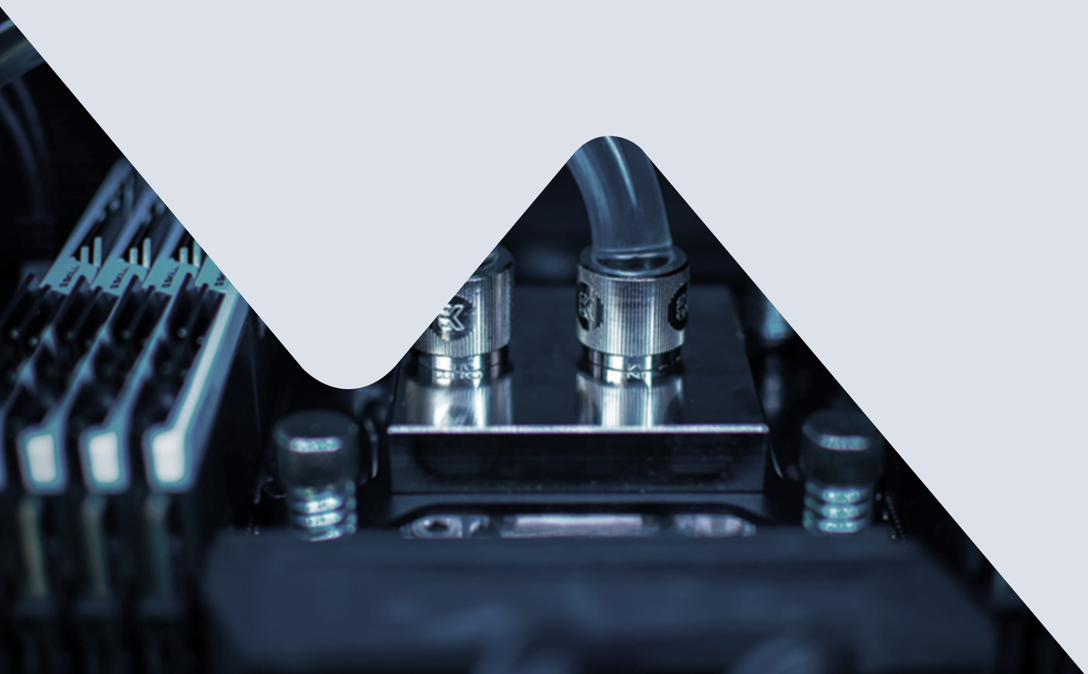
WATER∞AI NEXUS™

Principles For Sustainable Water Use By Data Centers: Building More Effective Public–Private Collaboration



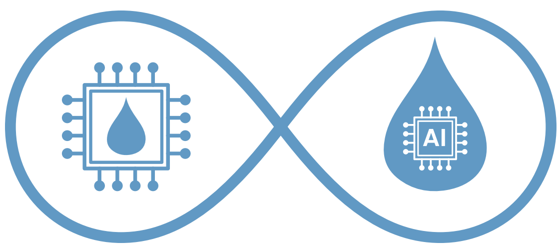
Contents

Water–AI Collaboration: A Call to Action

Advances in artificial intelligence (AI) are driving growth in data center and public infrastructure investments. Data centers, similar to utility systems, leverage economies of scale to deliver efficiency. While water utilities provide safe water to communities, data centers consolidate energy and water use to improve efficiency, reliability, and scalability for compute, storage, and AI workloads for our digital lives. The efficiency gains ensure that power and water infrastructure constraints are minimized as the industry meets the challenge of high growth. Supporting environmental and economic goals while also responding to policy needs and the public interest, the Water-AI Nexus™ Center of Excellence aims to guide both utilities and data center developers on responsible practices to minimize impacts on watersheds.

The Water-AI Nexus Center of Excellence is a global hub accelerating innovation at the confluence of water and AI, scaling solutions for water resilience while enabling a sustainable AI economy. Anchored by founding leaders—including the Water Environment Federation, Amazon, The Water Center at the University of Pennsylvania, and Leading Utilities of the World—the Water-AI Nexus Center of Excellence is designed to catalyze collaboration, research, and real-world applications at the intersection of water and AI.

