Ceres

Drained by Data

The Cumulative Impact of Data Centers on Regional Water Stress

September 2025

About Ceres

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Executive Summary

The explosion of data centers across the U.S. is one of the economic hallmarks of the 2020s, as the growth of artificial intelligence, cloud computing, and other high technology has spurred the buildout of facilities to house the necessary digital infrastructure. And with data in demand, so too is the demand for water these centers need to operate.

While data centers' direct on-site water use is significant and has been subject to increasing attention, this analysis finds that data centers' indirect water use — primarily from power generation to meet their massive energy needs — has an even greater impact.

Because data centers tend to cluster near one another in geographic areas, the cumulative impacts of multiple facilities on local and regional water supplies are substantial but, until now, little understood. In many cases, data center clusters are forming in already water-stressed areas, where future growth will only exacerbate the issue.

These dynamics present financial, operational, reputational, legal, and regulatory risks for data center operators and high-tech businesses.

This analysis uses Phoenix, Ariz. — a water-stressed region, fast-growing metropolis, and booming data center hub — as an illustrative example to highlight the impacts of data center water use on regional water stress. It uncovers important insights, such as:

- In the coming years, annual water use associated with data center electricity consumption is expected to **increase by 400%**, from an estimated 2.9 billion gallons to over 14.5 billion gallons — enough to supply the entire city of Scottsdale, Ariz. (population 244,000) for over 2 years.
- Water use associated with data center cooling operations is expected to **increase by 870%** as more facilities come online, from 385 million gallons a year to more than 3.7 billion gallons – enough to supply a city the size of Flagstaff, Ariz. (population 77,000) for 1.75 years.
- Data center growth could increase water stress in already strained basins **by up to 17% annually** — with even higher spikes in peak seasons.

Alongside key takeaways and unique data, this analysis offers highly relevant recommendations for companies, investors, water managers, and policymakers alike. While grounded in the Phoenix region, its findings apply across the many jurisdictions dealing with water stress amid the global data center boom.

Background

AI Demand Surge

Data centers are physical facilities that contain Information Technology (IT) infrastructure such as servers, storage devices, and networking equipment that support vast volumes of data. They are critical in supporting a wide range of digital services, including artificial intelligence (AI) and cloud computing. Within the tech sector value chain, data centers occupy a central position, sitting downstream of mining of critical minerals, semiconductor manufacturing, and production of other components, and upstream of cloud platforms, digital services, and software provided by high-tech companies.

In recent years, data center development has surged due in large part to increased computing demands from data intensive applications. The rapid growth is projected to continue, especially as AI expands, and high-tech

companies are placing substantial investments into expanded and new facilities. U.S.-targeted investments in the next four years amount to approximately $450 billion in planned spending on data centers and related technology, making the U.S. one of the largest data center markets globally.

Direct and Indirect Water Use

Data centers require large volumes of water to operate, and water use is mostly characterized as either "direct" or "indirect."

Direct water use refers to the water consumed on-site. Cooling systems account for the majority of a data center's operational water withdrawals. Depending on size, a data center uses anywhere from 18,000 gallons (68,000 liters) to 550,000 gallons (2.1 million liters) — equivalent to the daily water use of approximately 60 to 1,833 U.S. households. Commensurate with the growth in data centers, water consumed in data center operations in the U.S. grew from just over 5.5 billion gallons (21 billion liters) in 2014 to almost 17.5 billion gallons (66 billion liters) in 2023.

Indirect water use refers to the volume of water consumed within the data center value chain, including in the generation of electricity to power the data centers. The water use embedded in purchased electricity depends on the mix of energy sources supplying the electricity grid. For example, renewable energy sources relying on wind and solar have a lower indirect water footprint compared to natural gas and nuclear power generation.[1] The total indirect water consumed through electricity use by data centers in the U.S. was estimated to be 211 billion gallons (800 billion liters) in 2023.

Additionally, substantial indirect water use occurs in upstream manufacturing processes, such as the fabrication of semiconductors and chips that form the core hardware infrastructure of data centers. An average chip manufacturing facility today can use 10 million gallons of ultrapure water per day — matching the water use of about 33,000 U.S. households.

Clustering of Data Centers

Data centers are often clustered geographically, with many companies building facilities in the same regions to reap the benefits of tax incentives, infrastructure access, and network connectivity. These clusters of data centers can collectively place significant strain on local water supplies, ecosystems, and power grids, especially if they are in regions already struggling with water availability. In fact, two-thirds of new U.S. data centers built or in development since 2022 are located in areas already experiencing high levels of water stress, and a recent study found that 32% of data centers in the U.S. are in areas of high or extremely high water stress. Five states (Arizona, California, Texas, Virginia, and Illinois) account for 72% of the new data centers in high-stress regions. Seasonal variation, particularly in arid or drought-prone regions, further exacerbates these pressures as increased cooling and power demands during the summer season elevate data centers' water consumption.

Emerging Risks

Data center water demands present their owners and operators with financial risk because of the potential for water scarcity to cause higher operational costs and disrupt operations. Companies can also face financial

1 It is possible that new nuclear power plant designs may be capable of operating with less water use.

risk from the potential of future regulations or permit restrictions as policymakers begin to tackle the impact of data centers on water. Litigation risk and reputational risk are also of concern, especially if local communities are adversely affected and revoke the company's social license to operate.

These risks are playing out in real time. For instance, a planned data center in Chesterton, Ind., was blocked after residents expressed concern with impacts to local water resources. In Newton County, Ga., future data center development is under additional scrutiny after residential water wells were plagued with sediment tied to the construction of a nearby data center.

Some companies have responded to these challenges with new approaches and technologies to decrease water use. However, some of these strategies involve tradeoffs that lower water use but increase energy demand, which can result in higher greenhouse gas emissions, greater demand on the electric grid, and negative impacts on local air quality. For instance, because they require more energy to run, air-cooling systems are generally less efficient at cooling data centers than water-cooling systems, resulting in higher energy use, more indirect water use, and increased electricity costs.

