Cooling the Cloud: Considerations for Water Utilities Evaluating Data Center Development



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American Water Works Association

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Abbreviations, Acronyms, and Units

ADD	average day demand
AI	artificial intelligence
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
AWWA	American Water Works Association
Carollo	Carollo Engineers
CBA	Community Benefit Agreement
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
COC	cycles of concentration
EBMUD	East Bay Municipal Utility District
ESG	Environmental, social, and governance
IT	information technology
ISO/IEC	International Organization for Standardization and International Electrotechnical Commission
MDD	maximum day demand
mgd	million gallons per day
MLD	minimum liquid discharge
NPDES	National Pollutant Discharge Elimination System
POTW	publicly owned treatment works
PUE	power usage effectiveness
RO	reverse osmosis
SacSewer	Sacramento Area Sewer District
SDC	system development charge
TDS	total dissolved solids
US	United States
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
WUE	water usage effectiveness
ZLD	zero liquid discharge

Foreword

Water utilities are foundational to local economic development and industrial growth, making their early involvement in community planning essential for major development projects. The rapid growth of data centers, and the public debate accompanying that growth, places water professionals at the center of complex decisions about water resources, infrastructure investments, system capacity, and community development priorities.

The American Water Works Association (AWWA) has long worked to inform the conversation around emerging water sector challenges by advancing knowledge, sharing best practices, and developing helpful resources for water professionals. AWWA's 2025 report, *Cooling the Cloud: Water Utilities in a Data-Driven World,* provided an overview of how data centers impact water utilities and communities. The report emphasized the importance of early utility involvement, careful planning, cost accountability and consideration of existing and future water users.

This new report expands on that work with greater detail and recommended approaches for utilities. *Cooling the Cloud: Considerations for Water Utilities Evaluating Data Center Development* is an examination of the resource, technological, financial, and contractual considerations that may arise as utilities evaluate proposed data center developments. It provides a practical planning and decision-making framework for utilities, addressing present and future water supply reliability, recovery of growth-related costs, wastewater impacts and environmental considerations. Recognizing that data center water and infrastructure demands may not be reflected in existing community long-term plans, the report emphasizes the importance of considering impacts on anticipated future capacity and protecting customers from subsidizing new development.

This report is not a public policy document and does not advocate for or against data center development or operations. Rather, it provides water professionals with information and considerations as they evaluate projects, engage with other stakeholders and support informed decision-making.

Each community will ultimately consider many factors and viewpoints as it assesses data center proposals. *Cooling the Cloud: Considerations for Water Utilities Evaluating Data Center Development* provides a practical framework for water utilities to engage in data center deliberations, strengthening their role as anchor institutions in their communities.

Sincerely,



David B. LaFrance

CEO
American Water Works Association

1 Executive Summary

This report is a practical planning and decision-support resource for water and wastewater utilities evaluating the impact of proposed or expanding data centers on utility operations. The report is intended to help utilities screen proposed projects, identify information gaps, evaluate utility capacity, compare infrastructure and water-supply alternatives, establish development conditions, and prepare for negotiations with data center owners and developers. The purpose of the report is to educate utilities encountering data center development by considering: utility reliability, financial sustainability, environmental stewardship, regulatory obligations, and community expectations. Data centers should generally be evaluated as large industrial customers requiring early engagement, detailed engineering review, transparent demand projections, and clearly assigned responsibilities.

The report should be used as an informational resource. Individual water and wastewater utilities must work within state and local legal requirements and practices specific to their circumstances. National averages, industry benchmarks, and published water-use-efficiency values provide useful context, but they do not replace project-specific demand analysis, water and wastewater capacity assessment, cost-of-service study, or water-quality evaluation. Utilities should document the analysis boundary, proposed water sources, average and peak demands, seasonal demand profile, cooling modes, cycles of concentration (COC), consumptive losses, wastewater characteristics, drought response, emergency requirements, and demand associated with each development phase. Assumptions should be tested under low-, reference-, and high-demand conditions, as well as delayed-build, accelerated-build, and partial-buildout scenarios. The analysis should be updated whenever the development schedule, information-technology load, cooling system, water source, or operating strategy changes.

Water utilities and municipalities should adapt these materials to their legal authority, adopted plans and rates, engineering standards, permits, regulatory requirements, climate conditions, water availability, and community priorities. As technologies and project plans evolve, utilities should revisit assumptions, maintain ongoing communication with the data center operator, and modify agreements or infrastructure strategies when necessary.

2 Introduction

2.1 Background

As artificial intelligence (AI), cloud computing, and other digital services continue to drive unprecedented demand for digital infrastructure, the siting of data centers is becoming an increasingly significant consideration for water and wastewater utilities. This report serves as a practical planning and decision-support resource for utilities evaluating the impacts of proposed or expanding data center developments, providing guidance on assessing water and wastewater capacity, identifying infrastructure needs, evaluating alternative water supply strategies, and supporting informed decision-making. The rapid growth of data centers is creating new demands on water, energy, and public infrastructure systems, requiring utilities, municipalities, developers, and communities to proactively balance economic development with reliability, financial sustainability, environmental stewardship, regulatory compliance, and long-term community interests. As data center technologies, cooling strategies, and resource requirements continue to evolve, early engagement, rigorous analysis, and ongoing coordination among stakeholders are essential to ensure that development can be accommodated without compromising existing utility services or future system resilience.

This report is intended to complement American Water Works Association's (AWWA) *Cooling the Cloud: Water Utilities in a Data-Driven World*, published in October 2025, which introduced the emerging challenges and opportunities associated with data center development and growth. While *Cooling the Cloud: Water Utilities in a Data-Driven World* provides foundational context regarding data center water use, infrastructure impacts, and utility considerations, this report expands upon those themes by offering practical considerations, evaluation criteria, and decision-support resources to assist utilities in planning for and managing data center development. Advances in cooling technologies, server design, AI workloads, water reuse, and energy efficiency are changing what were once more predictable assumptions about water and power demand. The rapidly evolving nature of data center demands and constraints underpins the preparation of this report.

2.2 Water as a Site Selection Constraint

As data centers are expanding their footprint across the country, water and wastewater infrastructure are increasingly emerging as schedule-critical elements of data center development. Although power availability, fiber connectivity, land, and taxes often dominate early site-selection discussions, water availability can ultimately determine whether a proposed facility can be developed and operated reliably and is scalable. Data centers may use water for cooling, humidification, equipment maintenance, domestic uses, and fire protection. Their broader water footprint also includes water consumed indirectly through electricity generation. Facility size, computing workload, cooling technology, climate, source water availability, and regional grid characteristics govern the magnitude and significance of these demands (AWWA 2025a).

While there is growing awareness of the role of water services in data center siting, water often remains a secondary consideration. Cooling systems are the primary source of data center water demand. Facilities using chilled-water systems with evaporative cooling towers consume water through evaporation and blowdown, whereas dry or air-side cooling can reduce on-site water use, sometimes with an energy-use tradeoff.

Avoiding inadequate source, treatment, storage, pumping, distribution, wastewater, or reclaimed-water capacity requires adequate consideration and planning as early in the siting process as possible. Meeting data center siting needs may include extending transmission mains, constructing storage or pumping facilities, expanding treatment capacity, modifying cooling-system designs, obtaining additional permits, or developing alternative supplies. Because cooling systems and other fundamental design choices can be difficult or expensive to change after construction, important demand-reduction opportunities are also an important element of early site planning and design (AWWA 2017a).

Local context is particularly important. National or corporate water-use values provide planning context but do not establish whether a specific utility can reliably serve a proposed facility. Data center water footprints vary substantially with size, location, cooling configuration, server efficiency, utilization, climate, and power supply. Some facilities also operate in watersheds experiencing moderate to high water stress, where added demand may compete with municipal, agricultural, industrial, and environmental needs (Siddick, Shehabi, and Marston 2021, 064017; Lei, Lu, and Shehabi 2025, 108310). It is important to evaluate proposed demands under average, peak-day, seasonal, drought, emergency, and full-buildout conditions and include direct on-site consumption and wastewater discharges, such as cooling-tower blowdown, treatment residuals, dissolved solids, temperature, and chemical additives.

Before making a capacity commitment, utilities should understand the project-specific water balance that identifies average-day, maximum-day, peak-hour, seasonal, emergency, and phased-buildout demand. The developer should provide the proposed cooling technology, water-quality requirements, wastewater characteristics, anticipated conservation measures, backup-supply arrangements, on-site storage, potential use of reclaimed water, and the schedule for each development phase (Cejudo, Pamintuan, Stoughton 2023). Because facility-level water-use data remain limited, standardized reporting and transparent technical documentation are essential for distinguishing decision-grade forecasts from preliminary estimates.

Early engagement allows the utility to consider the developer's proposed use, supply alternatives, and cooling strategies before the design becomes fixed. Dialogue between the data center and water utility can ensure on-site water conservation and reuse strategies and future plans are taken into account in utility infrastructure planning. Data centers can optimize cooling-tower cycles of concentration (COC), add side-stream filtration, recover cooling-tower blowdown, use reclaimed water or other non-potable supplies, or select dry or hybrid cooling where climate and energy conditions support those approaches. Each option presents energy, water-quality, treatment, reliability, cost, and residuals tradeoffs; the lowest water use option is not automatically the most sustainable or economical. A site-specific evaluation will identify the combination that best balances water efficiency, energy efficiency, operational reliability, and environmental protection as well as facilitates delivery of water services by the utility (Karimi et al. 2022, 106194; Habibi Khalaj and Halgamuge 2017, 1165-1188).

Front-end water planning also strengthens the negotiating position of utilities and municipalities. A documented capacity evaluation provides the technical basis for assigning infrastructure responsibilities, connection charges, cost-recovery provisions, capacity-reservation fees, financial security, conservation expectations, reporting requirements, and conditions for expansion. These provisions protect existing customers from subsidizing facilities, especially in instances where facilities are delayed, downsized, or never fully constructed (AWWA 2017b; AWWA 2025b; Audit and Review Commission 2024). Transparent communication of projected demands, infrastructure costs, environmental effects, and mitigation measures can improve public understanding and community trust. Addressing water early reduces uncertainty, supports defensible permitting decisions, safeguards utility reliability, and creates a clearer

path for communities to realize potential employment, tax, community and economic-development benefits (AWWA 2014).

2.3 Environmental and Capacity Considerations

Environmental considerations for new data center development are diverse, including not only electricity demand and water demand, but also impacts to water resources (from uses and discharges), infrastructure considerations, noise pollution, land use concerns, and overall community sustainability. Careful analysis is needed as gains in one area could have adverse impacts in another, with cooling technology choice being an example of where optimization of multiple needs is necessary. Data centers require reliable cooling systems to remove the heat generated by computing equipment. Depending on the cooling technology selected, this can result in significant water demand. Although many new data centers are pursuing more efficient cooling strategies and water reuse practices, communities and utilities must evaluate the cumulative impacts of increased water withdrawals, wastewater generation, energy consumption, and other needs. Early assessment of water availability, source reliability, drought resilience, and anticipated future demand facilitates integrating data center associated demand into community plans while meeting the needs of existing and anticipated residential, commercial, and/or agricultural uses (Siddick, Shehabi, and Marston 2021, 064017; Ristić, Madani, and Makuch 2015, 11260-11284).

By viewing water as a strategic resource rather than simply a utility service, communities can better prepare for anticipated growth, minimize environmental impacts, and create a sustainable framework that benefits both data center operators and the surrounding community (AWWA 2025a). Communities should strive to engage with data center developers early to understand both short-term and long-term resource requirements, including future expansion plans. There are opportunities to integrate data center development into strategic water infrastructure improvements. Improvements like reclaimed water infrastructure, developing additional raw water supplies, and expanding raw or finished water supply storage can improve overall system resilience. Such improvements require substantial planning, financing, and often a number of years to construct.

3 Data Center Classification and Infrastructure Demand

3.1 Facility Types

Data centers vary substantially in scale, ownership structure, cooling architecture, and infrastructure demand. Understanding the proposed facility type is the first and most consequential step in any water utility review. Lacking appropriate information on facility type and demand can result in severely undersized infrastructure, inadequate cost recovery, and long-term impacts to ratepayers. Table 1 provides a basic breakdown of data center types and their relevant features that are of importance to water utilities.

Table 1 Data Center Types: Infrastructure Demand Summary

Type	Typical Deployment Pattern	Water-Demand Profile	Infrastructure Implications	Cooling and Heat-Rejection Characteristics
Hyperscale	Large campuses developed in phases	Project-specific; can range from low to high depending on information technology (IT) load and heat rejection	May require dedicated or phased source, treatment, conveyance, storage, and wastewater capacity	Air or liquid cooling at server level; dry, hybrid, or evaporative heat rejection
Colocation	Multi-tenant facilities with variable tenant load	Project-specific; depends on occupancy, density, controls, and heat rejection	May create staged or uncertain capacity needs that vary over time due to tenant changes	Mixed systems and operating modes may vary by tenant and service offering
Enterprise	Single-organization facility or campus	Project-specific; often smaller than hyperscale but not inherently moderate	Often served by existing infrastructure where capacity permits; localized upgrades may be necessary	Customized for internal workloads; chilled-water or direct-expansion systems are common
Edge	Distributed facilities near users or data sources	Usually lower total demand per site; fleet-wide demand can be material	Individual sites may have modest needs; dispersed sites complicate forecasting	Often air-cooled or paired with dry heat rejection; design varies by rack density and climate

3.1.1 Hyperscale Data Centers

Hyperscale data centers are facilities designed to support the operations of large-scale cloud service providers such as Amazon Web Services, Microsoft Azure, and Google Cloud. These data centers are optimized for scalability, efficiency, and automation, often housing hundreds of thousands of servers. Due to their size and operational intensity, hyperscale data centers are among the largest consumers of water. Their cooling systems often utilize advanced technologies, such as direct-to-chip liquid cooling, to manage the heat generated by dense server racks. For instance, a single multi-gigawatt hyperscale data center can consume between 1 and 5 million gallons per day (mgd) for cooling during peak summer months (Lei, Lu, and Shehabi 2025, 108310; Ahmad et al. 2025, 115339; Soliman et al. 2022). Many hyperscale operators are investing in water conservation measures, including the use of reclaimed or non-potable water and the implementation of waterless cooling technologies (Aili 2023, 510-516).

3.1.2 Colocation Data Centers

Colocation data centers provide shared infrastructure for multiple organizations. These facilities lease space, power, cooling, and network connectivity to tenants, enabling businesses to outsource their data center requirements without the need to construct or maintain their own facilities. Colocation centers are designed to be highly scalable, making them an advantageous choice for small- to medium-sized enterprises as well as large corporations seeking redundancy in their operations. Water consumption by colocation data centers varies depending on the cooling technologies implemented, level of occupancy, and type of activities performed by clients. In response to environmental concerns, many colocation providers are transitioning to more water-efficient solutions, including air-cooled and liquid-cooled designs, to minimize their ecological footprint (Ewim et al. 2023, 16397-01e).

3.1.3 Enterprise Data Centers

Enterprise data centers are company-owned and operated facilities, typically located on corporate campuses and tailored to serve internal users (Cisco Systems 2026). They allow organizations to retain control over and customize their computing infrastructure. However, enterprise data centers vary substantially in size, equipment utilization, energy demand, and cooling configuration (Shehabi, et al. 2024). Their water demand should therefore be evaluated from project-specific conditions rather than inferred from the enterprise classification. Important determinants include IT heat load, server utilization, climate, cooling and heat-rejection technology, and infrastructure efficiency (Lei, Lu, and Shehabi 2025, 108310).

3.1.4 Edge Data Centers

Edge data centers are smaller facilities strategically located closer to end users. This helps reduce latency (the time from when a digital user makes a request to when they receive a response) and enhances the performance of internet-connected application services. Edge data centers are facilities operated by a single organization to support its internal computing, storage, networking, and business applications. They range from branch-office server rooms to midsize internal facilities and may be integrated into larger organizational buildings or located at dedicated sites (Shehabi et al. 2024). Their energy and water demand vary substantially with IT load, equipment utilization, climate, operating practices, and cooling-system configuration (Lei, Lu, and Shehabi 2025, 108310). Facilities using water-cooled chillers, cooling towers, or other evaporative heat-rejection systems have direct water consumption, whereas air-cooled or dry systems generally use less on-site water but may require more electricity (USDOE 2019). Consequently, enterprise-facility water demand from the proposed cooling design is important for data centers with environmental, social, and governance (ESG) goals but cannot be discerned from the facility classification alone.