Water for AI
Ensuring AI infrastructure uses water as efficiently as possible



AI for Water
Leveraging AI capabilities to solve pressing water scarcity and management challenges

Data centers comprise critical infrastructure for key sectors, including utilities, government, and finance. With advances in AI technology, data centers will increasingly leverage economies of scale and infrastructure to deliver the high compute power required to train large language models that underpin AI tools.

Data centers use water for cooling to increase power efficiency. This helps to reduce carbon emissions and provides relief for power distribution constraints while infrastructure providers work to upgrade electrical grids. With rising water scarcity and demands for sustainable solutions, efficient use of water and energy is essential for the data industry's growth. Data centers must strategically and carefully use water for cooling in a way that minimizes the impact on both water and energy resources.

The Water-AI Nexus Center of Excellence was established to encourage collaboration among data centers, water and wastewater utilities, municipalities, and businesses toward the goal of responsible development to meet AI demands. The Center of Excellence can provide insights into how and when data centers utilize and source water, and founding partners have outlined four principles for responsible water use: improve design and siting practices, reduce water consumption, effectively reuse and use sustainable sources, and engage with local communities. Adopting these principles promotes balance between the needs of the data industry and the public interest.

PRINCIPLE 1:

Improve Design and Siting Practices

The landscape of data processing has evolved from on-premises server rooms to large purpose-built facilities, requiring a deeper look at planning and development. The shift from on-premise information technology (IT) capacity into the cloud is driven by lower costs, improved water and power efficiency, increased security, and the potential for on-demand scalability of services. Modern data center providers must balance factors that include land availability and cost, power infrastructure and renewable energy access, network access and connectivity, customer proximity (latency), cooling-water availability and water stress, climate conditions, and risk of natural disasters.

The impact of water use differs based on location, and the choice of data center cooling technology should reflect the relative scarcity of water resources in a given location. In regions with high or extremely high water stress, air cooling without the use of water may be preferable despite the resultant higher energy use. Many data center providers have opted for air-cooled designs in highly water-stressed locations, such as parts of India, South Africa, Mexico, and Arizona in the United States. Where there are no solutions like sustainable sources or replenishment projects that conserve or increase available freshwater, a design that doesn't evaporate water for cooling is preferable. Where power is constrained and local water resources are not stressed, water-efficient evaporative cooling designs help reduce both power demand and water consumed in the power generation process.

PRINCIPLE 2:

Reduce Water Consumption

Understanding water use as a function of cooling IT capacity is the first step in achieving water reductions. The data center industry uses Water Usage Effectiveness (WUE) to measure liters of water used per kilowatt-hour of IT energy. But many data center operators have not calculated or reported their WUE. Cooling system approaches encompass a wide variety of designs, such as direct/indirect evaporative cooling (DEC/IEC), air-cooled chillers (ACC), free cooling (using outside air), and emerging liquid-cooling technologies. DEC systems are highly efficient, using evaporative cooling only for 1% to 15% of total annual operating hours, with the remainder served by free-air cooling. ACC systems that eliminate on-site water use for cooling can consume anywhere from 10% to 65% more energy depending on location,[1,2] placing greater strain on power grids. Hybrid approaches aim to balance water and energy efficiency.

Data center operators use advanced modeling to optimize designs. For example, hyperscale facilities often contain thousands of sensors that monitor temperature, airflow, and water quality, and can determine water needs and volumes at minute-level precision. AI tools and other cloud services are capable of gathering multiple data sets and instantly informing data center operations teams of inefficiencies, ensuring a more proactive approach to managing water use. Liquid cooling is becoming the standard for high-density AI workloads, and new chips that produce more workloads per kilowatt-hour (kWh) can withstand higher temperatures to lower evaporative water use requirements. Industry collaboration up and down the supply chain is key to developing standards and best practices for water use that can be shared across the data processing industry.