Data Center Water Risk Analysis: The Phoenix Example

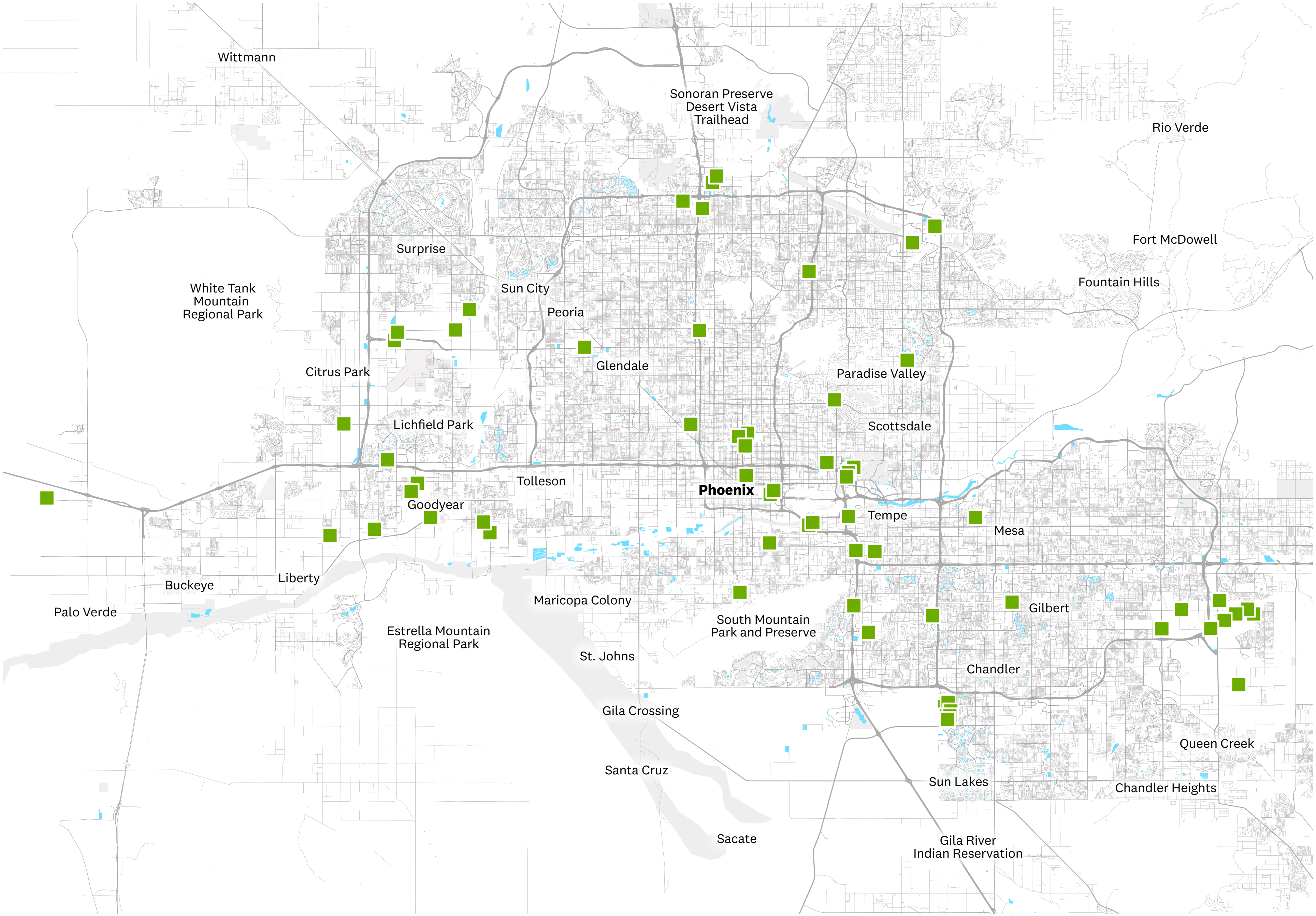
The cumulative impact of data centers on local water availability can be significant but may be overlooked without a holistic, place-based, sector-wide assessment. At the time this analysis was written, corporate water stewardship strategies adopted by data center owners and operators primarily focused on addressing water use at their direct operations and offsetting their own water use through replenishment strategies. However, this narrow focus neglects two important drivers of water risk: the indirect water use associated with electricity generation that powers the facilities and the cumulative water impacts of many data centers on local water supplies. This shortcoming exposes high-tech companies, data center owners and operators, energy providers, water utilities, and their investors to greater risks than are currently acknowledged.

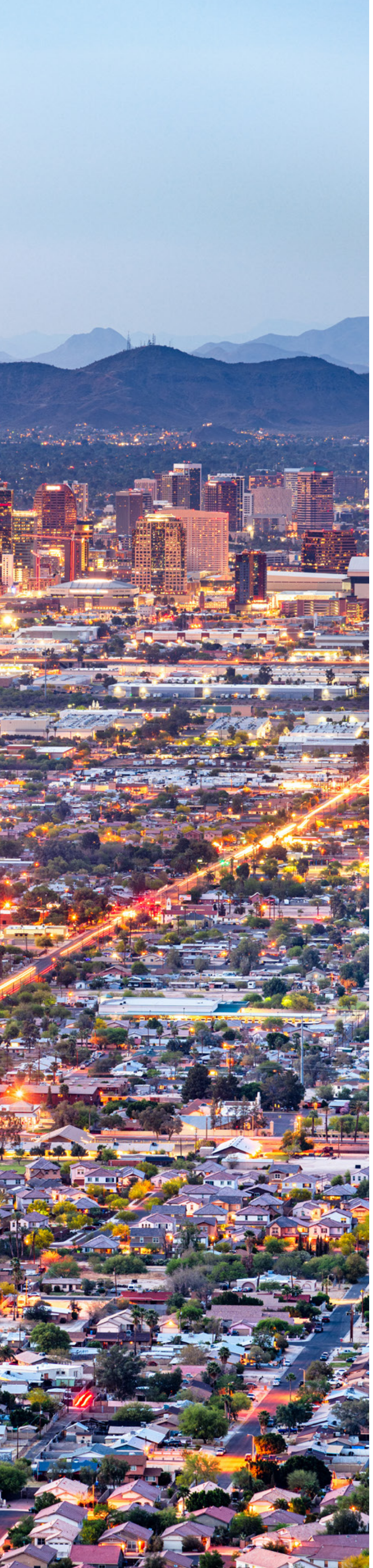
This analysis aims to shed light on the full suite of potential water risks associated with data centers, using the Phoenix, Ariz. region (Figure 1 - see map next page) as an illustrative example.

The Phoenix region was chosen for this analysis to illustrate the intersection of data center growth and regional water risk. The region is experiencing rapid growth in new and planned data centers, is one of the fastest-growing metropolitan areas in the U.S., and faces increasing water stress due to prolonged drought, climate conditions, over-allocation of limited water supplies from the Colorado River, and dwindling groundwater supplies. Further, the region provides enough data to allow for sufficient analysis.