3.2 Data Center Water Demand

As private entities, data centers will vary in their focus on ESG goals and their achievement. For water utilities, this larger consideration of data center water footprint beyond direct consumption is a topic of community dialogue.

Data centers use water directly for heat rejection, humidification, equipment operation, and ancillary services, while also creating an indirect water footprint through electricity generation. Consequently, reported estimates depend strongly on whether the accounting boundary includes only on-site

consumption, total operational consumption, water withdrawal, or scarcity-weighted impacts. An early accounting framework published by the Multidisciplinary Digital Publishing Institute distinguished site-level water-use effectiveness from source-level and workload-based water footprints (Ristić, Madani, and Makuch 2015, 11260-11284). A subsequent review emphasized the difference between withdrawal and consumption and identified persistent disclosure gaps: fewer than one-third of surveyed operators measured water use (Mytton 2021, 11).

National totals, however, do not adequately describe water-resource consequences. A spatial analysis linking servers, electricity suppliers, power plants, and watersheds across the U.S. found that approximately one-fifth of servers' direct water footprint occurred in moderately to highly water-stressed watersheds (Lei, Lu, and Shehabi 2025, 108310). Nearly half of the servers were also at least partly powered by electricity generation located in water-stressed regions. Thus, two facilities with comparable annual water demand may have substantially different impacts depending on source reliability, drought exposure, competing uses, and the water intensity of the regional electricity supply. Water-scarcity conditions should therefore accompany volumetric estimates during utility planning and data center site evaluation.

Cooling technology selection and local climate are also major determinants of water demand. Climate- and technology-specific modeling has shown that water-use effectiveness varies with cooling configuration, outdoor temperature and humidity, indoor operating setpoints, cooling-tower operation, and economizer availability (Han et al. 2026). The International Organization for Standardization and International Electrotechnical Commission (ISO/IEC) found that data centers in hot-arid climates and facilities using air-side economization similarly demonstrate that water and energy performance must be evaluated together (ISO/IEC 2022). Dry or air-based cooling can reduce on-site water consumption but may increase electricity demand and its associated indirect water use. Conversely, evaporative cooling systems may reduce energy consumption while increasing direct water consumption, blowdown production, and dependence on local water quality. Water use effectiveness (WUE) is a commonly used metric that measures how much water a data center consumes relative to the energy used by its IT equipment, typically expressed as liters of water per kilowatt-hour. WUE helps quantify the water efficiency of a data center and provides a standardized way to compare the impacts of different cooling technologies, operating practices, and facility designs. However, a low on-site WUE does not necessarily represent the lowest total water footprint. WUE is further expanded upon in a later section of this report, "Water Balance Methodology and Demand Modeling."

Scenario studies illustrate both the potential scale and uncertainty of future water demand. The Center for Secure Water estimates that European internet services could consume approximately 273 to 820 million cubic meters per year by 2030, depending on service growth, technology adoption, and efficiency assumptions (Privette et al. 2026). In the U.S., direct on-site data center water consumption was estimated by the National Association of Regulatory Utility Commissioners to have increased from 21 billion liters in 2014 to approximately 66 billion liters in 2023 (Navarro and Knoll 2026). However, facility-level averages may conceal substantial operational variability. A workload-level assessment estimated large variations in water use per computing workload, driven by server efficiency, equipment utilization, cooling technology, infrastructure efficiency, climate, and grid water intensity. Workload-based metrics are therefore important when comparing facilities that provide different amounts of useful computing.

The rapid expansion of AI introduces additional uncertainty. Global AI-related water withdrawal was projected to reach 4.2 to 6.6 billion cubic meters in 2027 (Capone and Marston 2025). A U.S. AI-server

assessment projected approximately 29 percent attributed to direct water consumption and 71 percent to electricity-related indirect water use (Cohen, Beyer, and Shwisberg 2026). A separate global assessment estimated a 2025 AI water footprint of 312.5 to 764.6 billion liters per year, emphasizing the substantial uncertainty created by limited corporate disclosure (Energy Systems Integration Group Large Loads Task Force 2025).

For water and wastewater utilities, these studies support project-specific evaluations rather than reliance on generic gallons-per-megawatt assumptions. Utilities should request annual, maximum-day, and seasonal water demands; cooling technology and operating setpoints; WUE with an explicit accounting boundary; COC; blowdown quantity and quality; source water requirements; reclaimed water feasibility; drought-curtailment provisions; and regional electricity-water factors. This also includes the water and wastewater services needed during construction of the data center facility. Passivation programs for closed-loop systems and the start-up flows during the initial commissioning process can be challenging. The passivation programs can be particularly troublesome as the chemicals associated with passivation and disinfection may result in passing of inhibitory compounds to the community's wastewater treatment plant along with metals that may result in problems for the solids management. Service decisions should clearly distinguish withdrawal from consumption and direct utility demand from the total water footprint. Alternative cooling, reuse, and water-source strategies should then be evaluated jointly with their energy, carbon, wastewater, reliability, and community impacts.

3.2.1 Considering Indirect Water Demand and Use

For water and wastewater capacity planning, indirect water use should generally remain separate from the facility's service-demand estimate. Hydraulic models, treatment-capacity analyses, connection charges, and service agreements should be based on water physically supplied to the site and wastewater (including any cooling tower blowdown) physically returned to the utility. Indirect water use becomes a local planning concern when the electricity provider's generating facilities use water from the same watershed, depend on the same water utility, or compete for a shared regional supply. In those circumstances, water utilities, electric utilities, resource agencies, and regional planners should coordinate their assumptions so that the same water is not overlooked or double-counted.

3.3 AI-Driven Demand Escalation

Traditional data centers and AI-optimized data centers have materially different water demand profiles. AI workloads generate significantly higher heat loads because advances in processor performance and server design are enabling substantially more computing power to be concentrated within the same physical rack footprint. As chip densities increase and high-performance GPUs replace traditional computing hardware, rack power densities can rise dramatically, requiring more advanced and often more resource-intensive cooling solutions. As a result, data center water demands can vary widely based on workload type (e.g., traditional enterprise versus AI), cooling technology, climate, and operating strategy, ranging from less than 0.5 mgd for smaller facilities to more than 5 mgd for large hyperscale campuses. While these ranges provide useful context, actual water demand is highly site- and technology-specific and should be evaluated on a project-by-project basis. As such, water utilities should not rely on historical demand assumptions to AI- and future-optimized facilities. Utilities should develop project-specific forecasts from installed and operating IT load, cooling configuration, seasonal operating modes, source water conditions, and phased buildout (Lei, Lu, and Shehabi 2025, 108310).

In addition to understanding the primary water and wastewater demands, utilities must also accurately plan for seasonal variation in cooling water demand, as fluctuating weather patterns require the ability to adapt quickly throughout the year. Data centers can quantify this range by providing expected minimum and maximum flow rates, and while peak demand has received significant attention because infrastructure sizing depends on those numbers, minimum flows are often overlooked. That gap can create operational challenges during low-demand winter months when equipment may sit idle for a period of time and operate at its minimum design flow. This may result in the need to maintain some low-level base load to prevent adverse long-term consequences for cooling systems, resulting in continuous use of water regardless of IT or cooling demands.

3.4 Phased Buildout and Demand Uncertainty

Hyperscale and colocation campuses are frequently developed in phases over five to 20 years. Each phase may introduce new cooling modules, additional IT load, and incremental water demand. Water utilities must account for full buildout demand in infrastructure planning, even when initial phases appear modest. Failure to plan for full buildout capacity can result in costly mid-project infrastructure expansions, rate disruptions, and service reliability risks for existing customers. While there are risk management and construction efficiencies to be gained by building infrastructure for full data center buildout, water system considerations include assuring the efficient function of installed infrastructure prior to full buildout. Drinking water distribution system infrastructure that is not fully utilized can lead to protracted water age and consequently operational expenses to manage water quality deterioration.

4 Cooling Technologies: Engineering Characteristics and Water Demand

4.1 Importance of Early Cooling Technology Disclosure

Cooling technology is the single most important variable in determining a data center's water demand, wastewater characteristics, power requirements, infrastructure sizing requirements, and capital cost implications for both the incoming data center and the water utility (Lei, Lu, and Shehabi 2025, 108310; Habibi Khalaj and Halgamuge 2017, 1165 1188). Water utilities should encourage cooling technology disclosure at the earliest stage of development discussions, before any service commitment is made. Since different cooling technologies have large variations in power and water demand, identifying the cooling technology early gives utilities time to properly plan for the required power and water demand. Cooling technology can also influence localized heat and microclimate conditions, making site design and heat mitigation strategies important considerations during development. As facilities increase in scale and computing density, many operators are implementing design and operational measures to reduce thermal impacts on adjacent properties and communities. For example, larger setbacks between data center buildings, cooling equipment, and property boundaries are one way to reduce the intensity of heat experienced by adjacent developments. Many developers are incorporating thermal impact studies into site planning to identify optimal building spacing and equipment locations. Computational Fluid Dynamic modeling allows operators to quantify anticipated temperature increases, identify potential hotspots, evaluate climate and weather scenarios, and test mitigation options.

As computing density increases and equipment becomes more complex, traditional open-circuit cooling is no longer sufficient or economical (Lei and Masanet 2022, 106323; Rose, Wemhoff, and Fleischer 2019). The industry is transitioning toward closed-loop fluid cooling strategies for the majority of cooling needs, with limited evaporative cooling used during peak thermal conditions. The differences between these cooling systems are demonstrated in Table 2. Power Usage Effectiveness (PUE) is the industry-standard metric used to measure a data center's energy efficiency (ISO/IEC 30134-2:2026). It is calculated by dividing the total power entering the facility by the power consumed by the IT equipment, meaning a PUE of 1.0 would indicate that all incoming power is used directly for computing with no overhead for cooling, lighting, or other supporting systems. In practice, lower PUE values indicate greater efficiency. Traditional or older data centers often operate with PUEs between 1.7 and 2.0 or higher, while modern hyperscale facilities commonly achieve PUEs between 1.1 and 1.4.

Table 2 Data Center Cooling Technology Types

Technology	WUE Tendency	PUE Tendency	On-site Water Demand	Wastewater Generation	Key Utility Consideration
Open-circuit evaporative (Wet) Cooling Towers	Higher when water is consumed; climate and controls determine the measured value	Often lower cooling energy in favorable climates	Highest among common heat-rejection modes; strongly seasonal	Blowdown, drift, and cleaning waste	Peak demand, water quality, COC, and blowdown management
Dry Cooling Towers (Closed loop cooling)	Near-zero process water for heat rejection; auxiliary uses remain	Cooling energy can rise in hot conditions	Minimal routine heat-rejection water	Minimal routine cooling wastewater	Power-water tradeoff and high-ambient performance
Hybrid Cooling Towers	Varies with wet and dry operating modes	Varies with mode and controls	Low to moderate; seasonal and control-dependent	Intermittent blowdown and washdown	Peak-season storage capacity and typically higher water quality required
Direct-to-chip and immersion cooling	Does not determine facility WUE; the final heat sink controls on-site use	Can reduce server and fan cooling energy	Determined by final heat-rejection system	Coolant management plus any heat-rejection residuals	Coolant circuit, final heat sink, containment, and waste-heat options

4.2 Cycles of Concentration (COC) Analysis

Water used for cooling systems contains minerals and other constituents. Cycles of concentration (COC) refers to how many times dissolved minerals and other constituents become concentrated in a cooling tower's recirculating water relative to the incoming makeup water. As water evaporates from the cooling tower, most dissolved solids remain behind in the remaining circulating cooling water. This causes the concentration of these materials to increase over time. To control this buildup, a portion of the concentrated circulating water is periodically discharged as blowdown and replaced with fresh makeup water. COC is defined as the ratio of total dissolved solids (TDS) concentration in the recirculating cooling water to that in the makeup water and is a key indicator of cooling tower water-use efficiency.

COC's **relationship to water use** is defined below**:**

- **Higher COC:** Lower makeup water demand and reduced overall water consumption, but higher constituent concentrations in blowdown and potentially greater loading to the sewer.
- **Lower COC:** Higher makeup water demand and water consumption, but lower constituent concentrations in blowdown and reduced constituent loading to the sewer.
- **Typical operating range:** COC of approximately three to six for systems using potable water. With advanced pretreatment of makeup water, COCs higher than six may be achievable, depending on water chemistry and cooling system design.

COC is an important consideration for both water supply and wastewater utilities. Increasing COC can reduce the volume of water a data center requires but may increase the concentration of dissolved solids, treatment chemicals, and other constituents discharged to the wastewater system. Furthermore, the increased COC concentrations can result in material concerns downstream within existing conveyance systems due to high corrosion potential. Utilities need data center developers to provide COC assumptions, makeup and blowdown volumes, and support water chemistry analysis as part of describing the facility’s water balance.

4.3 Open-Circuit (Wet) Cooling Towers

Evaporative cooling systems reject heat through the latent heat[1] of evaporation. In a traditional open-circuit cooling tower, warm condenser water is distributed over the top of packing/fill material while air is induced or forced through the media from the bottom of the tower in a countercurrent path, promoting evaporation that removes heat from the remaining water (Lei, Lu, and Shehabi 2025, 108310). The cooled water that has not evaporated is collected in a basin and recirculated back to the cooling system. While this approach provides highly efficient heat rejection and overall lower energy consumption than dry cooling alternatives, it inherently results in evaporative water losses, drift, and cooling tower blowdown, requiring a continuous source of makeup water and associated wastewater management (Habibi Khalaj and Halgamuge 2017, 1165-1188). Blowdown contains elevated TDS, chlorides, biocides, corrosion inhibitors, and antiscalants, with COC governing blowdown volume and constituent loading. Higher COC reduces water consumption but increases blowdown concentration. *Legionella* management and biocide programs are required for all evaporative systems. Many older data centers that relied on water-intensive cooling towers are now actively seeking retrofits to reduce water consumption. Figure 1 shows a wet cooling tower schematic.