The Lawrence Berkeley National Laboratory notes that the U.S. average for WUE in 2023 was 0.36 L/kWh, based on modeled data from the data center industry.[3] This means that for the average 50 MW data center, the typical annual water use is an estimated 157 million liters (~41 million gallons). WUE varies by cooling design and by location, with warmer climates requiring more water to maintain lower air temperatures in the data centers. For instance, a standard direct evaporative design in Sweden might generate a WUE of 0.02, while the same design in Eastern Oregon may see a WUE of 0.16.[4] While some regions will invariably require more water use per kWh of IT load because of climate, design decisions can significantly impact water use. For instance, an indirect evaporative design using cooling towers can use 8 to 10 times the annual volume of water compared to a direct evaporative design in the same location. It is imperative to continuously improve efficiency for both existing and future facilities. Setting goals to reduce withdrawals will drive innovation and commitment to efficiency. After launching programmatic efforts to reduce, reuse, and replenish water in communities where data operations exist, Amazon Web Services (AWS) reduced its global WUE from 0.25 to 0.15, a 40% improvement over four years.[5] Other data center providers have seen equally impactful efficiency gains over the same time span. These efficiency improvements ensure that the growing industry's water needs will be reduced over time.

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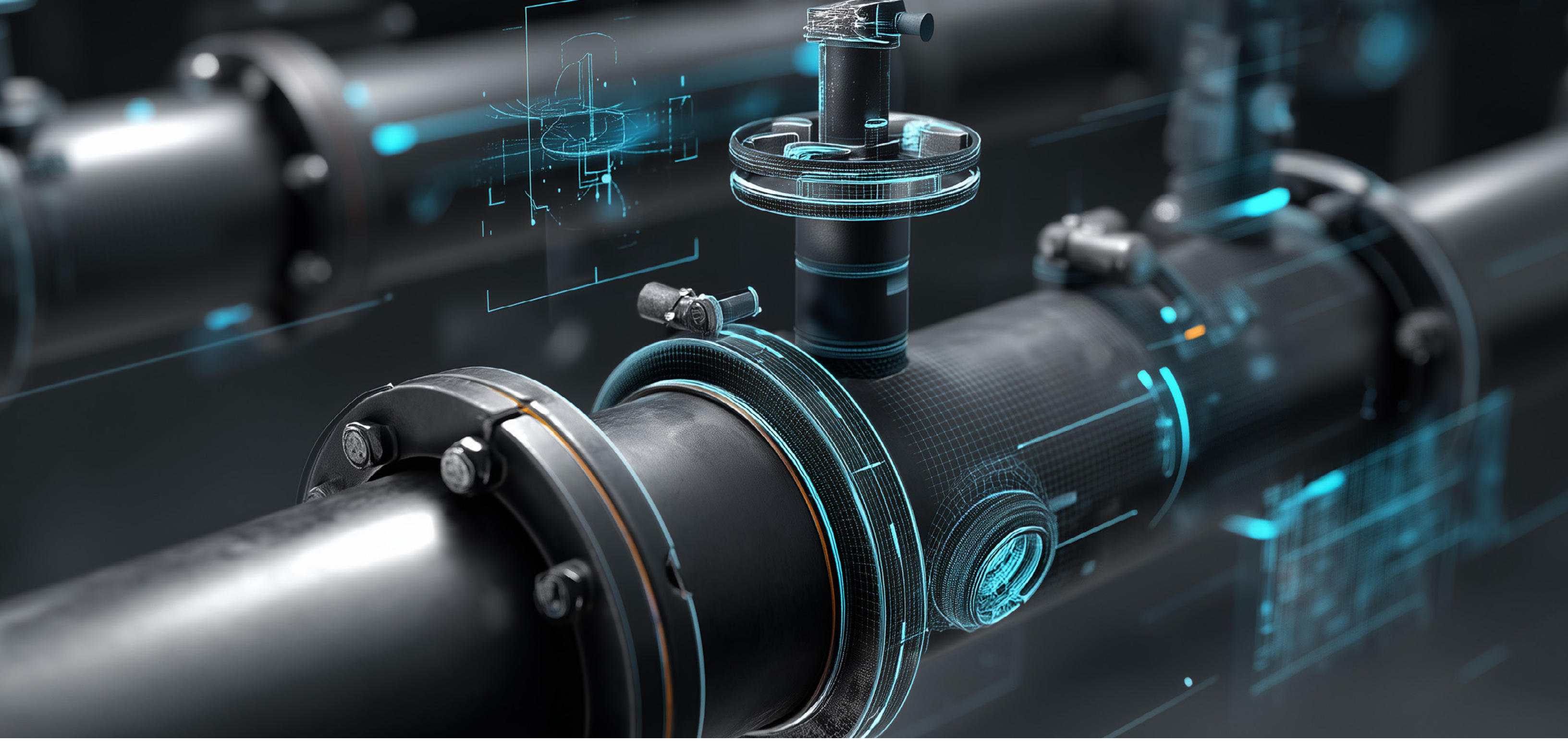