However, the findings and recommendations of this analysis are applicable across many jurisdictions facing similar challenges.

Figure 1. Locations of current and planned data centers (green squares) in and around Phoenix, Ariz., as of May 2025





Data Analysis

Using publicly available data from Data Center Map, data center company websites, U.S. Energy Information Administration (EIA) forms 860 and 923, Arizona Public Service and Salt River Project websites, and company-specific disclosures, the analysis characterized 124 data centers[2] by operational status ("current" or "planned"), facility size, cooling technology, and operational metrics like Power Usage Efficiency (PUE) and Water Use Efficiency (WUE).[3] Missing data were imputed based on facility size, cooling type, and industry averages for PUE and WUE.

The analysis also mapped the data centers to their respective balancing authority — the Arizona Public Service or Salt River Project — to understand their power mix and power-generation water withdrawal intensities. Direct on-site cooling demands and indirect electricity-related water withdrawals were combined to develop an estimate for total water use by the data centers. These values were then compared against the water stress indicators from WRI's Aqueduct tool to evaluate current and potential future stress conditions from data center growth. For simplicity, the analysis assumes constant water use and demands from other sectors in the region to isolate the impact of the data center's growth. For additional details on the methodology, see the Appendix.

2 Accessed from Datacentermap.com by May 31, 2025.

3 Any data center classified as "commissioned" or "built out" in the Data Center Map data set or the site owner's website was categorized as "Operational" for the purposes of this analysis. Facilities in various stages of planning, such as announced or scheduled builds and those under construction, were grouped together under "Planned." Based on industry averages, data center development – spanning from planning to commission – typically takes 1.5 to 6 years depending on facility size and complexity.

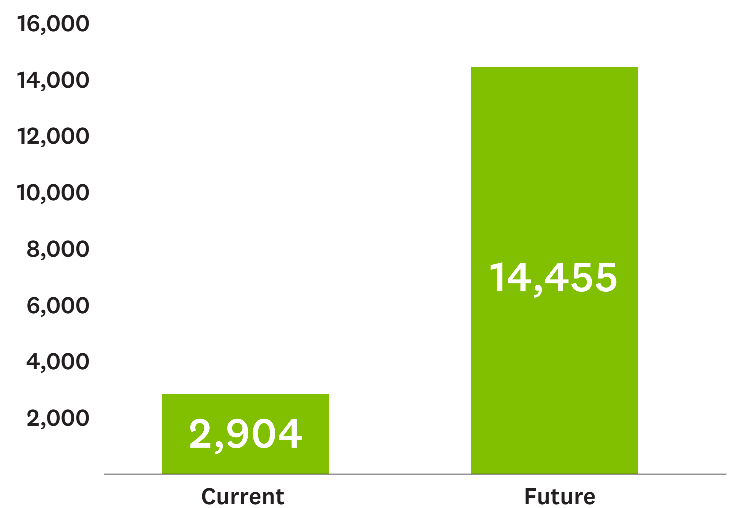
4 The boundary of the indirect water use covered in this analysis is electricity generation itself, and excludes the water used in extracting, processing and transporting coal and gas. Due to existing gas transmission pipeline infrastructure, much of the gas consumed in electricity generation originates in the Permian Basin (in Texas and New Mexico). Most coal burned in Arizona originates from Wyoming, New Mexico and Montana. These areas have their own water scarcity and quality issues.

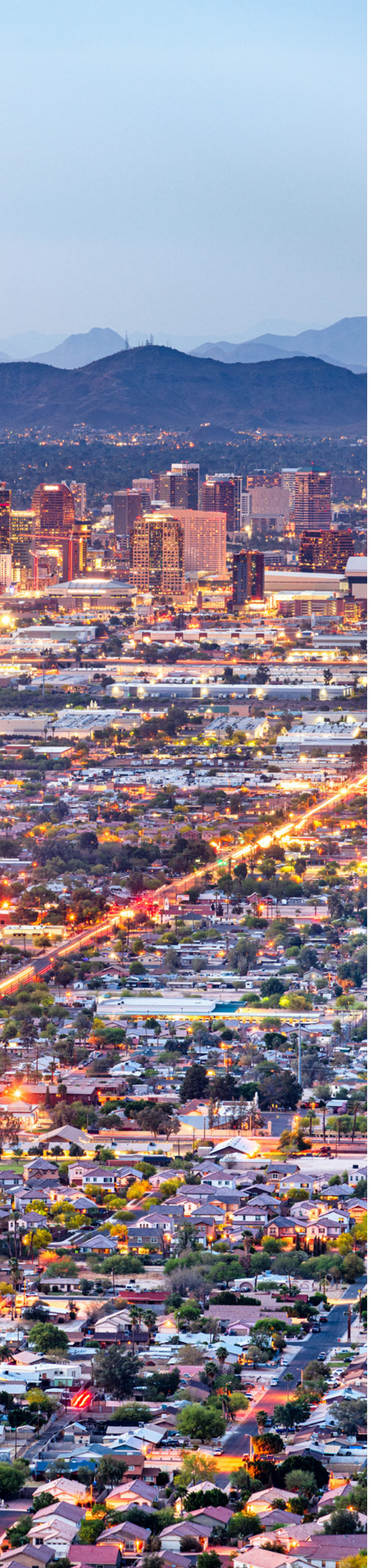
5 IT power load will increase significantly with planned data centers coming online. In the Phoenix region, IT power capacity is projected to grow by 324%, from 1,193 MW today to 5,057 MW as planned data centers are built.

Key Findings

- **Embedded water use in purchased electricity is the largest driver of data center water use.** Indirect water use attributed to embedded water in the electricity consumed by the data centers is the main driver of water withdrawals from data centers in the Phoenix region, with a large increase anticipated due to planned data center expansion.[4,5] If all planned data centers in the region come online over the next six years, which is the typical length of construction for larger and more complex facilities, indirect water use will increase by almost 400% from an estimated 2.9 billion gallons to nearly 14.5 billion gallons, as illustrated in Figure 2. To put this in perspective, 14.5 billion gallons is enough to supply the entire city of Scottsdale, Ariz., with a population of more than 244,000, for over 2 years.