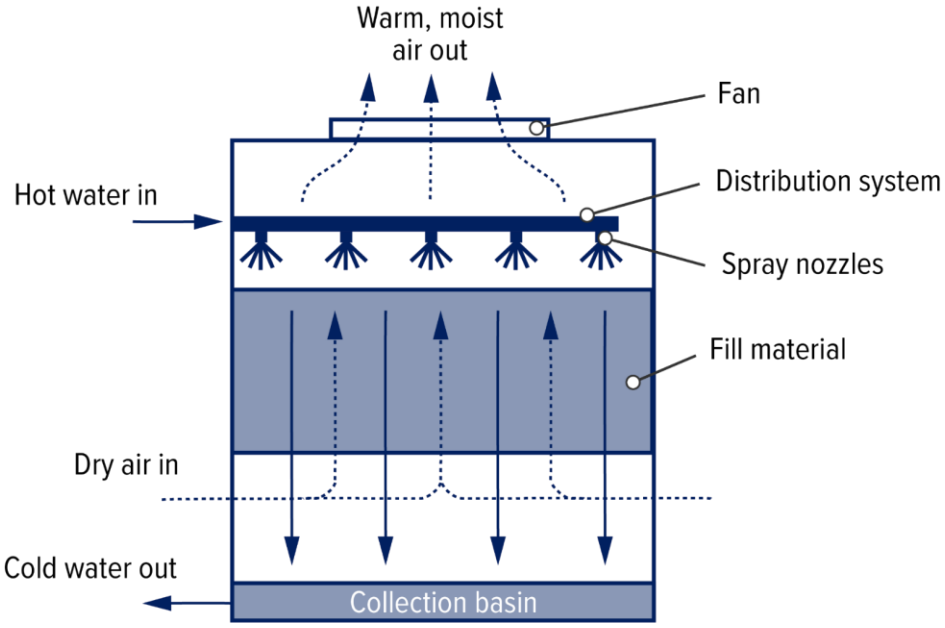


Figure 1 Evaporative Open Circuit Cooling Tower Schematic

4.4 Dry Cooling (Air-Cooled Fluid Coolers)

Air-cooled fluid coolers (i.e., dry coolers) function similarly to automobile radiators, moving large volumes of air over large surface areas to dissipate heat without evaporative loss. A dry cooler rejects heat from the process fluid by transferring sensible heat[2] to ambient air. The process fluid is sensibly cooled while the air is sensibly heated. Because no evaporation occurs, all heat rejection is through sensible heat

[1] Latent heat is the portion associated with water vapor content — it represents the energy required to evaporate the moisture present in the air.
[2] Sensible heat is the portion of enthalpy associated with air temperature — it changes when dry-bulb temperature changes.

transfer. This technology eliminates evaporative losses and substantially reduces water consumption and wastewater generation. This makes dry cooling highly attractive in water-stressed regions and areas with limited water or wastewater infrastructure. However, because air is a relatively poor heat transfer medium compared to water, dry coolers require larger heat-exchange surfaces, higher fan power, and often deliver reduced cooling performance during hot weather (Habibi Khalaj and Halgamuge 2017, 1165-1188). As ambient temperatures rise, the approach temperature (the temperature difference between the cooling fluid exiting the heat exchanger and the ambient air) between the cooling fluid and the surrounding air narrows. This reduces cooling effectiveness and increases energy consumption. Unlike evaporative cooling towers, dry coolers do not generate routine blowdown wastewater because the cooling fluid remains in a closed loop. Wastewater generation is typically limited to periodic maintenance activities and equipment cleaning, so in general, the wastewater product is a non-contact cooling wastewater. As western U.S. markets and water-constrained regions continue to attract data center development, dry cooling has become increasingly common because it decouples facility growth from municipal water availability (Khatib et al. 2025, 48-53). Figure 2 shows a dry cooling tower schematic.

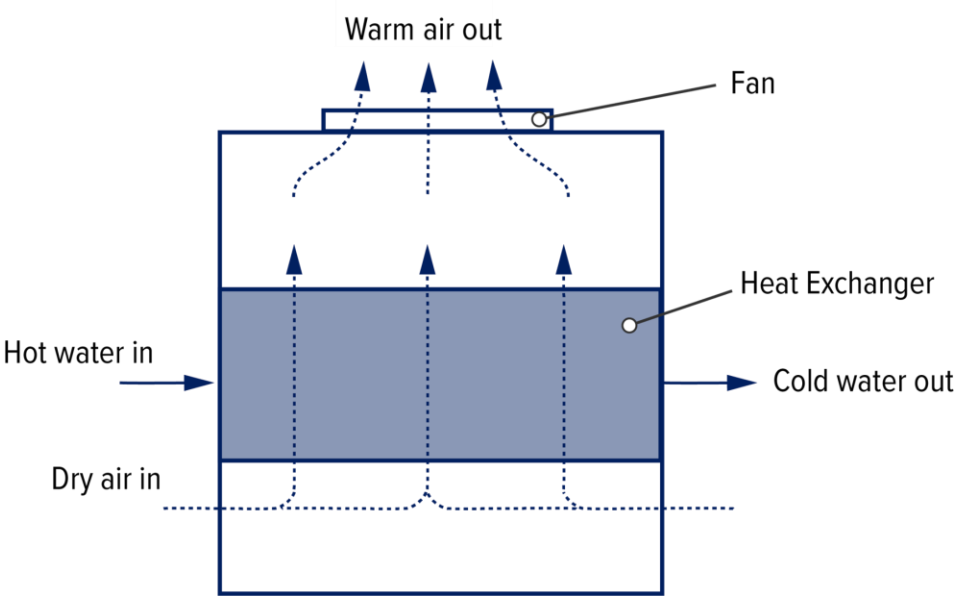


Figure 2 Dry Cooling Tower Schematic

4.5 Closed-Loop Fluid Cooling (Closed-Circuit Cooling)

Closed-fluid cooling is a cooling technique where the process fluid that removes heat from the data center remains in a sealed system and never comes into direct contact with outside air. Heat is thereafter transferred from the closed-loop fluid to the atmosphere through either a heat exchanger, closed-circuit cooling tower, dry cooler, or hybrid cooling system. This design protects the cooling loop from airborne contaminants, evaporation losses, biological growth (e.g., *Legionella*), and water quality degradation (CDC, 2025). For modern hyperscale and AI data centers, closed-loop cooling has become increasingly attractive because it provides greater reliability, improved water quality control, and compatibility with direct-to-chip liquid cooling systems.

4.6 Hybrid Cooling Towers

Hybrid cooling towers (shown in Figure 3), represent an advanced integration of both evaporative (wet) and dry cooling methods, optimizing water usage while enhancing operational performance across a variety of weather conditions. In a hybrid design, these towers operate in dry mode, like an air-cooled radiator, during cooler periods, and transition to wet mode for evaporative cooling during warmer conditions or peak load situations. This functionality is typically achieved through the inclusion of finned dry cooling coils or heat pipes adjacent to the wet cooling sections, or through the implementation of an adiabatic precooling stage.

During milder weather or periods of lower data center loads, the hybrid system predominantly relies on air convection for heat dissipation, significantly reducing water consumption. Conversely, when the demand for cooling capacity increases, water is introduced to facilitate evaporative cooling, achieving lower temperatures than would be possible with dry cooling alone. This dual-mode operation provides a strategic balance between water conservation and energy efficiency, making hybrid systems particularly advantageous in regions characterized by seasonal climate variations or limited water resources.

Furthermore, hybrid cooling towers contribute to plume abatement by allowing the dry cooling phase to heat or mix the discharged air with saturated moisture, thereby mitigating the visibility of vapor plumes. Although the complexity of hybrid systems may lead to higher initial costs due to additional heat exchange components, they offer considerable benefits in aligning with stringent water-use regulations and sustainability objectives. In the context of data centers, hybrid cooling solutions are especially relevant in water-scarce locations or in scenarios where minimizing water usage is a priority, while still leveraging the efficiency of evaporative cooling during periods of peak demand. For example, a hybrid tower may operate in dry mode during winter and transitional seasons, reserving water usage for the hottest hours of the summer.

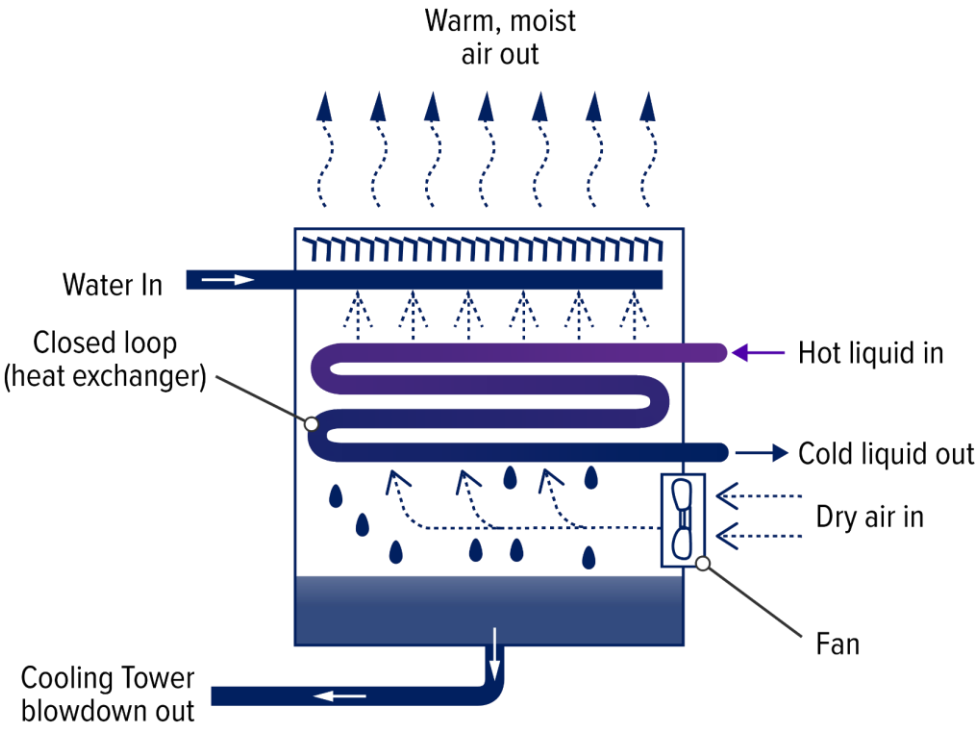


Figure 3 Hybrid Cooling Tower Schematic

In summary, there is no one-size-fits-all solution. Every cooling approach is a balance between water usage, energy consumption, and cooling performance. Table 3 describes the main characteristics of the differing cooling technologies discussed above.

Table 3 Characteristics of Different Commonly Deployed Cooling Technologies at Data Centers

Type of Cooling Technologies	Characteristics of Cooling Technology
Open-Circuit (Wet) Cooling	• Lower Process Fluid Temperatures Achievable: The degree of evaporation, and consequently the heat exchange, is influenced by the wet-bulb temperature rather than the dry-bulb temperature. This distinction is particularly notable during summer months when the wet-bulb temperature can be significantly lower than its dry-bulb counterpart. For instance, on sweltering summer days where dry-bulb temperatures surpass 95 degrees Fahrenheit, the wet-bulb temperature might drop to as low as 71.6 degrees Fahrenheit, enabling process fluid cooling down to 77 degrees Fahrenheit through evaporative cooling methods. • Compact Design: The design offers a reduction in area usage by 50 percent compared to similar air-cooled systems, facilitating easier installation. • Refrigerant Charge: The highly efficient configuration features a more compact heat exchanger that requires a minimal refrigerant charge. • Significant Energy Savings: Evaporative cooling methods are capable of transferring more heat compared to traditional air-cooled techniques while necessitating four times less airflow. • Utility impact: Highest water demand; increases water supply and wastewater requirements but generally reduces power demand.

Type of Cooling Technologies	Characteristics of Cooling Technology
Dry Cooling	• Dry coolers use air as their cooling source and are particularly suited for applications or locations where water resources are scarce or when there are concerns regarding water quality. • Generally, dry cooling requires more energy than water-assisted cooling because air is less effective than water at transferring and rejecting heat. As a result, dry-cooled data centers can have higher cooling-related power consumption, particularly during periods of high ambient temperatures. Dry cooling is often selected when minimizing water consumption is a priority, as it can significantly reduce or eliminate cooling water demand when compared with water-assisted systems. Dry coolers are preferred in regions with limited water availability or where reducing water consumption is a key sustainability objective. • Utility impact: Minimal water demand; increased electrical demand, and potentially larger electrical infrastructure requirements.
Closed-Loop Fluid Cooling	• Water Quality Protection: Because the process loop is isolated from the atmosphere, contaminants, debris, minerals, and microorganisms are largely prevented from entering the cooling system. This reduces scaling and corrosion risk. • Improved Reliability: Data centers benefit from more stable operating conditions and lower maintenance requirements for heat exchangers, cooling coils, and liquid cooling equipment. • Compatibility with AI workloads: Closed-loop systems are well-suited for high-density GPU clusters and direct liquid cooling systems, which are increasingly being deployed in AI-focused facilities. • Utility impact: Low to moderate water demand; systems require additional heat exchangers, pumps, controls, and often larger heat rejection equipment compared to traditional open cooling tower systems.
Hybrid Cooling	• Water Conservation: Utilizing a minimal quantity of water to precool the air entering the heat exchanger effectively reduces the necessary airflow and fan power when compared to air-cooled systems, while simultaneously decreasing the fluid temperature returned to the system. In optimal adiabatic systems, the air is cooled nearly to the wet-bulb temperature. This significant reduction in air temperature leads to a marked enhancement in both cooling capacity and energy efficiency relative to designs that rely solely on dry methods. When ambient temperatures are near freezing or during periods of lower demand, the unit can be switched to dry-only mode, thereby minimizing water consumption. • Versatile Operational Modes with Controls: The controls for hybrid products are engineered for adaptability, intelligence, and user-friendliness, maximizing the benefits of dual operating modes. At a design point chosen by the customer—such as cooler ambient dry bulb temperatures combined with reduced heat loads—the unit can cease water usage and transition to dry mode. Additional control functionalities include daily maintenance settings, energy-saving options, and modes focused on conserving water. • Utility impact: Moderate water demand; reduces power demand compared to dry cooling but requires additional water supply capacity.

5 Water Balance Methodology and Demand Modeling

5.1 Project-Specific Water Balance

A project-specific water balance is the foundational engineering document for evaluating water and wastewater service to a proposed or expanding data center. It should be prepared before the utility makes a binding service commitment, establishes customer-specific capacity charges, or authorizes final design of major water and wastewater infrastructure. Although national averages and reported WUE values can provide useful screening-level context, they are not substitutes for a facility-specific analysis. Data center water demand varies substantially with installed IT capacity, actual server utilization, cooling technology, climate, equipment efficiency, control settings, water quality, treatment-system recovery, operating practices, and the timing of phased development.

A decision-grade model should quantify annual-average, monthly, maximum-day, and short-duration peak conditions for each development phase. It should also estimate corresponding wastewater flows and constituent loadings. Results should be presented for normal operation and for reasonably foreseeable conditions such as hot-weather operation, drought-related supply restrictions, equipment outages, treatment-system maintenance, emergency refill, delayed buildout, and full campus development. For service areas considering several data centers, the utility should also evaluate the coincident demand of multiple facilities rather than reviewing each project in isolation.

5.2 Water Balance Components

The water balance components presented here account only for direct water consumption at the data center. They do not include indirect water consumption associated with electricity generation. Assessment of water use attributable to the power generation technologies supplying the facility should be conducted separately. A complete water balance for the data center must account for the following:

- Water Inputs:
    - Potable supply (average day, maximum day, instantaneous peak).
    - Reclaimed water supply.
    - Groundwater or surface water (if applicable).
- Internal Uses:
    - Cooling tower makeup water (function of COC, evaporation rate, and drift losses).
    - Water treatment for cooling water quality management.
    - Domestic and sanitary uses.
    - Fire suppression system storage.
    - Humidification systems.
- Losses and Discharge:
    - Evaporative losses from cooling towers (primary consumptive use).
    - Drift losses (typically 0.001 to 0.002 percent of circulating flow).
    - Cooling tower blowdown (function of COC and makeup water quality).
    - Water treatment waste streams.

    - Sanitary wastewater.
    - Process wastewater from pretreatment systems.

5.3 Demand Metrics and Modeling Parameters

Recent, reliable, and accurate information is crucial to initiate proper planning for the development of an efficient facility and system. Demand models for data centers must account for weather, square footage, cooling type, and owner-specific operational practices. The essential demand metrics from every data center developer should include:

- **Average day demand (ADD):** ADD represents the baseline daily water use expected under normal operating conditions. For data centers, ADD provides utilities with a consistent measure of typical water consumption and helps set initial water supply requirements. ADD should reflect expected operating conditions at the anticipated IT load and cooling configuration.
- **Maximum day demand (MDD):** MDD represents the highest expected water use during a single day and is typically driven by periods of high ambient temperatures and increased cooling requirements. This is particularly true for data centers in arid regions, where rising temperatures increase cooling demand and drive higher water consumption at the same time water supplies may already be constrained.
    - For evaporative cooling systems, MDD can be significantly higher than ADD, commonly ranging from 1.5 to 2.5 times ADD. MDD is a key metric for evaluating water supply capacity and infrastructure needs during peak conditions.
    - For hybrid and adiabatic cooling systems, water consumption is often highly intermittent and weather dependent. Water use may be negligible during cooler periods when the system operates in dry mode, but can increase sharply during design-day or near-design-day conditions when wet assistance is required. This concentration of consumption into a limited number of hot days can result in MDD-to-ADD ratios significantly greater than those observed for continuously evaporating cooling systems, making MDD a critical design parameter for water supply planning.
- **Instantaneous peak demand:** Instantaneous peak demand represents the highest water flow rate expected at any given point in time. Unlike ADD and MDD, this metric focuses on short-duration flow rather than total daily consumption. It is critical for sizing pipelines, pumps, storage, and pressure zones serving the data center.
- **Monthly demand profile:** A monthly demand profile provides a 12-month projection of expected water use and shows how demand changes throughout the year. Data center water demand can vary significantly with seasonal temperatures and cooling requirements, particularly for evaporative and hybrid systems. This profile helps utilities evaluate seasonal capacity and identify periods of elevated demand.
- **Buildout demand:** Buildout demand represents the total water demand expected when the full data center campus reaches its planned maximum IT capacity. This metric is critical because data center campuses are often developed in multiple phases over several years. Understanding ultimate demand allows utilities to plan water supply, treatment, storage, and distribution infrastructure well ahead of future expansion.

