2016-17 Stephen Schoenholtz (Virginia), 2017-18 Sam Fernald (New Mexico), 2018-20 Daniel Devlin (Kansas), 2020-21 Doug Parker (California), 2021-22 Kevin Wagner (Oklahoma), 2022-23 Nicole Misarti (Alaska), 2023-24 Jeffrey Peterson (Minnesota), 2024-25 Gerald McAdams Kauffman (Delaware), 2025-26 Yu-Feng Forrest Lin (Illinois), and President-elect 2026-27 Linda K. Weavers (Ohio). On September 30-October 2, 2024, we commemorated the 60th Anniversary of three water associations at the Joint AWRA/UCOWR/NIWR Conference in St. Louis, MO (Figure 2). On February 23-26, 2025, over 80 Directors, Delegates, and staff met at the annual National Institutes for Water Resources annual meetings in Washington, D.C. (Figure 3).

Concluding Remarks

The 54 National Institutes for Water Resources are Congressionally authorized by the Water Resources Research Act of 1964 and 1984, as amended (42 USC 10301 et seq.). We have been in existence for six decades, celebrating our 60-year anniversary in 2024. The WRRA law states: “Subject to the approval of the Secretary of the Interior . . . one water resources research and technology institute, center, or equivalent agency . . . may be established in each State (. . . includes the Commonwealth of Puerto Rico, District of Columbia, Virgin Islands, Guam, American Samoa, Commonwealth of the Mariana Islands and Federated States of Micronesia) at a college or university which was established in accordance with the Act approved July 2, 1862 (12 Stat. 503) [7 U.S.C. 301 et seq.] and the institute in such State shall . . . be established at the one such college or university designated by the Governor of the State . . .” The 54 Institutes, at land grant schools that stretch halfway across the world, exist to assist the public in addressing water problems as our core mission by law. It is in our nation’s educational institutions—elementary and high schools, vocational and trade schools, and community colleges and universities—where we have opportunities to gain scientific knowledge and obtain meaningful employment to provide for our families and contribute to the betterment of our nation. This was the vision of President Johnson and Congress in enacting the WRRA in 1964, and the ongoing goals of the organzations of NIWR and UCOWR. As we look back to the historic year of 1964 where civil rights and the principles of scientific water research became the law of the land, we look ahead cogently to the next 60 years of good and civil water science and policy in the United States.

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