PRINCIPLE 3:

Reuse and Sustainably Source Water

Data centers reuse cooling water both on-site and off-site by:

- Maximizing cycles of concentration (CoC) in evaporative systems
- Using closed-loop liquid cooling for AI chips
- Treating water for reuse both on-site and in centralized utility-scale facilities

The industry is increasingly developing and using municipal recycled water for cooling. This eases constraints around potable supplies and ensures potable water is prioritized for community purposes. AWS announced in 2025 that it is expanding its use of recycled water from 24 locations in 2024 to more than 120 locations by 2030 in the United States, driven by partnerships with utilities to develop the infrastructure needed to meet cooling-water demands. Using recycled water requires careful water-quality management. But it helps improve water resiliency.

On-site reuse has many forms, with the most common being an evaporative process producing condensation that is reused several times before it is discarded. Data centers monitor and optimize the number of times CoC water can be reused to maximize efficiency. Targeting between three and five CoC for DEC sites and six to ten CoC for IEC sites that use cooling towers maximizes reuse potential and lowers overall water volume required to support cooling. To achieve these targets, water treatment should remove contaminants that can lead to scaling or corrosion of the mechanical cooling systems and inefficiencies in operation. Dissolved metals or constituents naturally occurring in water will determine the appropriate treatment.

Water reuse is also seen with liquid-cooling designs. Liquid cooling is more complex to deliver to servers than simply pushing cool air. But because liquid is more than 900 times denser than air, it can absorb much more heat. Advanced AI chips require a constant flow of liquid that is comprised of water and chemicals like glycol to be reused in a closed-loop system. As with air-cooled systems, data centers should use just enough liquid to keep servers from overheating and do so with the least amount of additional energy. Some data centers use an evaporative process to indirectly cool the liquid used for heat exchange as it is recirculated to cool AI chips. The underlying direct evaporative cooling process for air handlers still consumes water, resulting in indirect water usage for liquid-cooled workloads. This approach allows for higher operational temperatures, balancing high efficiencies for both water and power use to keep AI services running.

Another sustainable source comes in the form of on-site rainwater harvesting. Although not always a reliable cooling resource, in some locations rainwater can supplement cooling needs while reducing storm water runoff. It also lowers the power requirements of delivering water to data center campuses. Rooftop collection has low mineral content that improves system efficiency, while runoff from roads will require treatment of dissolved heavy metals. This approach creates localized storage and a reduction in community supply needs.

Once data centers are finished using water for cooling, the discarded cooling water often remains suitable for irrigation or other purposes. For example, Meta has invested in water infrastructure that allows spent cooling water to be used as irrigation for non-edible crops in Idaho.[6] Reusing water discarded from the cooling process can avoid costly and energy-intensive wastewater treatment and distribution infrastructure.

PRINCIPLE 4:

Engage with Communities

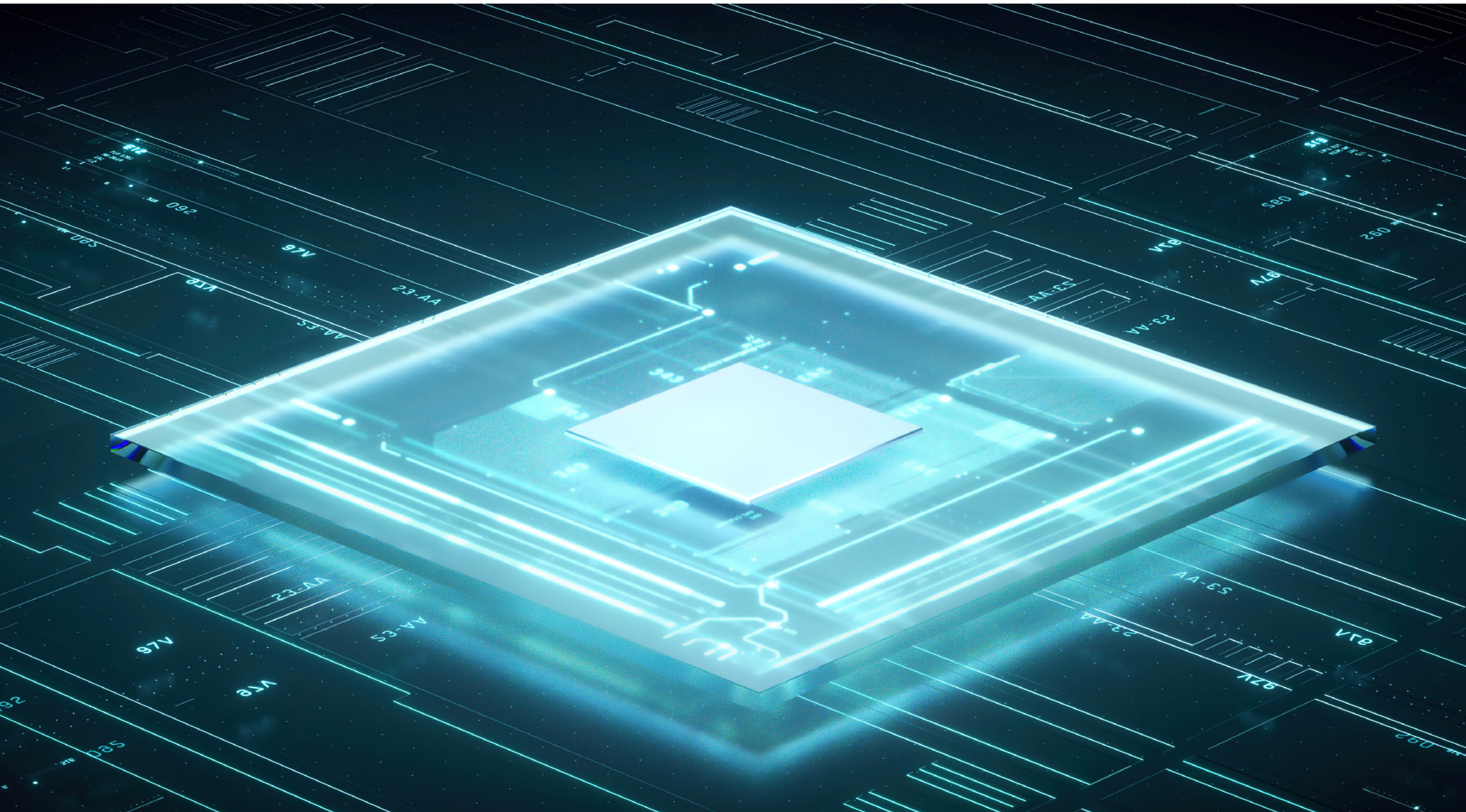
Data center developers and operators must recognize both the near-term and long-term impacts of their development and water use over the lifetimes of their facilitities. A best practice for sustainable development is to identify areas of water stress through community engagement with local water and wastewater utility owners and operators, as well as with other critical infrastructure stakeholders, government agencies, and community groups. Water and wastewater utilities and data center leadership can work together to share best practices to benefit from shared knowledge.

After evaluating use of sustainable sources and advancing water efficiency efforts in data centers, water replenishment serves as a pathway to deliver water back to communities and ecosystems, and represents the final critical component of a comprehensive data center water stewardship strategy. Broadly, replenishment can include watershed restoration; water, sanitation, and hygiene (WASH) investments; irrigation optimization; and utility-scale water efficiency measures, including system leakage reduction and pressure management. Achieving water replenishment requires careful project selection, use of established quantitative methods, and project monitoring.