5.4 System Boundary and Accounting Framework

The water balance should begin with a clear definition of the physical boundary, accounting period, and terminology. For the on-site facility boundary, a typical governing relationship is:

$$\sum Q_{External\ Input} = \sum Q_{Consumptive\ Loss} + \sum Q_{Discharge} + \Delta S$$

Where $\sum Q_{External\ Input}$ represents the volume or flow of water during the selected time interval entering the site boundary and $\sum Q_{Consumptive\ Loss}$ represents the total volume of water consumed during the selected time interval and not returned to the source, which includes evaporation, drift, blowdown, and other consumptive uses. $\sum Q_{Discharge}$ represents the volume or flow discharged from the site boundary during the selected time interval and ΔS represents the change in water storage during the selected time interval, including water in tanks, basins, piping, cooling systems, treatment systems, and other on-site facilities. A positive value indicates an increase in stored water, while a negative value indicates a decrease (AWWA 2014).

External inputs may include potable water, reclaimed water, groundwater, surface water, captured rainwater or stormwater, imported alternative water, trucked emergency supply, and recovered water entering the defined facility boundary. Each source should be reported separately because source reliability, water quality, treatment requirements, regulatory constraints, cost, and effects on existing customers may differ materially. A facility that uses reclaimed water for cooling may have the same fundamental cooling requirement as a facility using potable water, but its effect on potable supply capacity will be different.

Internal water uses may include cooling-tower makeup, humidification, treatment-system feed, equipment washing, domestic use, sanitary use, landscape irrigation, fire-protection system filling, and initial filling or periodic replacement of water in closed-loop cooling systems. Internal transfers and reuse should be shown so that the utility can understand how water moves through the facility.

Outputs should distinguish cooling-tower evaporation, drift, blowdown, sanitary wastewater, membrane concentrate, filter backwash, softener-regeneration waste, equipment drainage, maintenance discharges, water exported for off-site reuse or disposal, and any other flow leaving the facility. Evaporation and drift are generally consumptive losses, whereas blowdown and treatment residuals are discharged flows that may return to a wastewater system or another receiving environment. The model should also account for temporary changes in storage, particularly during initial filling, commissioning, emergency refill, seasonal storage operation, and maintenance.

Water withdrawal and water consumption should be reported separately. Withdrawal is the volume entering the facility from a source. Consumption is the portion that is evaporated, incorporated into a residual, transferred to another basin, or otherwise not returned promptly to the same water system or watershed. A data center can therefore have a relatively high withdrawal but lower net consumption if much of its water is discharged and recoverable. Conversely, an evaporatively cooled facility may return a smaller proportion of its withdrawal because evaporation is a primary mechanism of heat rejection. The source, return-flow location, water quality, timing, and withdrawal-versus-consumption basis should accompany each reported quantity.

5.5 Water Use Efficiency

ISO/IEC 30134-9 defines WUE as a data center's water consumption relative to the energy used by its IT equipment (ISO/IEC 2022).

$$WUE = \frac{V_{Site\ Water\ Use}}{E_{IT}}$$

WUE is generally expressed in liters per kilowatt-hour. The reported value should identify the measurement category, water uses included in the numerator, IT-energy measurement point, reporting period, and treatment of alternative water sources. A WUE value without this information may not be comparable with values reported by another facility.

WUE is useful for tracking facility-level performance, but it is not a complete measure of utility demand (Shehabi et al. 2024; USDOE 2019; AWWA 2025a, 27). An annual WUE value does not directly describe maximum-day withdrawal, instantaneous flow, source reliability, wastewater discharge, or constituent loading. It may also obscure seasonal variation because it combines an entire year of water use and IT energy into one ratio. Utilities should therefore use WUE as one input to the water balance rather than as the sole basis for capacity planning.

Electricity-related water use may be estimated separately by multiplying the facility's electricity consumption by an appropriate water-consumption or withdrawal factor for the supplying electrical grid. This estimate can vary by generation technology, cooling system, geographic region, season, and accounting method (Ristić, Madani, and Makuch 2015, 11260-11284; Lei, Lu, and Shehabi 2025, 108310; Mytton 2021, 11). Because on-site and electricity-related water use occur at different locations and may use different withdrawal and consumption definitions, the two values should not be combined unless their boundaries, time periods, water-use definitions, and data sources are consistent. The report should present them separately and clearly label any combined lifecycle or water-footprint estimate.

5.6 Demand-Model Structure and Inputs

The demand model should calculate water use from physical and operational drivers rather than relying primarily on building area or a generic gallons-per-day-per-megawatt factor. A conceptual representation of the model is:

$$Q_t = f\left(P_{IT,t}, U_t, W_t, C_t, N_t, R_t, O_t\right)$$

Where, $P_{IT,t}$ represents installed and operating IT load, U_t represents server utilization, W_t represents weather conditions, C_t represents cooling technology, operating mode, control settings, and cooling efficiency. N_t represents makeup water quality and COC. R_t represents treatment recovery, reuse availability, and storage operation. O_t represents other operating practices, equipment redundancy, maintenance, and control sequences.

The model distinguishes installed IT capacity from actual operating load. A campus may be permitted or constructed for a large ultimate electrical capacity while energizing equipment gradually over several years. Applying a water-use factor to the ultimate capacity without considering the load ramp can overstate near-term demand. Conversely, assuming that early operating conditions will continue through full buildout can understate long-term demand if later phases use higher-density servers or different cooling equipment.

Weather data informs the cooling system's operating logic. For evaporative and hybrid systems, dry-bulb temperature, wet-bulb temperature, humidity, and the hours during which each cooling mode operates affect water demand. For a dry-cooled system, water demand may be relatively low during routine operation but may increase during maintenance, humidification, or operation of an evaporative-assist mode. The model should therefore represent the cooling sequence rather than assign a single annual water intensity to the entire facility.

Treatment-system assumptions should include feed water quality, pretreatment requirements, recovery, backwash, regeneration, membrane cleaning, brine concentrate production, and downtime. Reclaimed water should not be assumed to provide a one-for-one replacement for potable water without considering treatment losses, potential required treatment, seasonal availability, storage, distribution reliability, and the need for a backup source (Cejudo, Pamintuan, Stoughton 2023). Where potable water and reclaimed water are used in combination, planning facilities should consider both average potable water demand and the maximum potable water demand if reclaimed water is not available.

6 Water Source and Cooling Water Quality Requirements

6.1 Water Source Options

Data centers may obtain water from community drinking water systems, reclaimed water systems, permitted groundwater or surface water sources, captured rainwater or stormwater, and/or on-site non-potable streams. A utility will need to evaluate each source on a consistent basis relative to: legally and physically available yield; seasonal and drought reliability; raw water quality; treatment, storage, and conveyance requirements; regulatory authorization; environmental constraints; cost allocation; and backup arrangements (Cejudo, Pamintuan, Stoughton 2023; USDOE 2019; Campisano et al. 2017, 195-209). A portfolio of different options to acquire water from non-potable sources can reduce potable water demand only when it can be reliably and sustainably obtained.

6.1.1 Potential Water Sources

Water-source selection defines both utility dependencies and facility operating constraints. No source category is inherently "primary" or "supplemental" for every project. The service basis identifies the permitted quantity, dependable seasonal yield, quality envelope, interruption risk, required treatment and conveyance, storage, backup supply, and the party responsible for each asset and permit. Regulatory requirements vary by source, end use, and jurisdiction, particularly for reclaimed water, direct withdrawals, stormwater capture, and on-site non-potable systems. Potential sources include:

- Potable water.
- Community reclaimed water.
- Permitted groundwater.
- Permitted surface water.

Many successful data center projects improve water reliability by combining multiple sources in combination with demand reduction strategies.

Community water supplies: Water from public and private water systems is one of the most highly utilized sources for data center cooling systems. Data centers often rely on local water utilities to provide a consistent supply for their operations. This type of water is already treated to meet safety and quality standards, making it suitable for use in sensitive cooling systems either without additional treatment or with modest on-site treatment. However, this dependency can create challenges, particularly in regions where water scarcity is a concern. In the US, water rates vary significantly by region, ranging from $1 to $5 per 1,000 gallons, depending on local availability, infrastructure, utility revenue requirements, conservation needs, and a host of other factors. Utilities should ensure that appropriate rates, cost recovery strategies, and supply reliability strategies are in place for data centers seeking to connect to public water systems.

Groundwater resources: In areas where other water supplies are limited or unreliable data centers are using groundwater. Drilling wells may offer a cost-effective solution. However, excessive reliance on groundwater can lead to aquifer depletion and land subsidence. While groundwater withdrawals are typically permitted under state law, local government may have ordinances in place that specify use of available water infrastructure.

Aquifers are a shared resource. While groundwater is an important element of the community's supply, it may be necessary to monitor trends in aquifer withdrawals, including major withdrawals from users such as data centers, as part of community water supply planning. In addition, a comprehensive assessment of aquifer sustainable yield should be conducted to determine the long-term viability of groundwater withdrawals under projected operating conditions. Such evaluations help inform data center withdrawals will not result in overdraft conditions or impair the availability of groundwater resources for other existing and future users utilizing available aquifers.

Reclaimed and treated wastewater: Reclaimed and treated wastewater is an increasingly popular alternative for data centers aiming to reduce their reliance on other sources. Local incentives and mandates have increased the favorability of reusing water among data center operators. This approach involves treating wastewater to a quality suitable for industrial use, including cooling systems. Treated wastewater can offer several benefits, including reduced costs and lower environmental impact. In some cases, data centers collaborate with local utilities to establish wastewater treatment facilities, creating a sustainable water loop. This practice is particularly beneficial in water-stressed regions, where water resources may be limited or previously allocated. The use of reclaimed water in cooling systems may also introduce additional regulatory, permitting, and operational considerations.

Surface water sources: Some data centers develop their own surface water withdrawals to meeting their cooling water needs by utilizing rivers, canals, lakes, or reservoirs that are available to the site. In western states, water rights are a consideration for this option.

The use of surface water is not without its challenges. Surface water use is typically subject to state and/or federal permitting requirements. Those requirements vary based on the source, volume of withdrawal, and intended use. Depending on the project, permits or authorizations may be required for water withdrawal, intake structures, treatment, and discharge. Even with permitting, seasonal variations and long-term trends, like sustained droughts, can impact surface water quality and consequently the operational challenge an on-site water treatment system faces, as well as supply reliability.

Combined solution advantages: While identifying potential water sources is important, many successful data center projects improve water reliability by combining multiple sources with water reuse and demand reduction strategies. The following example demonstrates how a community leveraged reclaimed water, alternative supplies, and advanced treatment technologies to reduce reliance on potable groundwater while supporting continued growth.

Expanding Supply Through Water Reuse in Quincy, Washington

In one of Washington's driest regions, the City of Quincy and Microsoft demonstrated that meeting data center water demands does not always require developing new potable water supplies. Instead, they created the Quincy Water Reuse Utility, a $31 million closed-loop reclaimed water system that captures cooling water blowdown from Microsoft's data center, removes dissolved minerals through advanced treatment processes, and returns the water for reuse in cooling operations (USEPA 2026i).

The project illustrates how communities can pursue multiple strategies to improve water reliability, including water reuse, alternative source development, and demand reduction. In addition to reclaimed water that would otherwise be discharged, the system supplements supply with surface water from the Columbia Basin Project and Quincy Irrigation District canals, reducing dependence on groundwater to only about 5 percent of make-up water needs. Operational since 2021, the utility saves approximately 138 million gallons of water annually while supporting continued industrial growth, improving cooling efficiency, and extending the value of existing water resources (USEPA 2026i).

Key Takeaway: Quincy demonstrates that reliable water supplies for data centers can be achieved through a portfolio of solutions, not just new water sources. By combining reuse, alternative water supplies, and operational efficiency improvements, communities can reduce demand on potable water systems while supporting sustainable economic growth.

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6.2 Cooling Water Quality Requirements

Cooling water quality requirements are established by the data center's cooling system design, heat exchanger metallurgy, equipment manufacturer specifications, and chemical treatment program (Chien et al. 2012, 024101). Utilities supplying water for cooling tower makeup can provide water quality information that can be evaluated against these requirements to determine compatibility and identify potential on-site water treatment needs (Soliman et al. 2022, 376; USDOE 2019).

The determination of whether on-site treatment is required is typically made by the data center developer, design engineer, or water treatment specialist. If the available water quality does not meet cooling system specifications, filtration, clarification, reverse osmosis (RO), or other treatment processes may be required. Table 4 summarizes typical cooling water quality parameters that are evaluated for a multitude of cooling systems.

Table 4 Water Quality Parameters Commonly Evaluated for Cooling Systems

Parameter	Why It Matters	Project-Specific Evaluation Basis	Monitoring or Treatment Implications
Hardness	Calcium and magnesium can form scale as COC and surface temperature increases	Source water range, target cycles, saturation modeling, metallurgy, and heat-transfer temperature	Softening, acid or antiscalant program, blowdown control, and trend monitoring
Alkalinity	Controls carbonate equilibria, buffering, scale potential, and response to acid feed	Seasonal source data, pH, hardness, target cycles, and treatment chemistry	pH and alkalinity monitoring, acid-feed control, and scale verification
pH	Influences corrosion, scale formation, disinfectant performance, and chemical speciation	Metallurgy, treatment program, concentration cycles, and discharge limits	Continuous or frequent monitoring, alarms, and chemical-feed interlocks where warranted
Chloride and Sulfate	Conservative ions concentrate in recirculating water and can increase corrosion risk	Source variability, concentration factor, metallurgy, temperature, and corrosion-control program	Conductivity or ion monitoring, corrosion coupons or probes, and blowdown control
TDS and Conductivity	Provide an operational indicator of dissolved-solids concentration and blowdown demand	Source water ionic composition, target cycles, equipment limits, and wastewater constraints	Conductivity-controlled blowdown with periodic laboratory confirmation
Silica	Can form difficult-to-remove deposits, especially at higher concentrations and temperatures	Reactive and total silica, pH, temperature, recovery systems, and vendor limits	Pretreatment, recovery limits, inhibitor selection, and deposit inspection
Iron and Other Metals	Can foul surfaces, promote deposition, stain equipment, and interact with treatment chemicals	Dissolved and total concentrations, corrosion products, source treatment, and reclaimed water quality	Oxidation, precipitation and/or filtration where applicable, and metals monitoring
Turbidity and Suspended Solids	Increase deposition, biofilm attachment, nozzle plugging, and heat-transfer resistance	Particle size and loading, airborne contamination, source type, and equipment tolerances	Filtration, side-stream treatment, basin cleaning, and turbidity trending
Microbial Indicators	Biofilm can impair heat transfer, and aerosolized systems can create *Legionella* exposure	Water-management program, source type, disinfectant demand, operating temperature, and aerosol pathways	Validated biocide program, monitoring, corrective-action triggers, and *Legionella* controls (Liang et al. 2021, 2852; USEPA 2026d; National Environmental Policy Act)
Temperature	Affects heat-transfer performance, scale kinetics, corrosion, microbial growth, and disinfectant demand	Seasonal source temperature, cooling-loop operating range, surface temperature, and equipment limits	Continuous or frequent monitoring, seasonal control settings, and source-switching procedures
Organic Matter and Nutrients	Can increase biological growth, disinfectant demand, fouling, and nutrient loading in blowdown	Source type, treatment level, total organic carbon or equivalent indicator, nitrogen and phosphorus, and concentration cycles	Source control, biological treatment or filtration where applicable, biocide validation, and trend monitoring
Treatment Chemicals and Disinfectant Residuals	Can interact with metallurgy, scale and corrosion inhibitors, microbial control, and wastewater limits	Chemical inventory, source disinfectant, feed rates, degradation products, compatibility testing, and discharge authorization	Feed interlocks, residual monitoring, material-safety controls, and change management
Observed System Performance	Confirms whether bulk water chemistry produces acceptable heat transfer, corrosion, deposition, and cleaning frequency	Approach temperature, pressure loss, inspections, coupons or probes, deposit analysis, cleaning history, and warranty criteria	Performance trending, root-cause investigation, operating-limit adjustment, and corrective-action verification

Hybrid and adiabatic cooling systems are typically more restrictive than open-circuit (wet) cooling towers because wetted media, spray nozzles, and finned heat exchangers can be more susceptible to scaling and fouling. Water quality requirements for hybrid and adiabatic cooling systems are highly dependent on manufacturer design and operating strategy. Final water quality criteria should be confirmed with the equipment manufacturer and water treatment specialist.