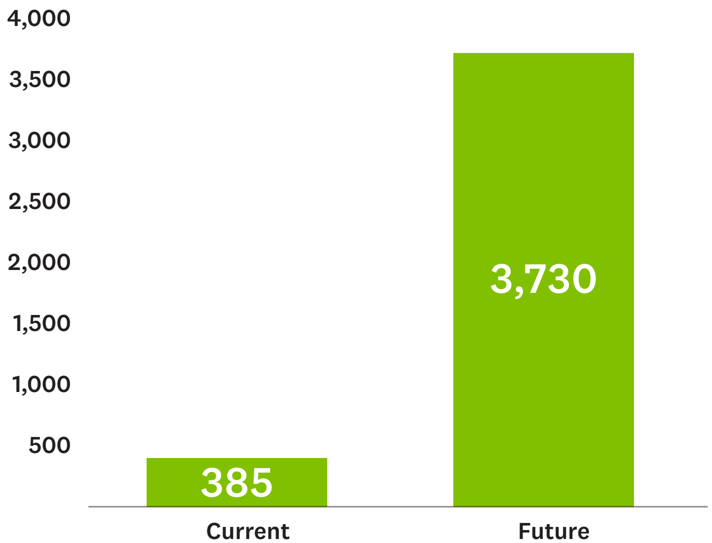
Figure 2. Current and future indirect data center water use in the Phoenix region, based on existing facilities and addition of planned facilities (million gallons)





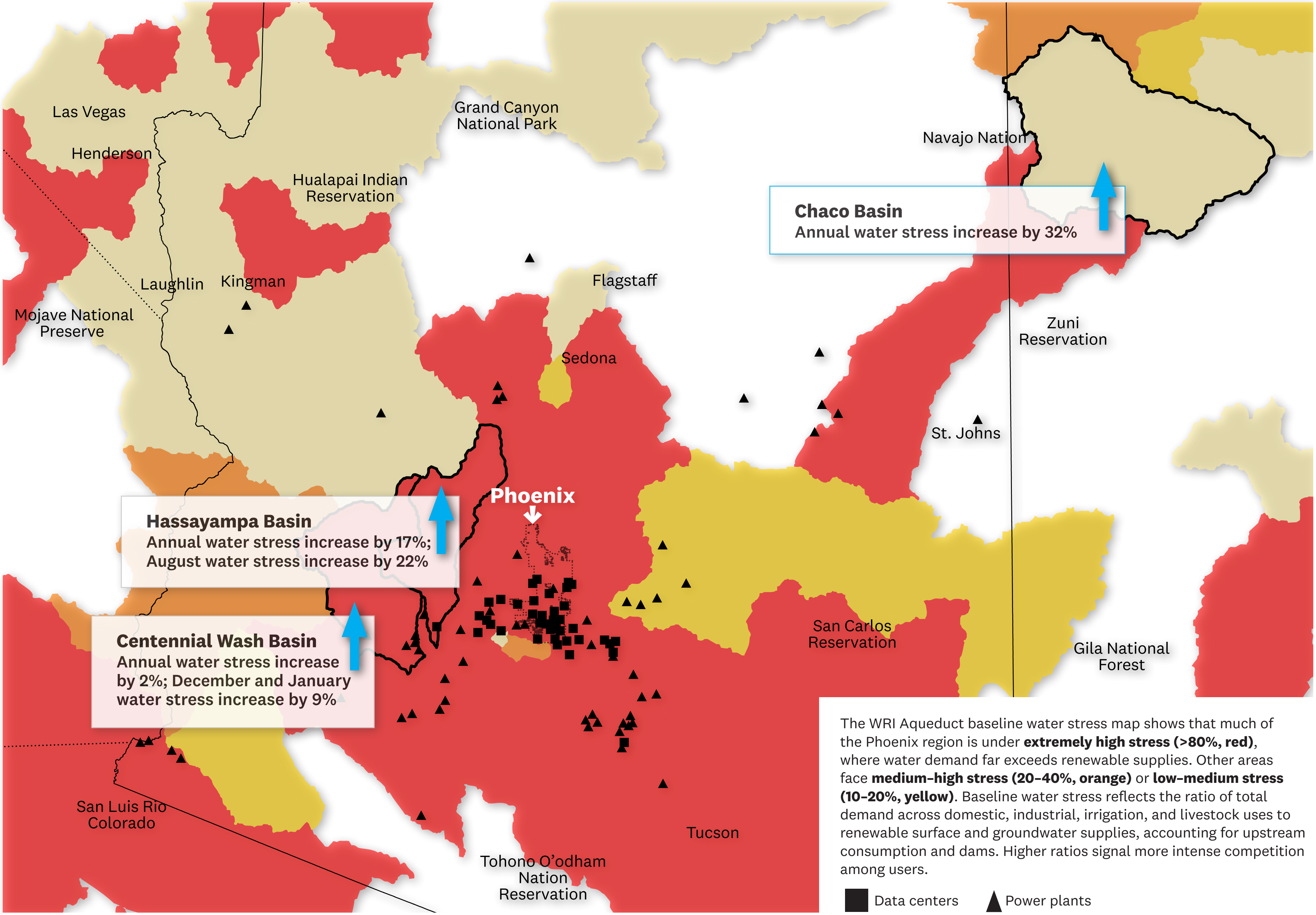
- **Direct water use attributed to data center cooling systems is significant.** Direct water use for cooling systems at data centers in the Phoenix region is estimated to be 385 million gallons a year. That number is expected to increase by 870% to more than 3.7 billion gallons as planned data centers come online (Figure 3). For comparison, that is enough water to supply a city the size of Flagstaff, Ariz., with a population of approximately 77,000 residents, for 1.75 years.

Figure 3. Current and future direct data center water use in the Phoenix region, based on existing facilities and addition of planned facilities (million gallons)