Project selection should be guided by clear criteria that address specific watershed challenges identified through risk analysis and community engagement. Projects must advance sustainable practices, meet additionality criteria [i.e., project(s) would not occur without support of the data center provider], and should be hydrologically connected to their operations. Replenishment projects should be tailored to watershed priorities. Common project types that can address water quality and ecological benefit include wetland restoration, groundwater recharge, forest management, and storm water treatment. Projects that address water quantity include agricultural irrigation efficiency, utility leak detection and/or pressure management, and storm water diversion for groundwater recharge.

Quantitative methods for calculating benefits include resources, such as the Volumetric Water Benefit Accounting (VWBA) guide, one of the industry standard methodologies for measuring and reporting water stewardship outcomes. This guide supports quantifying project benefits from a range of activities and project objectives (e.g., improved water quality, reduced water demand, and improved resilience through flood/drought mitigation). Volumetric claims of watershed improvements should be validated by credible third-party auditors.

Project monitoring ensures projects are functioning as intended, and provides data to improve future initiatives. Project results can be measured through three main approaches: direct measurement using flow meters or similar devices, modeled estimates updated with actual inputs such as precipitation data, or conservative modeled estimates for projects where direct measurement is unfeasible. For nature-based solutions where direct measurement is impossible, operators should update volumetric benefit calculations annually using actual precipitation data or environmental condition data. Incorporating new technologies and deploying sensors for data collection can help ensure projects are measuring benefits for 10 years or longer. But shorter-term pilot projects may be valuable for testing more-novel solutions.



The Water-AI Nexus™ Center of Excellence

The Water-AI Nexus Center for Excellence defines the four principles for water use by data centers in order to responsibly reduce water use while promoting collaboration among the data industry, water and wastewater utilities, and impacted communities so that the challenges of AI demands can be met in a sustainable manner. The Center for Excellence supports achieving these four principles in the following ways:

1. **Improve design and siting practices** by providing data centers with the tools, resources, and standards for developing a comprehensive plan for responsible use of water for cooling.
2. **Reduce water consumption** by highlighting examples of tools to help data center facility managers achieve higher efficiency. And show them how setting withdrawal reduction targets and public goals can help align internal stakeholders to produce tangible water savings that can benefit local communities.
3. **Reuse and sustainably source water** by sharing insights and best practices for treatment selection, and presenting emerging water purification technologies to achieve higher efficiency, control biofouling, and ensure that alternative sources can be safely applied to mechanical cooling operations. The Center for Excellence will also provide information on how and where off-site reuse has been achieved.
4. **Engage with communities** by providing guidance aimed at successful implementation of water replenishment initiatives through project selection, application of quantitative methods, and ongoing project monitoring, with the end goal of ultimately lowering regional water stress.

The data center industry faces the challenge of balancing rapid growth with long-term sustainability. With a wide range of designs and frameworks for siting data centers, a standard of excellence is needed to promote responsible development. By focusing on the four principles of responsible water use, data center operators can support both technological advancement and environmental stewardship. Collaboration between data centers, water and wastewater utilities, and local communities is essential to develop innovative, flexible solutions that address local water resource constraints while enabling the continued digital transformation.

Due to rising regional water scarcity and demands for measurable sustainable solutions, efficient use of water and energy is essential, and focused solutions must include the adoption of the circular water economy framework. Circular economies are systems that keep materials in circulation for as long as optimally possible, which minimizes waste and maximizes efficiency. The circular water economy extends these principles to water systems, focusing on reducing waste, recovering nutrients and energy, and regenerating nature. Data centers can play a critical role in the future of the circular water economy by advancing sustainable water management practices.

The Water-AI Nexus Center of Excellence aims to address the challenges and opportunities that lie at the critical intersection of water resources and digital innovation. The Water-AI Nexus Center of Excellence provides a forum for sharing AI best practices and thoughtful leadership in the water sector, and fosters public-private collaboration to achieve sustainable development goals.

Acknowledgements

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Notes

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WATER ∞ AI NEXUS™

The Water-AI Nexus Center of Excellence is a first-of-its kind initiative to address water sustainability in AI development while harnessing AI to solve critical water challenges.

WEF, Amazon, The Water Center at the University of Pennsylvania, and Leading Utilities of the World collaborated as founding leaders to launch the Center of Excellence to develop sustainable water practices for AI infrastructure while also using AI to solve global water challenges.

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