6.2.1 Cycles of Concentration (COC) and Constituent Balance

For a conservative constituent with negligible chemical addition, precipitation, volatilization, leakage, or treatment removal, the concentration ratio between recirculating water and makeup water approximates operating cycles. Many important constituents do not behave conservatively. Even basic constituents like calcium, alkalinity, phosphate, silica, iron, ammonia, organic matter, suspended solids, and treatment chemicals are subject to multiple processes. Constituents precipitate, react, volatilize, and degrade. There can be additional entry through chemical feeds or airborne deposition. Conductivity supplies a useful control signal, but it does not replace a constituent balance or periodic laboratory confirmation (USDOE 2019; Zhang, Theregowda, and Small 2014, 570-581; USDOE 2026).

The cooling design identifies the constituent or operating condition that limits concentration for each source and blend. A change from potable to reclaimed water can shift the limiting factor from hardness or silica to chloride, sulfate, nutrients, organic matter, microbial demand, or blowdown limits. In addition, variations in source water quality over time can alter the constituent that governs maximum COC. For example, hardness may control blowdown requirements during one period, while elevated chloride concentrations during drier periods or changes in source water blending may become the limiting factor at other times. Maximum operating cycles can therefore vary by season, source blend, cooling mode, or chemical program. The control strategy outlines the approved range, blowdown setpoint, alarm logic, sampling confirmation, and response to a quality excursion rather than relying on one universal concentration target.

6.2.2 Scaling, Corrosion, and Materials Compatibility

Mineral scale and particulate deposition reduce heat transfer, restrict flow, increase pressure loss, interfere with nozzles and fill, and create surfaces that support under-deposit corrosion and biofilm. Evaluation begins with seasonal source water chemistry and expected concentration, then considers surface temperature, pH, alkalinity, hardness, silica, phosphate, metals, suspended solids, treatment additives, and residence time. Saturation indices provide screening information, but precipitation kinetics, scale inhibitor interactions, and surface deposition can lead to complex decisions (Li et al. 2011a, 748-760).

Corrosion review covers every wetted material, including carbon steel, stainless steel, copper alloys, galvanized components, aluminum, elastomers, coatings, concrete, and dissimilar-metal connections. Relevant drivers include pH, alkalinity, chloride, sulfate, ammonia, dissolved oxygen, temperature, velocity, deposits, microbiological activity, oxidizing biocides, and inhibitor chemistry (Li et al. 2011b, 4195-4200). Acceptance criteria reflect the specific material, criticality, design life, and warranty rather than a universal corrosion-rate value.

Performance verification combines water chemistry with evidence from the equipment. Heat-exchanger approach temperature, pressure loss, basin and fill inspection, deposit analysis, test surfaces, cleaning frequency, corrosion monitoring, and chemical consumption can reveal deterioration that conductivity alone misses. Pilot testing with representative water can be particularly useful when the source serving the data center varies, the design operates near a saturation limit, reclaimed water supplies most of the makeup, or the project depends on a high concentration factor.

6.2.3 Microbial Control and *Legionella* Risk Management

Open cooling towers provide warm water, aeration, nutrients, surface area, and aerosol generation, creating conditions that require active microbial risk management. Reclaimed water can increase nutrient and microbial loading, and studies have detected *Legionella* in non-potable reclaimed water systems (Johnson et al. 2018, 15-27). Experimental work also indicates that biocide performance varies with temperature, ammonia, concentration cycles, source treatment, and recirculating water chemistry (Chien, Dzombak, and Vidic 2013, 324-332).

The facility water-management program should identify the system, responsible personnel, operating control limits, startup and shutdown procedures, idle-equipment practices, cleaning and disinfection, drift eliminators, chemical feed, monitoring, corrective actions, documentation, and response to suspected illness or loss of control (CDC 2025). Bulk water results, disinfectant residual, temperature, visual condition, deposit or biofilm evidence, and maintenance history can provide different forms of information; no single measurement establishes control under every condition.

6.2.4 Monitoring, Commissioning, and Change Control

The monitoring plan connects measurements to operational decisions. Flow meters identify each external source, on-site source, treatment product, cooling makeup, blowdown, and bypass. Continuous or high-frequency instruments commonly track conductivity, pH, temperature, flow, tank level, and selected disinfectant or oxidation-reduction parameters where those measurements support the approved control program. Periodic laboratory analyses confirm ionic composition, hardness, alkalinity, silica, metals, suspended solids, organic or nutrient indicators, and microbial parameters appropriate to the source.

Commissioning verifies the complete system under representative source, blend, load, and weather conditions. The test plan covers treatment capacity and recovery, water chemistry, concentration cycles, chemical feed, blowdown control, corrosion and deposition indicators, microbial controls, storage, redundancy, alarms, source switching, bypasses, and residual disposal. Where approval depends on a high concentration factor or a variable non-potable source, an agreed operating-demonstration period provides evidence before the utility reduces backup or wastewater capacity.

Ongoing reporting compares actual performance with the approved source and water-quality basis. A new source, changed blend, revised cooling mode, higher concentration cycle, modified treatment chemistry, sustained quality excursion, or repeated loss of microbial control should initiate a technical review and, where applicable, revision of the service agreement, discharge authorization, or operating limits.

6.3 Drought Risk and Supply Reliability

Data centers operate 24 hours a day, seven days a week with zero tolerance for service interruption. Most facilities require a 99.9 percent (or greater) uptime requirement. This includes evaluating both the facility's average-day and peak-day water demands in the context of the utility's existing system capacity, source water availability, seasonal demand patterns, and emergency supply capacities. This evaluation should consider not only normal operating conditions but also the utility's ability to reliably meet demand during periods of peak system usage, drought restrictions, infrastructure outages, and other supply disruptions (Cejudo, Pamintuan, Stoughton 2023; USDOE 2019). Key considerations include:

- Availability and reliability of supply sources under normal, peak-demand, and drought conditions.
- Interruptible versus firm service designations and their contractual implications.
- Drought contingency planning requirements and demand reduction obligations.
- Emergency and redundant supply sources available to maintain service reliability.

Utilities should encourage data centers to consider on-site measures to assure supply resiliency through on-site storage and water supply diversification.

6.3.1 Reliability Scenarios and Source Switching

Continuous data center operation does not automatically require firm water service at every forecast volume. The required reliability depends on cooling architecture, weather, IT load, on-site storage, alternative heat rejection, source diversity, and the customer's contractual tolerance for curtailment. The utility and developer should evaluate normal, maximum-day, heat-wave, drought, source-outage, treatment-outage, power-loss, commissioning, maintenance, and emergency conditions (AWWA 2021). Each scenario identifies available water, cooling demand, storage duration, operating response, notification, and resulting wastewater conditions.

The drought analysis aligns the facility with the utility's adopted stages and shortage-allocation rules. It defines phase-specific firm and interruptible volumes, reduction triggers, response time, enforcement, and restoration. An alternative source is only viable when access is legally sound, hydraulic access exists under drought conditions, and operational considerations including treatment capacity, water quality, storage, and operator readiness can be maintained during a drought. Reclaimed water production can decline or face competing uses, rainwater may be very limited during prolonged dry periods, and groundwater can face pumping or quality constraints.

Source switching creates hydraulic and water-quality transitions. A sudden change in hardness, alkalinity, chloride, sulfate, silica, disinfectant, ammonia, organics, or temperature can destabilize scale-control films, inhibitors, disinfectant residuals, and deposited material. The operating plan should define allowable blends, transition rates, chemical-feed adjustments, sampling, flushing or drainage, alarm limits, and authority to stop the transition. The service agreement should record the approved source hierarchy, delivery limits, quality envelope, monitoring responsibilities, notification, and change-control process (Campisano et al. 2017, 195-209).

7 Wastewater Characterization, Pretreatment, and Discharge Control

7.1 Wastewater Review Framework

Wastewater review for a proposed data center consists of an industrial-discharge capacity and compatibility assessment rather than as a routine sewer-connection review. Although the average discharge from some facilities may be modest, wastewater can contain concentrated dissolved minerals, cooling water chemicals, treatment residuals, or intermittent batch discharges that affect the collection system, publicly owned treatment works (POTW), treated effluent, reclaimed water production, or residuals management. The review should therefore consider wastewater flow, constituent concentration, pollutant mass loading, discharge timing, and abnormal operating conditions. It should also distinguish indirect discharge to a POTW, which is governed by the applicable Control Authority under federal, state, and local pretreatment requirements, from direct discharge to surface water, which requires separate National Pollutant Discharge Elimination System (NPDES) authorization (USEPA 2026a; USEPA 2011).

7.2 Wastewater Streams and Characterization Basis

Data center wastewater characteristics depend primarily on cooling configuration, makeup water treatment, chemical-management practices, and the degree of on-site water recovery (USDOE 2019). An evaporatively cooled facility commonly produces cooling-tower blowdown as its largest routine process-wastewater stream. Blowdown removes accumulated dissolved minerals from the recirculating cooling water and can contain elevated TDS, chloride, sulfate, hardness, silica, suspended solids, corrosion products, residual oxidants, nonoxidizing biocides, corrosion inhibitors, scale inhibitors, and other treatment chemicals (Ahmad et al. 2025, 115339). Concentrations generally increase with COC, although the resulting wastewater quality also reflects makeup water quality, chemical additions, side-stream treatment, drift, leakage, and operational control (Khatib et al. 2025, 48-53).

Increasing COC normally reduces blowdown volume but increases the concentration of conservative dissolved constituents in the remaining discharge. It therefore does not necessarily reduce the mass of every pollutant delivered to the sewer. Conductivity can be useful as an operational surrogate for dissolved mineral accumulation, but it should not replace laboratory measurement of TDS, chloride, sulfate, or other regulated parameters unless the Control Authority has approved a documented correlation.

On-site treatment can generate additional concentrated streams. RO or nanofiltration systems produce concentrate containing constituents rejected from the feed water, while ion-exchange softeners produce regeneration brine. Media-filter backwash, clarifier sludge, cartridge-filter drainage, membrane-cleaning solutions, and chemical-storage-area drainage can contain suspended solids, cleaning chemicals, acids, bases, antiscalants, metals, or other concentrated residuals. Water-recovery systems can reduce the volume of discharge while producing a smaller and more concentrated residual stream (Cejudo, Pamintuan, Stoughton 2023). Consequently, the ultimate management pathway for concentrate, sludge, spent regenerant, and cleaning wastes is an important facet of any reuse or recovery strategy.

Dry-cooled facilities generally have lower routine process-wastewater flows, but they cannot be assumed to be wastewater-free. Humidification systems, water-treatment equipment, equipment cleaning, closed-loop cooling-fluid replacement, and commissioning activities can still generate non-domestic wastewater. Hybrid facilities can produce seasonal blowdown and treatment residuals that vary with weather, IT load, and the operating mode selected by the facility.

Closed-loop liquid-cooling systems normally recirculate coolant rather than continuously discharging it. However, initial flushing, maintenance drainage, leaks, or complete coolant replacement can produce episodic wastes containing glycol, corrosion inhibitors, biocides, metals, suspended material, or proprietary additives. These fluids should be characterized from the product formulation and safety data sheets and should not be assumed to be equivalent to sanitary wastewater or uncontaminated noncontact cooling water.

Sanitary wastewater from employees and visitors are estimated separately from process wastewater. Construction and commissioning flows are also separated because they can include hydrostatic-test water, pipe and cooling-loop flushing, tower-basin drainage, disinfection water, construction dewatering, and initial water-treatment residuals. These temporary flows may have much higher short-term rates than normal operations and may require a temporary discharge authorization, controlled release schedules, equalization, off-site hauling, or another approved management method. Particular attention should be given to wastewater generated during passivation, cleaning, and disinfection activities, as these streams may contain elevated concentrations of corrosion inhibitors, disinfectants, metals, and other treatment chemicals. If not properly managed, these constituents can interfere with municipal wastewater treatment processes, impact biosolids management programs, or result in permit compliance concerns, necessitating additional pretreatment, monitoring, or alternative disposal methods.

7.3 Two-Stage Wastewater Characterization

Because actual wastewater does not exist before startup, pre-service review should begin with a predicted characterization, and be followed up with sampling when the facility is operational. The wastewater utility will need process-flow diagrams, a site water balance, discharge-point descriptions, anticipated average and maximum flows, batch volumes and frequencies, proposed COC, membrane recovery assumptions, source- and makeup water analyses, chemical inventories, safety data sheets, expected temperatures, proposed monitoring locations, and planned residual-disposal pathways (USEPA 2011). Information is needed to understand normal operation, seasonal modes, startup, maintenance, cleaning, upset conditions, spills, and emergency shutdowns.

The second stage should consist of controlled commissioning and initial operation sampling. Samples are collected after wastewater is generated but before unrestricted discharge is authorized. Sampling locations are selected to allow individual process streams to be evaluated before commingling, where practical. Initial monitoring includes commissioning, early ramp-up, expected stable operation, and materially different seasonal operating modes. The facility's predicted values can then be reconciled with measured flow, concentration, and mass-loading data. This information serves to inform any necessary adjustments to permit conditions if the actual discharge differs materially from the anticipated wastewater effluent (USEPA 2017).

The timeframe for monitoring is parameter-specific. Instantaneous or short-duration parameters such as pH, temperature, residual oxidants, and certain volatile constituents generally entail field measurements or grab samples (USEPA 2017). Parameters used to estimate representative daily loading may require

time- or flow-proportional composite samples. Sampling duration, preservation, analytical methods, detection limits, quality assurance, and the handling of nondetective results are established with the regulatory authority and will reflect the discharge pattern and applicable permit requirements.

7.4 Flow, Concentration, and Mass-Loading Evaluation

The analysis should include average-day, maximum-day, peak-hour, and event-based conditions. A low-flow stream can create an important slug load if it is released as a concentrated batch, while a larger but dilute stream may primarily create hydraulic-capacity concerns. The utility should combine the proposed project loads with existing POTW headworks loads and compare the result with treatment-process capacity, the POTW's maximum allowable headworks loading, the available industrial allocation, NPDES permit requirements, reclaimed water objectives, and residuals-management constraints (USEPA, 2004).

Commissioning discharges require a time-based hydrograph rather than a total volume only. The hydrograph should identify the expected start time, duration, peak rate, total volume, constituent concentrations, and proposed release controls. The utility can then determine whether the collection system and treatment plant can receive the discharge directly, whether it should be equalized and released at an allowable rate, or whether temporary storage and authorized off-site hauling are necessary.