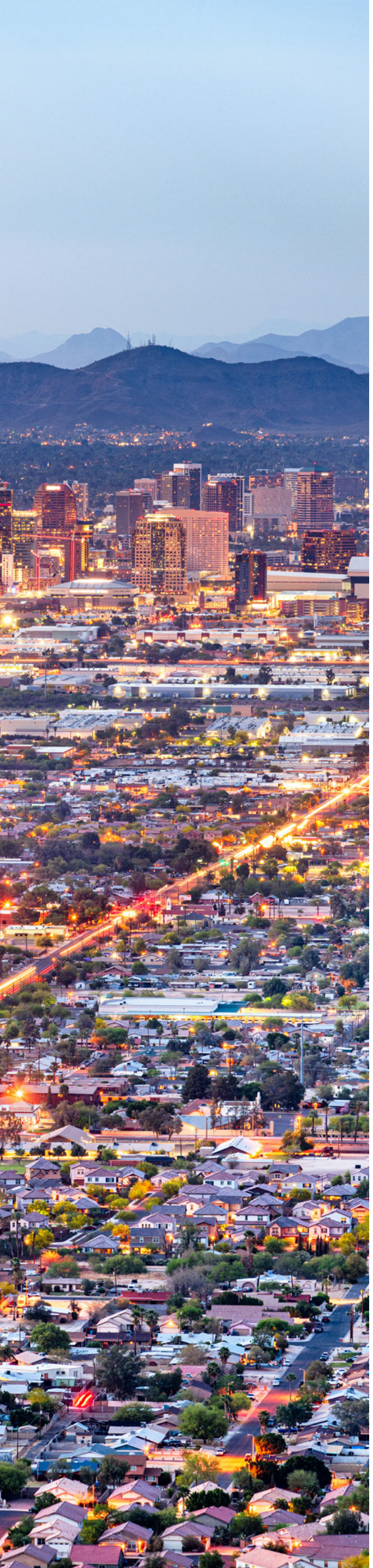


- **Data centers may contribute up to a 32% increase in annual water stress.** The cumulative impact on water availability from the proliferation of data centers in the Phoenix region will create additional water management challenges in an already severely water-stressed region. The Centennial Wash and Hassayampa water basins located west of the City of Phoenix will be particularly hard hit, with estimated increases in their annual water stress levels of 2% and 17% respectively if all planned data centers in the region come online. While the Chaco water basin north of Phoenix may see an increase in annual water stress of up to 32% due to increased data center cooling demand from the APS Four Corners coal-fired power plant located near Fruitland, N.M., the basin is not currently categorized as water-stressed (Figure 4 - see map next page).

Figure 4. Growing water stress in the Phoenix region

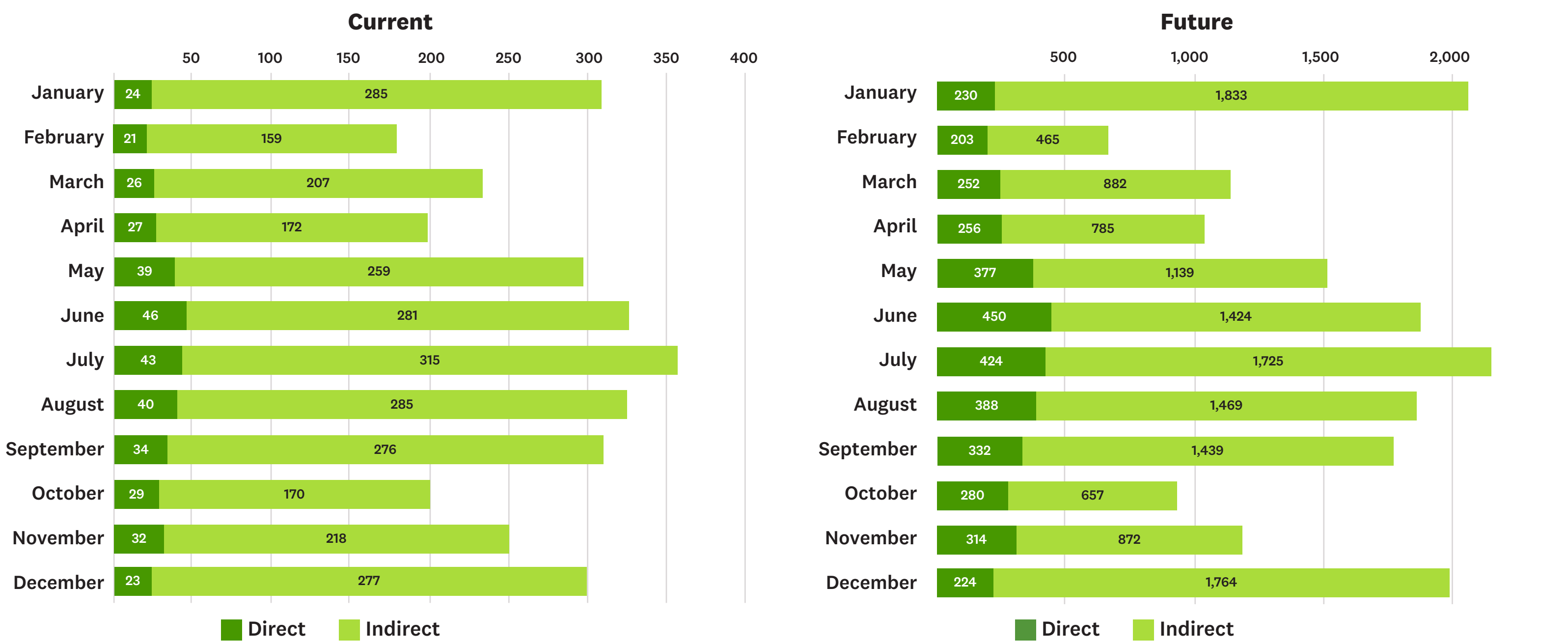


The WRI Aqueduct baseline water stress map shows that much of the Phoenix region is under **extremely high stress (>80%, red)**, where water demand far exceeds renewable supplies. Other areas face **medium-high stress (20–40%, orange)** or **low-medium stress (10–20%, yellow)**. Baseline water stress reflects the ratio of total demand across domestic, industrial, irrigation, and livestock uses to renewable surface and groundwater supplies, accounting for upstream consumption and dams. Higher ratios signal more intense competition among users.