7.5 Potential Effects on POTW Operations

TDS, chloride, sulfate, and other conservative dissolved constituents are generally not removed to a significant degree by conventional biological treatment. Their discharge can therefore negatively impact POTW operation, increase POTW effluent concentrations, affect receiving water or reclaimed water quality, contribute to corrosion or scaling under certain conditions, and limit downstream reuse options. Salinity effects should be evaluated through mass balance and, where treatment-process sensitivity is uncertain, through bench-scale or pilot-scale treatability testing.

Cooling-water chemicals can present different concerns. Residual chlorine, bromine, azoles, and nonoxidizing biocides may inhibit biological treatment or nitrification when delivered at sufficiently high concentrations. Phosphorus-containing corrosion or scale inhibitors can increase nutrient loading, while zinc or other metals may affect effluent or biosolids management. Cleaning solutions can produce extreme pH, elevated chemical oxygen demand, surfactants, solvents, suspended solids, or other constituents that differ substantially from routine blowdown. The chemical inventory and safety data sheets should therefore be reviewed together with expected dilution, reaction products, degradation behavior, and discharge frequency.

Elevated temperature can inhibit biological activity, while rapid changes in temperature, pH, flow, salinity, or toxicant concentration can create operational disturbances even when the long-term average load appears acceptable. High-flow discharges with relatively low nutrient and organic content may also disrupt biological treatment performance by diluting wastewater strength and altering the nutrient-to-biomass balance required for stable operation. Furthermore, cooling-system constituents may promote precipitation of inorganic solids within the treatment process, increasing inert solids accumulation, reducing active biomass fractions, and increasing solids wasting requirements. Elevated bicarbonate alkalinity and related water chemistry changes should also be evaluated because they may affect treatment performance, effluent quality, or whole-effluent toxicity outcomes. The assessment should

therefore examine peak and short-duration conditions rather than relying exclusively on monthly averages.

7.6 Pretreatment Classification and Permit Requirements

All nondomestic users introducing pollutants into a POTW are subject to the general and specific prohibitions in 40 Code of Federal Regulations (CFR) Part 403, regardless of whether they are classified as Significant Industrial Users or are subject to categorical standards. These prohibitions address discharges that cause pass-through or interference and prohibit conditions such as fire or explosion hazards, corrosive discharges, obstructive solids, interfering flow or pollutant loads, excessive heat, certain oils, toxic gases or vapors, and unauthorized hauled waste (USEPA 2026a).

Potential controls include equalization and flow pacing for hydraulic or batch-load management, pH adjustment, cooling, dechlorination or other residual-oxidant removal, clarification or filtration for suspended solids, precipitation for certain metals or phosphorus compounds, membrane treatment for water recovery, and segregation or authorized hauling of concentrated brines and cleaning solutions. These are evaluation options rather than universal design requirements. The appropriate treatment train should be selected from representative wastewater data, permit limits, residuals-management requirements, reliability objectives, and treatability testing (Ahmad et al. 2025, 115339).

A pretreatment system that transfers pollutants from one liquid stream to another does not, by itself, resolve the discharge issue. RO, for example, can produce reusable permeate while concentrating salts and treatment chemicals in the reject stream. The potential for concentrated pollutant loadings necessitates a complete mass balance showing the fate of water and pollutants through the proposed treatment system, including sludge, spent media, concentrate, cleaning waste, and any hauled residuals.

8 Water Reuse Integration, Minimum Liquid Discharge, and Zero Liquid Discharge

Water reuse is a part of an integrated water-management strategy. Evaluating water reuse opportunities begins with demand reduction and cooling-system optimization, proceeds to feasible on-site reuse and externally supplied reclaimed water, and considers blowdown recovery, minimum liquid discharge (MLD), or zero liquid discharge (ZLD) only after the lower-complexity measures have been assessed (USDOE 2026). This sequence is important because additional treatment can reduce freshwater withdrawals or liquid discharge while increasing electricity consumption, chemical use, operator workload, and solid-residual generation. The preferred strategy is therefore the one that provides the required reliability and environmental performance at the lowest lifecycle burden, not necessarily the one that produces the highest nominal water-recovery percentage (Tong and Elimelech 2016, 6846-6855).

8.1 Planning and Accounting Framework

Water-reuse planning begins with a facility-wide water balance that distinguishes potable water, municipal reclaimed water, on-site-collected water, internally recovered water, total withdrawals, evaporative consumption, liquid discharge, concentrate, and solid residuals. These flows are assessed based on average-day, maximum-day, seasonal, commissioning, maintenance, drought, and utility-outage conditions. Internal water reuse is not a new supply, and potable water substitution is not automatically characterized as a reduction in total water consumption. For example, using reclaimed municipal effluent as cooling-tower makeup can reduce potable demand, but the evaporated portion remains consumptive use and may reduce return flows available to downstream users or environmental systems (Purcell et al. 2021, 04021021).

Cooling-tower optimization generally precedes the installation of advanced recovery systems. Cooling-tower makeup water volume is approximately equal to evaporation, blowdown, drift, and other losses, while the required blowdown depends on the allowable COC and the chemistry of the makeup and recirculating water. Conductivity control, makeup and blowdown metering, leak correction, side-stream filtration, appropriate chemical treatment, and optimization of temperature and humidity setpoints can reduce avoidable demand before capital-intensive reuse is considered. The acceptable COC will reflect site-specific scaling, corrosion, deposition, and biological-growth constraints (USDOE 2019).

8.2 Cooling-Tower Blowdown Recovery

Cooling-tower blowdown can be treated and returned as makeup water, but its recoverability depends on the composition of the source water, concentration cycles, airborne contamination, treatment chemicals, and operating conditions. Characterization considers conductivity, TDS, hardness, alkalinity, silica, chloride, sulfate, suspended solids, organic carbon, corrosion inhibitors, scale inhibitors, oxidizing and nonoxidizing biocides, and relevant microbial parameters. Sampling should represent seasonal conditions, startup and shutdown events, cleaning periods, and the different makeup water sources that

may be used during drought or utility interruptions (Soliman et al. 2022, 376; Koeman-Stein et al. 2016, 11-17; Davood Abadi Farahani, Borghei, and Vatanpour 2016, 188-199).

There is not a universal recovery percentage to assign to blowdown treatment. The design recovery is derived from a constituent mass balance, saturation modeling, pilot results, treatment system requirements, equipment availability, and the authorized discharges of the resulting concentrate or residuals.

The selected reuse approach may range from simple conditioning and storage to advanced treatment, depending on the intended reuse application and associated water quality objectives. Because cooling-system blowdown is an industrial wastewater stream, opportunities for beneficial reuse may exist that are not subject to the same treatment requirements as discharging it to sewer, when the stream is segregated, managed separately, and directed to appropriate industrial, irrigation, or other non-potable uses. The design should also account for chemical consumption, treatment residuals, equipment replacement, cleaning waste, power demand, operator qualifications, storage, redundant trains, bypass conditions, and the space required for retrofits. Recovery claims are stated as expected operating ranges under defined feed water and loading conditions, with separate values for gross treatment recovery and net facility-level reduction in external water demand (USDOE 2019). When all of these metrics are taken into account, the data center can more accurately define a path to blowdown recovery success, as demonstrated in the following example.

Evaluating Multiple Water Options to Create Shared Value: Northeast Louisiana

In 2024, Carollo worked with a data center developer and a local municipality in Northeast Louisiana to evaluate multiple make-up water sources, cooling tower configurations, blowdown treatment options, and wastewater management strategies for a large industrial development. The team compared alternative treatment scenarios, assessed lifecycle costs, and examined centralized versus decentralized infrastructure approaches.

The analysis found that the greatest long-term benefit came from a centralized industrial and sanitary wastewater treatment system that could serve existing industries, future data center growth, and planned residential development. By directing multiple wastewater streams to a shared facility, the project improved treatment performance, created economies of scale, and reduced the need for separate treatment systems. The resulting solution, financed by the data center owner and ultimately owned and operated by the municipality, demonstrates how communities can evaluate a range of water and wastewater alternatives and identify a single strategy that supports economic development, utility resilience, and long-term growth for all stakeholders.

Key Takeaway: Industrial wastewater infrastructure should be evaluated with future expansion in mind. Early planning creates opportunities to optimize treatment capacity, system layout, and lifecycle costs. Additionally, shared treatment infrastructure can provide both technical and economic advantages when multiple industrial and residential users are located within the same service area.

8.3 Centralized Reclaimed Water

Centralized reclaimed water (provided by a water system) can provide a fit-for-purpose cooling supply where sufficient treatment capacity, distribution infrastructure, and year-round supply are available. It should not, however, be assumed to be the preferred source in every location. The utility and developer should compare reclaimed water with conservation, on-site reuse, potable supply, regulatory frameworks, and other alternatives using consistent criteria for reliability, cost, water quality, energy use, environmental effects, and infrastructure requirements.

Reclaimed water quality can differ substantially from potable water. Higher concentrations of chloride, sulfate, hardness, silica, nutrients, organic matter, and microorganisms can alter allowable COC and increase corrosion, scaling, biofouling, disinfectant demand, or drift-related concerns. Compatibility can be evaluated through water-quality modeling, materials review, treatment-vendor input, and testing under expected concentration cycles. Because cooling towers generate aerosols, microbial control should include consideration of *Legionella*, disinfectant residual, storage conditions, monitoring, and coordination with the facility's water-management program (Johnson et al. 2018, 15-27; Hsieh et al. 2010, 2345-2356).

The reclaimed water evaluation will need to address seasonal production, hydraulic capacity, pressure, storage, outage frequency, drought response, backup water arrangements, dual-distribution piping, cross-connection protection, and responsibility for supplemental treatment. It is also important to understand whether diverting wastewater effluent to a consumptive cooling use would affect permitted discharge, downstream flows, environmental commitments, or other reclaimed water customers (Purcell et al. 2021, 04021021). Geographic proximity alone does not establish feasibility; pipeline routing, pumping, retrofit requirements, water-quality compatibility, and lifecycle costs must be considered (Stillwell and Webber 2014, 4588-4595).

A data center could serve as an anchor customer for a community reclaimed water system when its long-term demand can support shared infrastructure. The service agreement should address capacity allocation, minimum and maximum deliveries, phased development, demand changes caused by cooling-technology upgrades, credit support, infrastructure cost recovery, supply interruptions, and end-of-life or decommissioning obligations. Loudoun Water illustrates both the opportunity and relevant constraints. Its reclaimed water system supplies industrial cooling, including data center demand, while proposed connections remain subject to supply availability, hydraulic limitations, program objectives, and utility capacity-allocation decisions (Loudoun Water 2025).

8.4 Minimum and Zero Liquid Discharge

For this report, MLD refers to a high-recovery treatment strategy that minimizes the remaining liquid residual without requiring its complete elimination. ZLD refers to a facility boundary condition under which no routine liquid wastewater leaves the defined system boundary. ZLD is not a single treatment technology. A typical configuration may combine pretreatment, membrane desalination, secondary brine concentration, thermal evaporation, crystallization, and management or beneficial use of the resulting solids (Liang et al. 2021, 2852).

ZLD does not indicate zero waste or zero environmental impact. It transfers constituents that would otherwise remain in a liquid discharge into concentrated brine, sludge, crystallized salts, air emissions, or other residual streams. Assessment of ZLD therefore includes electrical and thermal energy demand, greenhouse-gas emissions, chemical consumption, scaling and corrosion, cleaning waste, equipment reliability, noise and air-permitting implications, residual characterization, transportation, disposal capacity, and the potential for beneficial salt recovery. Proposed by-product recovery are credited only when product quality, market demand, regulatory status, and a reliable purchaser have been demonstrated (Tong and Elimelech 2016, 6846-6855).

A universal ZLD recovery percentage should not be used for utility planning. Achievable recovery depends on feed salinity, silica and hardness, organic constituents, temperature, pretreatment, concentration limits, crystallizer performance, and system availability. In some settings, an MLD configuration may provide most of the water-supply and discharge benefits of ZLD with lower energy use and operational risk. Deciding to utilize MLD or ZLD entails comparing conventional discharge, high-recovery treatment, MLD, and ZLD on a common lifecycle basis (Stillwell and Webber 2014, 4588-4595).

The utility should not reduce reserved wastewater capacity solely on the basis of a proposed ZLD design. Capacity commitments are needed sufficient for commissioning water, equipment cleaning, membrane replacement, startup and shutdown, maintenance, upset conditions, and emergency bypass unless an alternative authorized pathway has been demonstrated. Any reduction in wastewater capacity would follow successful commissioning and an agreed upon period of full-scale operation. The operating agreement defines notification, sampling, hauling, containment, and discharge requirements for planned and unplanned residuals (Loudoun Water 2025).

8.5 Implementation, Monitoring, and Verification

The municipality or utility should develop water-reuse and ZLD commitments through progressively more detailed water, constituent, energy, chemical, and residuals balances. Conceptual planning would identify sources, uses, regulatory pathways, and fatal flaws. Detailed design then defines treatment performance, storage, redundancy, bypasses, monitoring, residuals outlets, and lifecycle cost. Commissioning verifies the complete system under representative loads. Then post-commissioning monitoring is used to determine whether projected savings remain achievable as IT load, cooling configuration, makeup water quality, and treatment performance change.

Permanent meters on each external source, cooling-tower makeup, blowdown, recovered water production, concentrate, sanitary discharge, and every emergency or bypass flow will provide a reliable understanding of actual water quantities used. Monitoring conductivity and relevant water-quality parameters at locations appropriate to process control and compliance allow evaluation of actual operating conditions against the system design. Reporting distinguishes source substitution, total withdrawal reduction, consumptive use, recovered water production, liquid discharge, energy demand, chemical consumption, and solid-residual mass. Performance should be reconciled periodically against the approved water balance, with change-control provisions for expansions, cooling-system modifications, treatment changes, or sustained departures from the forecast. Table 5 summarizes the approaches for water reuse and ZLD.

Table 5 Considerations for Water Reuse, MLD, and ZLD

Approach	Primary Objective	Residuals and Tradeoffs
Cooling Optimization and COC Control	Reduce avoidable makeup and blowdown before adding treatment	Increased chemical-control requirements or risk of deposition if limits are exceeded
Blowdown Recovery	Return treated blowdown as cooling makeup	Concentrate, cleaning waste, membrane replacement, energy use, chemical use, and additional operator workload
On-site Collection and Reuse	Substitute locally available non-potable sources for external supply	Variable supply, storage turnover, overflow, treatment residuals, and backup water demand
Municipal Reclaimed Water	Reduce potable water demand using centralized treated effluent	Corrosion, scaling, biofouling, microbial risk, supply interruptions, and potential stranded infrastructure
MLD	Obtain high recovery while retaining a manageable liquid-residual pathway	Concentrated liquid residuals, cleaning streams, chemicals, power demand, and operational complexity
ZLD	Eliminate routine liquid discharge within a defined facility boundary.	High energy and capital requirements, greenhouse-gas emissions, solid waste, cleaning waste, air impacts, and outage risk
Waste-heat Integration	Offset treatment or external heating energy using recoverable data center heat	Additional capital, pumping energy, backup requirements, contractual risk, and limited seasonal demand

9 Financial Frameworks, Rate Structures, and Cost Recovery

When a large industrial user, such as a data center, wants to connect to a water system, the evaluation should consider whether existing ratepayers could be exposed to new capital costs, higher peak-demand costs, or stranded asset risk (AWWA 2014). The core financial objective is to ensure the project pays for the infrastructure and service it requires, rather than shifting those costs to the broader customer base. This cost-causation objective is consistent with accepted water utility rate-making principles in AWWA's 7th edition of the *M1 Manual: Principles of Water Rates, Fees and Charges* as well as the 8th edition *M1 Manual: Water Rates, Fees and Charges* (AWWA 2017b; AWWA 2025b).

The first issue is capacity cost recovery. Data centers can require major upsizing of water mains, storage, pumping, treatment, and wastewater treatment and conveyance, so the analysis should distinguish project-specific costs from shared system improvements. Project-specific costs are usually best recovered directly from the customer through developer-funded construction, contributions in aid of construction, or reimbursement agreements. The distinction between direct customer costs and shared system costs should be documented in the utility's cost-of-service and capital-cost-recovery methodology (AWWA 2017b; AWWA 2025b).

The second issue is rate design. A standard flat volumetric rate often under-recovers the fixed cost of serving a large, high-load customer, especially when demand is highly concentrated. Utilities often need a combination of fixed, capacity- or demand-related, and volumetric charges so that the customer contributes to both system readiness and actual usage, consistent with cost-of-service rate design principles (AWWA 2017b; AWWA 2025b).

The third issue is demand uncertainty. Data center designs can change quickly, and actual water use may differ from preliminary engineering estimates. That creates financial risk if the utility builds too much capacity too early or prices the project too low, so contracts should include true-up provisions, phased service commitments, and minimum annual charges where appropriate. Financial planning tests projected demands and revenues so that rates and charges are sufficient to support the utility's adopted financial requirements (AWWA 2017b; AWWA 2025b).

With respect to data center cooling system water demand, historically, data centers reach end of life when major mechanical systems require replacement. Today, end of facility life is more often a function of thermal significance. A facility is effectively at end of life when its cooling architecture cannot economically scale to future power densities, making thermal constraints the primary driver of retrofit, repurposing, or replacement decisions. The data center will align depreciation and investment horizons with the facility's expected thermal viability rather than its physical or mechanical lifespan. This same financial reality can inform the utility's approach to its own risk management decisions.

9.1 Financial Framework

The financial framework should distinguish among three cost categories: customer-specific facilities, shared system capacity, and ongoing operations and maintenance. This categorization is consistent with the M1 framework for identifying and allocating capital, customer-related, and operation and maintenance costs (AWWA 2017b; AWWA 2025b). Customer-specific improvements, such as dedicated mains, pumps,

meters, service lines, or local lift station upgrades, should generally be recovered directly from the project through upfront contributions, reimbursement agreements, or developer-funded construction (see ACWWA Case Study). Shared system costs, including treatment plant capacity, trunk mains, storage, and regional conveyance, should be recovered through lawful capacity-based fees, system development charges (SDC), or rate mechanisms that reflect the customer's proportional share of capacity-related costs, as permitted by applicable law (AWWA 2017b; AWWA 2025b).

For ongoing service, a rate structure that distinguishes fixed, capacity-related, and variable costs can better align recovery with the costs of serving a large-volume customer so that large-volume customers pay their fair share of system readiness, not just gallons consumed. This separation reflects M1's distinction between costs that vary with consumption and costs incurred to maintain customer service and system capacity (AWWA 2017b; AWWA 2025b). This is especially important for data centers because their demand can be very large, highly concentrated, and sensitive to cooling design, seasonal weather, and future technology changes. A well-designed framework should also include periodic reassessment so that charges remain aligned with actual demand over time.

The available mechanisms depend on the utility's governing law, charter, adopted rates and fees, bond covenants, procurement requirements, accounting policies, tax treatment, and governing-board authority. A mechanism that is lawful for one municipal utility may not be available to a special district, investor-owned utility, authority, or utility in another state. System-development charges, special contracts, capacity-reservation fees, customer advances, contributed assets, and project surcharges should therefore be evaluated with financial and legal counsel before they are offered or incorporated into a service commitment. California illustrates the importance of jurisdiction-specific review because water charges there are subject to constitutional cost-of-service limitations that may not apply in the same form elsewhere (Grimm, Green Nylen, and Kiparsky 2026).

A supplemental service or development agreement may address project-specific risks that are not covered adequately by standard tariffs, but it should supplement rather than conflict with adopted utility rules. Economic-development incentives, tax arrangements, or community-benefit commitments should be accounted for separately from utility cost recovery.

9.2 Rate Structures and Limitations

The applicable rate structure may use an existing customer class, a dedicated industrial schedule, a negotiated service agreement, or a lawful combination of these mechanisms. The cost-of-service analysis determines whether fixed, volumetric, demand-related, or capacity components correspond to the service's actual cost drivers. For reclaimed water, dual supply, or another nonstandard arrangement, the tariff and agreement allocate capital, operations, maintenance, backup supply, and emergency-response costs explicitly. The selection and design of such charges should be based on functionalized, classified, and allocated costs, consistent with M1 cost-of-service practices (AWWA 2017b; AWWA 2025b).

Wastewater rate analysis distinguishes domestic-strength flow from discharges that create additional collection, monitoring, pretreatment, treatment, or residuals-management costs. Authorized strength-based charges, special-waste fees, monitoring charges, or discharge limits can recover documented incremental costs and protect other customers from cost shifting. Metering and billing provisions also account for consumptive use, reuse, and any approved wastewater flow credit. These charges should be supported by documented incremental cost causation and the utility's legal authority (AWWA 2017b; AWWA 2025b).

A cost-supported industrial rate can combine a monthly fixed charge, a volumetric commodity charge, and, where warranted, a capacity or demand component. The fixed charge can recover customer, meter, billing, and readiness costs; the volumetric charge can recover costs that vary with use; and a defined capacity or demand determinant can recover peak-related or reserved-capacity costs. A minimum bill can address documented fixed exposure during ramp-up without requiring physical consumption of a minimum volume. This multi-part rate design is consistent with M1's discussion of fixed charges and usage-based charges in relation to underlying cost drivers.

A separate class or customized industrial rate may be warranted where service characteristics, cost drivers, or financial exposure differ materially from those of existing customer classes. The separate classification should be supported by material differences in service characteristics and cost responsibility (AWWA 2017b; AWWA 2025b). Seasonal or peak-demand pricing can reflect documented maximum-day or maximum-hour cost causation. Conservation requirements, reclaimed water options, and alternative supply commitments can complement the rate structure where authorized and operationally feasible.

Cost recovery follows documented cost causation and benefit rather than a universal allocation rule. When a data center requires new transmission, treatment, storage, or conveyance capacity, authorized connection fees, capacity charges, capital contributions, customer advances, or reimbursement agreements can recover the applicable project share. Funding dedicated facilities does not eliminate an authorized charge for shared capacity, but the calculation accounts for applicable credits and avoids duplicate recovery (AWWA 2014). M1 supports assigning costs based on documented cost causation and avoiding duplicate recovery through appropriate credits or offsets (AWWA 2017b; AWWA 2025b).

Cost recovery also addresses the risk of uncertain or changing demand. A defined true-up can reconcile charges when verified demand, capital cost, project timing, or service conditions depart materially from the approved basis. Reassessment occurs at specified phase gates or material-change triggers, such as a cooling-technology change, schedule delay, ownership transfer, sustained demand variance, observed adverse interactions of wastewater discharges with existing processes and infrastructure, or revised wastewater loading, rather than at an unsupported universal interval. Such reassessment helps maintain the alignment between rate/fee assumptions, service characteristics, and cost recovery (AWWA 2017b; AWWA 2025b).

9.3 System Development Charges

System Development Charges (SDCs), or impact fees, are a central tool for recovering growth-related capital costs because they allow the utility to collect the cost of expansion before service is delivered. M1 provides recognized framework for determining growth-related capital cost recovery through connection, capacity, and development-related charges, subject to state and local law. For very large customers, the utility may also need a separate resource acquisition fee if the project requires acquisition of new water rights, supply contracts, or source development beyond ordinary distribution and collection capacity. Where wastewater pretreatment or elevated biochemical oxygen demand/total suspended solids removal is needed, the utility can apply surcharges or separate industrial pretreatment charges tied to the added treatment burden (Cohen, Beyer, and Shwisberg 2026).

Infrastructure can be funded up front or amortized over time. Upfront recovery reduces the risk that existing customers are left carrying debt if the project is delayed, downsized, or abandoned. That concern is especially important for data centers because the long-term demand profile may not be as stable as that of a traditional institutional or manufacturing customer. The timing of recovery should be evaluated in relation to financial sufficiency, intergenerational equity, and the risk that future revenues may not materialize as forecast (AWWA 2017b; AWWA 2025b).

Traditional utility rate structures and development-charge methodologies are generally built from historical demand data, demand projections, and customer classifications; atypical large loads can require a separate assessment of their service characteristics and cost causation (AWWA 2017b; AWWA 2025b). Data centers are atypical in several critical ways (Navarro and Knoll 2026; Energy Systems Integration Group Large Loads Task Force 2025):

- For standard evaporative systems with constant recirculation and consistent IT loads, demand is typically non-diurnal and non-seasonal for evaporative systems; constant 24 hours a day, 7 days a week load.
- MDD can be 1.5 to 2.5 times ADD for hybrid systems.
- Full buildout demand may be significantly greater than initial phase demand.
- Facility closure or technology change can result in rapid demand reduction, creating stranded asset risk.

Revenue concentration risk: In a smaller community, a single data center may account for a substantial share of the utility's annual water and wastewater revenue—potentially comparable to, or greater than, the revenue generated by a large portion of the residential customer base. If the facility reduces operations, improves water efficiency, shifts to an alternative water source, closes, or otherwise lowers its utility use, the resulting revenue loss may be difficult to absorb without increasing rates for remaining customers, drawing on reserves, or deferring planned system improvements. Available rate and funding mechanisms can combine authorized capacity charges, direct facility funding, recurring fixed and volumetric charges, demand-related components, and contractual security. A cost-of-service analysis will support selection of appropriate mechanisms by evaluating relevant customer, capacity, and usage cost drivers (AWWA 2017b; AWWA 2025b). Selection follows the cost-of-service analysis, governing law, and the project's phase-specific risk profile (Cohen, Beyer, and Shwisberg 2026). Where the utility has legal authority, an SDC or capacity charge follows the adopted methodology, demonstrates nexus and proportionality, reflects the customer's capacity requirement, and applies authorized credits. Common SDC components are listed in Table 6.

Table 6 SDC Components

Component	Basis for Calculation	Data Center Consideration
Source Water Capacity	Permitted and dependable supply capacity allocated to the project	Phase-specific demand, drought reserve, competing uses, and backup supply
Water Treatment Capacity	Treatment capacity allocated at the applicable peak-demand condition	Peak demand, raw water variability, process compatibility, and redundancy
Transmission and Distribution	Pipe, pump-station, pressure-zone, and storage capacity allocated to the project	Dedicated facilities, rightsizing, fire flow, water age, and phased construction
Wastewater Collection	Hydraulic conveyance capacity allocated to routine and event discharges	Flow timing, batch releases, force-main or gravity-system constraints, and equalization

Component	Basis for Calculation	Data Center Consideration
Wastewater Treatment	Treatment and residuals capacity allocated by flow and constituent load	TDS and pollutant loading, biological treatment impacts, local limits, monitoring, pretreatment, and residuals cost
Future Expansion	Capital improvements attributable to later project phases	Milestones, reservation terms, reassessment triggers, and release of unused capacity

Notes:
(1) The applicable method for assigning costs to each component follows the utility's adopted cost-of-service and capital-cost-recovery methodology (AWWA 2017b; AWWA 2025b). Data center-specific considerations are illustrative and require engineering, legal, and financial validation.

9.4 Alternatives to SDCs

When a state statute or regulator prohibits (or tightly constrains) SDCs or impact fees, utilities typically pivot to other legally permissible mechanisms that still tie new-growth costs to new customers or beneficiaries. Below are the most common approaches and when they are typically used.

Identify a legally allowable charge:

Many jurisdictions allow "connection fees," "capacity reservation fees," "facilities charges," or "reimbursement agreements" even when "impact fees/SDCs" are restricted. The key is to structure them as:

- Capital recovery/connection charges for the incremental facilities needed to serve a specific parcel or customer (often allowed under utility tariff authority).
- Reimbursement/buy-in agreements where later users reimburse earlier users for oversizing, rather than a generalized development fee.

Use special assessments or local improvement districts:

- If SDCs are barred, many states will allow special assessments or local improvement districts (local improvement districts/municipal improvement districts/utility development fees) that levy charges on properties that benefit from specific infrastructure.

Developer-funded infrastructure and dedication:

- The developer (or anchor tenant) designs, finances, and constructs the needed extensions and capacity, then dedicates them to the utility.
- Common tools: Developer agreements, off-site improvement agreements, and dedication ordinances.
- Utility avoids debt; developer bears upfront cost and risk. This is often the simplest path when SDCs are prohibited.

Capacity reservation or "take-or-pay" contracts:

- For large users (e.g., data centers, industrial parks), use long-term capacity reservation agreements with fixed monthly/annual payments that amortize the capital cost.
- Payments can be structured to cover debt service on the incremental facilities, effectively replacing an SDC with a contractual revenue stream.
- Include termination fees sized to cover remaining debt to protect credit.

Rate-based surcharges or tariff riders (where allowed):

- Some states permit rate surcharges, riders, or zone rates targeted to new customers or specific service areas, even if stand-alone SDCs are barred.
- These options must be carefully designed to avoid cross-subsidizing existing customers and to meet "just and reasonable" standards.
- A cost-of-service study showing the incremental cost of serving new demand is often necessary.

9.5 Cost-of-Service Analysis

A cost-of-service analysis is a foundational financial planning tool that assigns utility costs to the customer classes and services that generate them. It supports equitable rate design, full cost recovery, and long-term financial stability by identifying fixed, variable, and demand-related costs and linking those costs to appropriate fees and rates. For large industrial users or wholesale customers, including data centers, the analysis is especially important because it provides the basis for capacity-based charges, special service agreements, and other measures needed to prevent cost shifting to existing customers. AWWA M1 identifies cost-of-service analyses as a core method for developing equitable, adequate, and defensible utility rates and charges.

Utilities can use a cost-of-service analysis, supplemented by project-specific engineering and financial analysis, to evaluate the costs associated with a data center customer or customer class, accounting for:

- Capital investment in new or upgraded infrastructure.
- Operations and maintenance costs attributable to the facility.
- Replacement reserve contributions.
- Reliability upgrade costs (redundancy, backup power, emergency storage).
- Administrative costs for monitoring, reporting, and permit compliance.
- Financial contingency, reserve, coverage, or contractual security requirements associated with material uncertainty in projected demand, timing, or revenue recovery.
- These items should be identified, functionalized, and allocated to the appropriate customer, capacity, and usage cost drivers (AWWA 2017b; AWWA 2025b).

9.6 Revenue Risk Management

Before committing to major capacity expansions, utilities can evaluate stranded-asset exposure under alternative demand, timing, and technology scenarios. If the data center closes, scales back, or shifts cooling technology, the utility may be left with debt service and maintenance costs for oversized facilities. That is why many utilities prefer phased buildout, contract minimums, security deposits, or reserved-capacity payments for very large demands (Energy Systems Integration Group Large Loads Task Force 2025). The rate and financial-planning analysis should evaluate whether projected revenues are adequate to support the utility's financial obligations under plausible changes in demand and service conditions (AWWA 2017b; AWWA 2025b).

The utility should also review legal and policy constraints on customized rates and SDCs, special contracts, and large-user discounts. Any special arrangement should still be supported by a cost-of-service rationale and documented to demonstrate that existing customers are not subsidizing the new demands. This is consistent with broader large-user rate practices, which increasingly emphasize cost

reflectivity and explicit treatment of system risks (Navarro and Knoll 2026). This approach reflects M1's reliance on cost-of-service support and equitable allocation among customers and customer classes.

Municipalities face significant revenue risk from data center customers due to demand volatility, technology change, and facility closure. The following tools are contractual and financial safeguards that may complement, but are not specifically prescribed by AWWA M1:

- **Minimum annual revenue guarantees:** Potential revenue-protection tools include minimum annual revenue guarantees regardless of actual consumption (take or pay incorporated into any agreement).
- **Demand ratchet provisions:** Billing based on maximum metered demand in a rolling 12-month period.
- **True-up mechanisms:** Annual reconciliation of actual versus projected demand with rate adjustments.
- **Infrastructure reimbursement agreements:** Requiring upfront or phased reimbursement for dedicated infrastructure.
- **Stranded asset provisions:** Depending on the magnitude and duration of exposure, the utility may consider security deposits, letters of credit, parent guarantees, cash reserve accounts, or other financial assurances for infrastructure that would be stranded upon facility closure.

The resulting revenues and commitments would be reflected in the utility's revenue requirement, financial plan, and cost-of-service analysis as applicable.