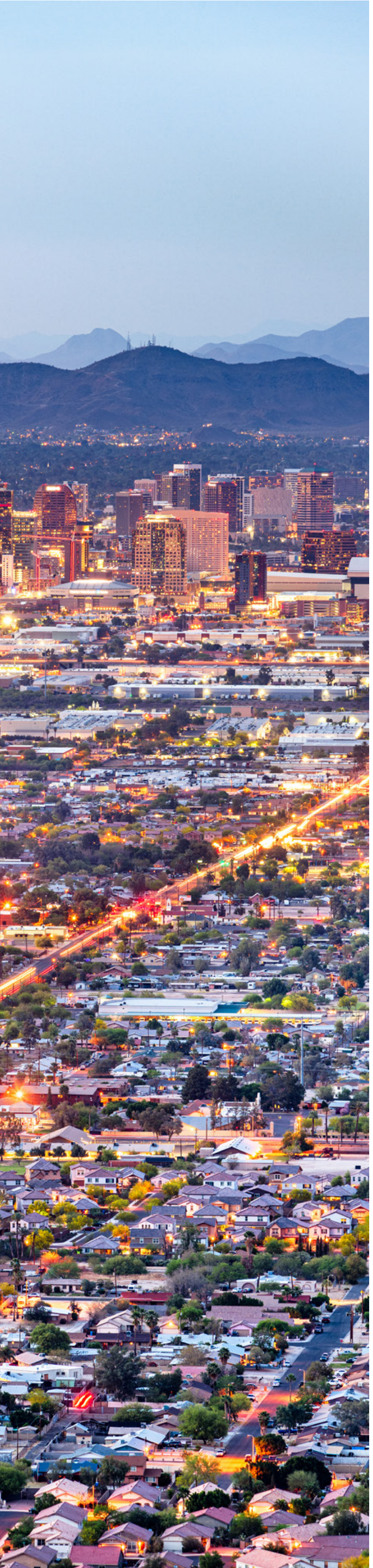


- **Data centers will drive increased water stress during the summer, up 22% from the baseline.** The summer period, already the most water-stressed period in the region, will result in even higher water stress levels due to increased power demands and cooling requirements at data centers. For example, the Hassayampa water basin will see a 22% increase from the baseline in its water stress level during the month of August compared to the annual average increase of 17%. While summer remains the most critical period in terms of water stress, elevated stress is also estimated in the months of December and January. This is likely because more water-intensive power plants in the region have a higher share of power generation of the grid during these months, according to EIA's 2023 monthly power generation records (Figure 5).[6]

Figure 5. Seasonal variability of total data center water use for Phoenix region (2023; unit: million gallons)



6 Results use EIA cooling-water data downloaded from their site. Of note, EIA data for February 2023 shows a sharp drop in water withdrawal at Four Corners (Units 4 and 5) from January 2023, while its generation increased.

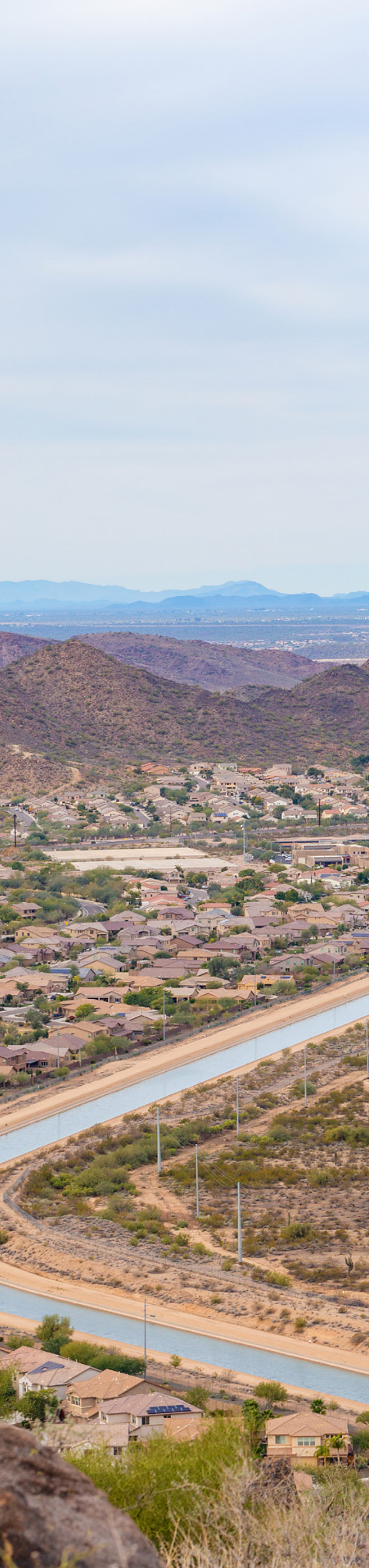


- **Other regions will see a 10x increase in water use due to Phoenix region data centers.** Impacts from the proliferation of data centers in the Phoenix region extend beyond it, touching multiple geographies and jurisdictions. Although the data centers are concentrated in the Phoenix region, the power plants supplying their electricity demand have a broader geographical footprint. For example, the County of San Juan in New Mexico will see an approximately 10-fold increase in water use related to data center development in the Phoenix region, due to rising electricity demand from the Arizona Public Service.

- **The cumulative water impacts from data centers can conflict with ongoing planning efforts.** In the Phoenix region, annual total data center water use is in potential conflict with the goals of the City of Phoenix's water resource plan. Water use reduction has been one of the key objectives in the City of Phoenix water resource plan. While the city's water demand has been slowly but steadily decreasing since the early 2000s — from roughly 114 billion gallons (350,000 acre-feet) in 2002 to close to 98 billion gallons (300,000 acre-feet) in 2019 — this trend will very likely be reversed due to the boom in regional data centers. Yet data centers are not discussed in the city's 2021 water resource plan.

- **The annual total water withdrawal from data centers is substantial.** To put this volume in perspective, current water demand from regional data centers is almost 3.3 billion gallons per year. For comparison, that is equivalent to about 3.4% of the City of Phoenix's annual water use based on 2019 estimates (98 billion gallons). As planned data centers are brought online, demand is expected to increase to a little over 18.1 billion gallons, or equivalent to 18% of the City's annual water budget.[7]

7 The comparison to the City of Phoenix's water use is for illustrative purposes only, as the water used to supply these data center needs would come from multiple sources.



Recommendations

For Data Center Operators

Enhance Disclosures

Corporate disclosures should be enhanced to better articulate water risks associated with data centers, provide relevant context about water stress conditions for the watershed in which operations take place, and explain how these risks inform actions and feed into broader water goals such as net-positive water and replenishment targets.

Specifically, in line with the recommendations put forward by the investor Corporate Expectations for Valuing Water, companies should assess and disclose the full suite of water risks associated with data centers in their value chain. This includes emerging considerations for data centers that some companies are already moving to provide, such as distinguishing between on-site and indirect water use and explaining how shifting to renewable energy and different cooling strategies can help reduce water use. Disclosures should include water withdrawal and consumption data for both direct operations and supply chains, along with information around local contextual challenges and details on how the company engages with local policymakers, municipalities, and stakeholders to address basin-level water issues. In addition, companies should disclose WUE and PUE data. This information will ensure companies and their investors have a complete picture of the potential financial value at risk and can adapt or mitigate risk accordingly.

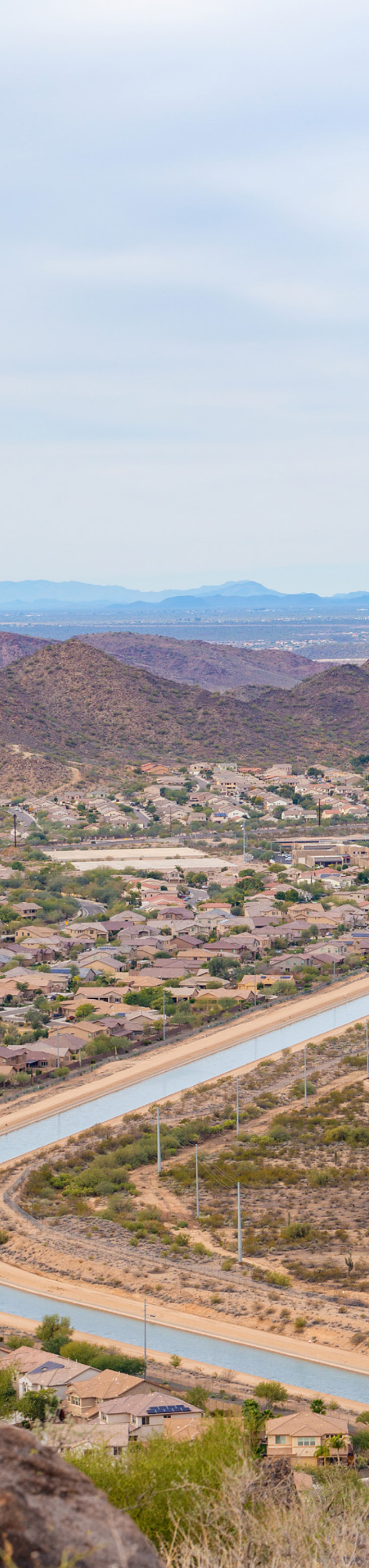
Adopt Water Management Best Practices

Companies should continue to evaluate water and energy efficiency gains that can be achieved through smarter site selection, infrastructure design, workload placement, and hardware choices. To do so, they must continue to expand collaboration across internal silos to evaluate cost-benefits and tradeoffs and to identify optimized solutions that reduce value at risk — both today and in the future.

Importantly, companies must expand collaboration with peers in a precompetitive space to mitigate sector-wide risks. Collaboration can support shared learning, industry-specific data collection, standard setting, and best practice sharing. This will help companies collectively address shared water risks, improve transparency, and align around solutions. The collaboration should also extend beyond industry peers to include regional water managers and energy providers to identify integrated solutions.

Examples of current best practice include:

- **Optimizing data center design to reduce environmental impacts**, such as by improving water efficiency measures and utilizing reclaimed water and other alternative water sources.
- **Implementing advanced cooling technologies**, such as water-free cooling, chip-level cooling, and liquid immersion cooling.
- **Contributing towards improved watershed health and resilience** to help restore and conserve water in high-stress basins.
- **Leveraging AI to maximize water efficiency**, such as by optimizing cooling systems, predicting demands, and detecting leaks.
- **Sourcing renewable energy** to reduce indirect water use by decreasing reliance on grid electricity.
- **Partnering** with other companies, utility providers, and local governments to innovate and address shared challenges in a basin.



For Investors

Assess and Evaluate Water Risk and Mitigation Efforts

Investors should engage with high-tech and data center companies to understand whether the companies are appropriately mitigating water risks, including those resulting from water use and the cumulative impacts of data centers on water availability in regions where they operate or plan to operate.

Investors should support companies in efforts to disclose the full suite of water risks related to data centers. Improved disclosures should provide insights into the measures being taken to mitigate the risks and how risks are factored into business planning decisions.

The Ceres Valuing Water Initiative offers a platform and tools to support investors as they engage with high-tech and data center companies on water risk issues.

Investors should also explore new ways to assess companies' water-related disclosures and mitigation strategies as part of their investment processes, sustainability integration frameworks, and engagement priorities. Notable thought leadership has already been developed in this area. For instance, investors have developed toolkits for how to address AI's growing water demand and thought leadership on how to evaluate related investment risks and opportunities.

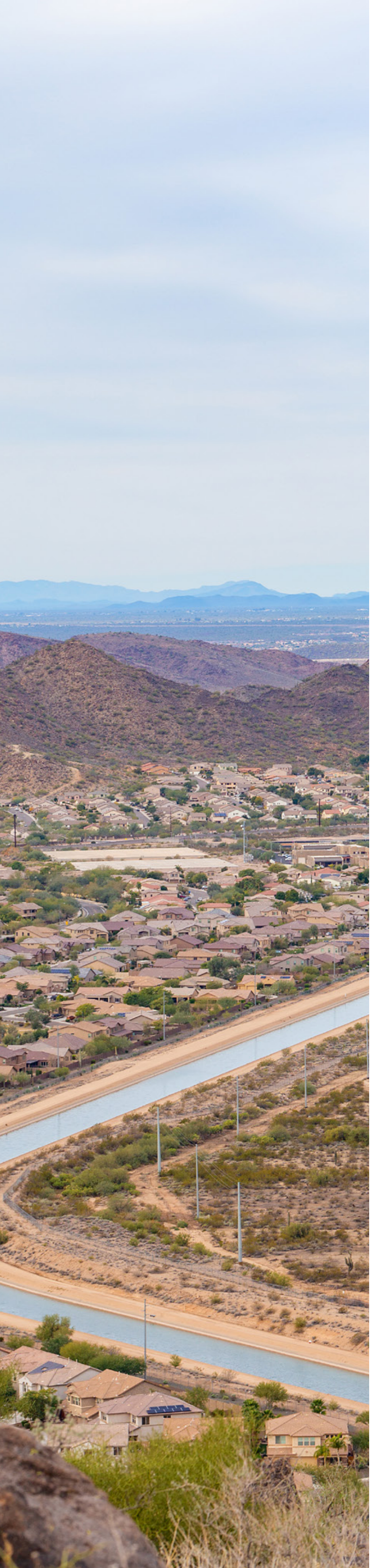
For Water Managers and Energy Providers

Understand Regional Water Risks and Pinpoint Solutions

Water managers from across jurisdictions should continue to collaborate to understand the potential cumulative data center impacts on shared water resources, alongside other industrial demands and challenges in a given basin. Equipped with a shared understanding of these overlapping pressures, water managers can continue to expand right-sized solutions from their respective toolboxes — including full cost recovery water pricing models, incentives for alternative water sources such as recycled water, innovative permitting reforms, and regulations.

Crucially, these efforts should be coordinated across stakeholders to ensure collaborative basin solutions. In Arizona specifically, this would include statewide water managers such as the Arizona Department of Water Resources and local water managers such as the City of Phoenix water services department. Neighboring municipalities also have their own water utilities, whose coordination will be essential given that this analysis of Phoenix shows that jurisdictions across water basins and in other states are impacted as data centers come online.

Energy providers (such as the Arizona Public Service or Salt River Project for the Phoenix region) should be included as well. Transitioning to a higher share of renewable energy will significantly reduce water use associated with power generation and thus impacts to water resources. Together, water and energy managers can play a critical role in ensuring data transparency and supporting infrastructure planning efforts that consider cumulative water risk, enabling systemic solutions that extend beyond individual company actions.



For Policymakers

Consider Cumulative Impacts

Policymakers play a vital role in prioritizing the consideration of near-term and long-term resource challenges and the potential impacts of data center planning and regulation. This analysis highlights the need for policy leadership in managing the cumulative water and energy impacts of data center development.

Public policy should support a wide spectrum of relevant practices, from helping to drive the uptake of water-efficient practices to improving corporate disclosures around data centers' water use. There are many policy-related efforts underway related to the management of the Colorado River Basin, for instance, where data center cumulative impacts should be considered. Additionally, policymakers should consider environmental justice and community impacts of siting decisions, particularly if it disproportionately affects water access for vulnerable populations.

Conclusion

This analysis shows that the concentration of data centers in high water-stressed regions could put financial value at risk for companies and their investors if not fully assessed and addressed, as water use and cumulative impacts can significantly impact water availability. The potential risk compounds as the cumulative water impacts from data centers can conflict with ongoing planning efforts to ensure sustainable water supplies, as observed in the City of Phoenix's water resources plan not directly contemplating data center water use. While the Phoenix region vividly illustrates these challenges, they will be felt across geographies as data centers and the industries that demand them continue to grow globally.

Even if companies implement measures to mitigate risk in data center operations, significant risk remains, including risks to companies' reputations as well as regulatory and litigation risks. Without further action, communities will continue to accuse the sector of broadly impacting regional water resources without distinguishing between perceived good actors and bad actors.

While outside the scope of this analysis, other industries can be considered similarly. In other words, the cumulative impacts to water resources from the concentration of all water users must become more prominent in water stewardship discussions. For example, the Phoenix region has seen significant growth in semiconductor manufacturing that requires large amounts of ultrapure water.

The methodology developed for this analysis (see Appendix) can be replicated for other geographies to better understand the full suite of water risks associated with data centers in a certain region. Stakeholders can get ahead of these potential impacts, but they need to act quickly. Investments will need to be made, collaborations will need to be formed, and public policy will need to ensure measures are in place so that the current and future water needs in the basin are met.

Appendix

Data Sources and Methodology

This analysis evaluates the cumulative direct and indirect water impacts of data centers using the Phoenix region as an illustrative example, encompassing both existing and planned data center facilities. Using publicly available data from *Data Center Map*, 124 existing and planned data centers in the Phoenix market were categorized by facility size, IT capacity, power usage effectiveness (PUE), and water usage effectiveness (WUE). Where information was not publicly available on the *Data Center Map* website, company-specific disclosures and media releases were reviewed to supplement the data, and imputations were applied for any remaining gaps.

Cooling technology categories from the *Data Center Map* website were first standardized and recategorized. Category-average WUEs were calculated with reported WUE either from *Data Center Map* or site-specific company disclosures. For data centers with WUEs missing, but cooling type information available, WUEs were assigned using the category-specific averages. For data centers without cooling type specified, average WUEs were assigned based on the data center type — i.e., hyperscale and colocation. Missing PUE data were imputed following a similar approach.

To better understand seasonal water demands associated with data centers, annual PUEs and WUEs were then disaggregated into monthly values using the temporal trends identified for air-cooled and water-cooled data centers in the Phoenix region by Karimi et al., 2022.

Current and planned data center type-specific load factors (or server operational/ utilization time) were retrieved and derived based on data from the 2024 US Data Center Energy Usage Report, ranging between 0.33 and 0.38 for colocations, and 0.49 and 0.51 for hyperscale.

Additionally, each data center was mapped to its respective balancing authority, either Arizona Public Service (APS) or Salt River Project (SRP), to understand their electricity and water demands. Data from EIA forms 860 and 923 for the year 2023 were used to determine at a monthly scale the power mix and power-generation water withdrawal intensities for APS and SRP, which were considered unchanged for the future. For indirect water use calculations, the analysis relies on primary data from the EIA whenever available. In limited cases, where EIA does not provide fuel-specific water withdrawal data, intensity factors from Reig et al., 2020 were used in the calculation of grid-level water intensities.

To estimate the total water withdrawal, the following formula was applied. The resulting calculation quantifies both direct water used on-site for cooling and indirect water consumption associated with electricity generation, where LF is the load factor, WUE is water usage effectiveness, and WI is power plant-specific water intensity.

$$\textit{Water use} = \textit{IT capacity} \times 365 \times 24 \times \textit{LF} \times \textit{WUE}_{onsite} + \sum_{(i=0)} \textit{IT capacity} \times 365 \times 24 \times \textit{LF} \times \textit{Generation share}_i \times W_i$$

Finally, the analysis assesses cumulative water demands from existing and planned data centers in the Phoenix region and compares that finding with regional water stress metrics (see Figure 4). Annual and monthly baseline water stress data were retrieved from Aqueduct 4.0, developed by the World Resources Institute. The dataset was used to evaluate the current levels of water stress at data center sites in the Phoenix region, offering a baseline for assessing potential water stress and vulnerabilities from the concentration of data centers in the region.

To analyze the potential increase of water stress conditions in local watersheds due to planned/announced data centers in the region, we use the Monthly Baseline Water Stress data from Aqueduct 4.0 as the baseline condition. We assume current data centers in operation are already contributing to that baseline, and for the future condition, we include both current and planned/announced data centers in the analysis. For purposes of simplicity and clarity we assume constant water demand from other sectors and no change in water supply due to factors such as climate change, which helps us isolate and focus on this specific driver of increased water demand from added data centers. Therefore, it is likely to be an underestimation of stress increases in the Phoenix region. Monthly water withdrawal and supply data of Aqueduct basins are from the Aqueduct 4.0 Pro databases. Monthly data center direct and indirect water withdrawals were modeled for each data center and power plant. They were then aggregated up to the watershed level for estimating the potential increase in watershed water withdrawals and thus water stress conditions.