The service agreement may include contractual, financial, and operational safeguards that align cost recovery with the project's system and revenue risks that align cost recovery with actual system risk, including phased commitments, security for capital recovery, and clear reassessment triggers if project demand, cooling technology, or supply conditions change materially. Furthermore, as utilities evaluate service agreements with large water users such as data centers, establishing a transparent and equitable cost recovery framework is critical.

9.7 Planning Safeguards

These safeguards should be integrated with the utility's adopted financial policies, rate design, and cost-of-service framework. A practical risk management package should include these safeguards:

- A phased connection agreement tied to specific milestones.
- Upfront capital contributions or dedicated facility funding.
- Minimum monthly bills or reserved-capacity charges.
- Security deposits, letters of credit, or parental guarantees.
- True-up provisions for actual versus estimated demands.
- Clear pretreatment, discharge, and curtailment language.
- Periodic reassessment of water supply, wastewater capacity, and rate impacts.

Table 7 provides a step-by-step process that utilities can refer to when a large industrial user or data center seeks water or wastewater service.

Table 7 Data Center Water Utility Financing Checklist

Item	Checklist
1	Review data center developer requests.
2	Collaborate with planning commissions and other relevant local government entities.
3	Confirm service need and parcel scope.
4	Estimate water and wastewater treatment demand.
5	Evaluate system fundamentals and consider stakeholder input.
6	Identify system impacts and required upgrades.
7	Separate customer-specific and shared costs.
8	Perform cost of service analysis.
9	Select rate class and service terms.
10	Set connection fees and capacity charges.
11	Define monthly fixed and volumetric rates.
12	Add true-up, minimum bill, and security.
13	Review legal and policy approval.
14	Execute service agreement.
15	Monitor actual usage and reassess.

10 Contractual Provisions and Development Agreements

10.1 Requirement for Formal Development Agreements

A large data center project can create concentrated water demand, wastewater loading, capital obligations, and long-lived operating risk that are not fully addressed by a utility's standard application or commercial-service form. A negotiated development or special-service agreement should translate the approved water balance, capacity analysis, infrastructure plan, financial framework, wastewater controls, and community commitments into enforceable responsibilities (Grimm, Green Nylen, and Kiparsky 2026, 65). Such agreements protect existing customers and utility reliability, while providing the developer with a clear path from preliminary review through phased construction, operation, expansion, and closure. The form and legal name of the instrument vary by jurisdiction, and some utilities may implement the same protections through several coordinated documents rather than one agreement (Audit and Review Commission 2024; City of Aurora, Colorado 2025).

The agreement should allocate risk rather than implying that every forecast or operational condition can be guaranteed. It should state which party controls each decision, identify the assumptions supporting the service commitment, define how performance will be measured, outline the course of action when assumptions change, and detail how public costs are recovered if the project is delayed, downsized, transferred, or abandoned. The following provisions should serve as a planning framework, not as legal advice or a universal contract form. Utility counsel will need to conform agreement provisions to enabling law, adopted tariffs and ordinances, rate-setting authority, bond covenants, procurement requirements, land-use approvals, environmental permits, public-records law, and the utility's actual capacity and operating practices (USEPA 2026b; USEPA 2026a).

10.2 Contractual Architecture and Order of Precedence

The parties must first identify the complete legal and administrative architecture. Adopted ordinances, tariffs, rate resolutions, utility rules, engineering standards, and permits generally establish obligations that a negotiated agreement cannot waive unless the governing authority has lawfully authorized a variance. The development or special-service agreement can then address project-specific phasing, facilities, funding, capacity, security, and remedies. Technical exhibits supporting the agreement provisions include the approved water balance, demand envelope, hydraulic criteria, wastewater characterization, infrastructure drawings, construction milestones, metering plan, and reporting forms.

The agreement should include an order-of-precedence clause that resolves inconsistencies without purporting to override controlling law. A practical hierarchy may place applicable statutes, regulations, permits, and adopted utility rules first; the executed agreement and approved amendments next; and technical exhibits, plans, schedules, and developer submittals thereafter. The hierarchy should distinguish a conflict from a later lawful change in rates, standards, or regulatory requirements. It also should identify which provisions survive a change in a tariff or ordinance, subject to the governing body's authority and any constitutional limitations on binding future legislative action.

Projects commonly require multiple coordinated instruments. A development agreement may allocate capacity and capital responsibility, a service agreement may establish connection and billing terms, a main-extension or reimbursement agreement may govern contributed facilities, an easement may secure access, a pretreatment control mechanism may regulate discharge, and a community-benefit or incentive agreement may address nonutility commitments.

The City of Phoenix's published civil-review materials illustrate this multi-instrument approach by grouping main-extension applications, repayment terms, design reports, notices to proceed, construction approvals, acceptance requirements, and bonds within coordinated water and sewer agreement packets (City of Phoenix, Arizona 2026). The example is useful for document architecture, but it is not data center-specific and does not establish the legal requirements of another jurisdiction.

10.3 Project Definition, Phasing, and Conditions Precedent

The agreement should define the project before allocating capacity. The definition should identify the developer, property owner, facility operator, billing customer, parent company or guarantor, site boundary, parcels, service connections, permitted uses, and relationships among affiliates. Each development phase should be described by building, electrical capacity, expected IT load, cooling configuration, commissioning period, target service date, and full-load operating date. If a campus may contain multiple operators, tenants, service accounts, or separately organized project entities, the agreement should define whether operational, financial, and compliance commitments apply to each service account, to the campus in the aggregate, or to both. This allocation is material for data center developments, which are commonly owned, developed, financed, and operated through special-purpose entities, holding companies, or joint ventures that are legally distinct from the recognized end user or "name-brand" company associated with the facility. The contracting entity may be a wholly owned affiliate of the end user, a joint venture involving a third-party investor, or an independently owned operator providing colocation or other data center services.

The utility's pre-execution due diligence should evaluate the contracting entity's legal identity, ownership structure, authority to enter the agreement, creditworthiness, and capacity to satisfy all contractual obligations over the agreement term. The agreement should identify the entity responsible for each operational, financial, indemnification, and compliance obligation and confirms that infrastructure-recovery and other fiscal commitments are supported by parties with demonstrated payment capacity. For agreements that rely on long-term payments to recover utility-funded infrastructure, the utility should evaluate the need for enforceable credit support, which may include a parent-company guaranty, joint-and-several liability among identified affiliates, a letter of credit, a security deposit, or another financial-assurance mechanism.

The technical baseline should be incorporated by reference and version controlled. Key information to incorporate includes average-day demand, maximum-day demand, instantaneous peak, monthly and seasonal profile, commissioning and maintenance demand, source-specific supply, consumptive use, sanitary flow, cooling blowdown, treatment residuals, emergency discharge, and pollutant mass loading. Rather than a single annual average demand, include specific demands for fire protection, landscaping, construction, domestic uses, humidification, equipment cleaning, and future phases. The baseline also describes the underlying assumptions that produce the forecast (e.g., the assumed computing load, utilization, weather year, redundancy mode, cooling sequence, COC, and water-quality constraints) (City of Aurora, Colorado 2025).

Each phase should include conditions precedents that must be satisfied before the utility authorizes construction, reserves capacity, sets a meter, or begins service. These conditions may include governing-body approval, final engineering review, executed easements, payment of applicable fees, delivery of financial security, evidence of site control and financing, required permits, completion of off-site facilities, approved pretreatment controls, successful commissioning, and confirmation that the phase remains consistent with the current capacity analysis. The agreement should clarify that preliminary correspondence, a will-serve letter, or acceptance of an application does not create an unconditional or perpetual capacity commitment unless controlling law expressly provides otherwise.

10.4 Capacity Reservation and Service Commitments

The agreement should define reserved capacity separately for water supply, treatment, transmission, storage, pumping, wastewater conveyance, and wastewater treatment because the limiting component may vary by phase or season. It should classify each reservation as firm, interruptible, or conditional; expresses it as flow, volume, pollutant load, or a defined combination; and state whether the values are independent or nested. An average-day allocation does not authorize an exceedance of the agreed maximum-day demand or instantaneous rate. The agreement should also identify pressure zones, points of delivery, wastewater discharge points, and any service-quality criteria within the utility's legal authority and operating capability.

The agreement should assign each capacity reservation a commencement date, duration, milestone schedule, and release mechanism. A staged reservation may align utility commitments with site acquisition, permitting, building completion, energization, cooling-system commissioning, and demonstrated load. If the developer misses a milestone, the agreement may allow a cure period, paid extension, reduction to the next supportable phase, or release of unused capacity (Cohen, Beyer, and Shwisberg 2026). These mechanisms are particularly important when the utility builds ahead of load or when one proposed campus could consume capacity needed by other customers. Recent large-load planning literature from the power sector likewise emphasizes forecast uncertainty, phased commitments, and investment risk when loads arrive late or below forecast; those sources serve as cross-sector analogies, not water-sector legal authority (Navarro and Knoll 2026).

The service commitment does not create an unrestricted guarantee of source availability, pressure, quality, or continuous supply. Its terms remain subject to the utility's adopted rules, lawful curtailment programs, emergency authority, permit limits, planned outages, and the customer's compliance with the agreement. If the developer requests service beyond normal utility standards, the agreement should identify the dedicated facilities, redundancy, storage, backup source, operating protocol, and cost responsibility associated with that service level. It also should state whether reserved capacity is transferable or usable at another parcel and whether an expansion requires a new capacity determination (AWWA 2021).

10.5 Rates, Charges, Financial Security, and Cost Recovery

This contractual section should operate together with the report's financial framework. The agreement should identify all applicable system-development charges, connection charges, meter and inspection fees, capacity-reservation payments, volumetric rates, demand or readiness-to-serve charges, wastewater-strength charges, reclaimed water charges, special-facility charges, and pass-through costs. It should state which charges are established by tariff or ordinance, which are project-specific and separately authorized, when each payment is due, and how the parties handle late payments, disputed invoices, credits, and refunds. A negotiated agreement does not freeze future generally applicable rates unless the utility has clear authority and has evaluated the financial and legal consequences.

The parties should reconcile cost recovery as information improves (AWWA 2017b; AWWA 2025b). A preliminary estimate may support an initial deposit, while final design, bidding, construction, commissioning, and actual financing costs remain subject to a documented true-up. The agreement should define eligible costs, accounting treatment, allocation of internal utility labor and overhead, audit rights, invoice timing, treatment of grants or third-party contributions, and responsibility for costs caused by developer delay or scope change. Minimum payments or reservation charges may be appropriate where the utility commits capacity or incurs debt before demand materializes, provided the method is cost-based, legally authorized, and coordinated with the adopted rate structure.

Financial assurance should match the utility's maximum unrecovered exposure (Government Finance Officers Association 2018). Depending on legal authority and credit risk, the agreement may require a cash deposit, letter of credit, performance and payment bonds, parent guarantee, escrow, advance payment, or a combination thereof. It should define acceptable issuer ratings, form, drawing conditions, renewal dates, replacement requirements, step-down criteria, and survival after termination. Security does not automatically decline merely because construction is complete; the utility may still face debt service, operating costs, unused capacity, or restoration obligations. Agreement administration should include periodic review of the security, public benefits, and continuing obligations that justified the arrangement.

10.6 Water Supply, Reclaimed Water, Drought, and Emergency Operations

The agreement is an opportunity to identify each authorized water source and the uses allowed for that source as well as establish how curtailment of supply will be managed. Separate metering and accounting of potable water, municipal reclaimed water, on-site-collected water, internally recovered water, and emergency backup water facilitate routine operations and managing disruptions in supply.

Drought and curtailment provisions incorporate the utility's adopted system-wide plan without creating an unsupported customer priority. The agreement is an opportunity to specify the demand baseline used to calculate reductions, the application of restrictions to each water source, notice procedures, reporting frequency, verification, and consequences of noncompliance. It can distinguish ordinary cooling demand from fire protection, health and safety, equipment protection, orderly shutdown, and restart requirements. If the facility asserts that a minimum flow is necessary to prevent damage, then technical demonstration by the develop is needed to understand the amount and duration, so that the agreement can assign responsibility for on-site storage, alternate cooling, load shedding, or backup supply before service begins (City of Aurora, Colorado 2025).

Emergency provisions should address utility outages, contamination advisories, pressure loss, main breaks, treatment failures, cyber or physical incidents, extreme weather, power interruption, and events at the customer site that could affect the utility. The agreement should establish emergency contacts, notification channels, isolation authority, data-sharing protocols, restart coordination, and post-event reporting. Subject to applicable law, the utility should retain authority to act immediately to protect public health, workers, infrastructure, or the environment. The data center facility or operator, as a utility customer, should maintain and test the on-site resilience measures needed to meet its business-continuity objectives rather than relying on the public utility to provide data center-grade redundancy (Khatib et al. 2025, 48-53).

Where the project proposes reclaimed water, the agreement elements will include the delivery point, target quality, responsibility for supplemental treatment, seasonal and outage limitations, cross-connection controls, conversion schedule, backup source, and allocation of costs if the reclaimed system is delayed. A reclaimed water connection does not constitute an unconditional promise of year-round quantity unless the supplying utility has committed that quantity under its governing rules; programs such as Loudoun Water's demonstrate that availability and capacity allocation remain material constraints (Loudoun Water 2025).

10.7 Wastewater, Pretreatment, Chemical Disclosure, and Residuals

The development agreement should acknowledge wastewater obligations without replacing an industrial-user permit or other control mechanism required by the POTW. Under the Clean Water Act (CWA) pretreatment framework, local control authorities may set enforceable limits, monitoring, reporting, access, and remedies that remain effective even if commercial terms change. The agreement, therefore, should require the customer to obtain and maintain all required discharge authorizations; comply with applicable local limits, prohibited-discharge standards, and other pretreatment requirements; pay applicable strength-based, surcharge, monitoring, or special-handling charges; and acknowledge that regulatory requirements and discharge limits may be revised through lawful processes. Because cooling water systems and other facility operations may use chemicals that are not addressed by existing local limits or current federal discharge criteria, the agreement should also require the customer to provide the municipality or receiving POTW with a complete and current inventory of all chemicals, additives, treatment products, and related constituents that may enter the wastewater stream or otherwise affect its character.

U.S. Environmental Protection Agency (USEPA) guidance outlines pre-treatment program participants including written notice and disclosure before the customer introduces a new chemical, changes a treatment formulation, or materially modifies an operational process that could affect wastewater quality or the POTW's treatment processes, biosolids management, worker safety, collection system, or ability to comply with its discharge permit. Where chemical formulations or supplier information are proprietary, the municipality may enter into an appropriate nondisclosure agreement with the customer and, as necessary, its chemical suppliers. Any confidentiality protections remain subject to the municipality's authority to evaluate potential treatment-process inhibition; establish monitoring, sampling, reporting, or constituent-specific discharge requirements; assess applicable charges; and restrict or prohibit compounds that could interfere with POTW operations or regulatory compliance (USEPA 2012).

The approved wastewater baseline includes identifying each stream, including sanitary wastewater, cooling-tower blowdown, cleaning and passivation water demand and wastewater discharge, membrane reject, softener regeneration, laboratory waste, condensate, fire-system testing water, and emergency bypass. It should state average and maximum flow, temperature, pH, conductivity, TDS, hardness, silica, chloride, sulfate, suspended solids, organic load, nutrients, metals, treatment chemicals, biocides, corrosion inhibitors, and other constituents relevant to the receiving system. Concentration limits alone may be inadequate when a large flow creates a material mass load. It is important to incorporate the monitoring parameters and measurement units needed to ensure the control mechanism adequately protects the utility's conveyance, treatment, sludge quality, worker safety, and the receiving water (USEPA 2026a).

Chemical disclosure is a part of operational change control. The customer should maintain an inventory of cooling, cleaning, pretreatment, and membrane chemicals; current safety data sheets; expected use rates; degradation products where material; and procedures for spills, slug discharges, and temporary cleaning events. As noted previously, the agreement provides for advance notice before the customer introduces a new chemical or materially changes a dose. Exceptions may be made where an immediate change is necessary for safety. In such situations, prompt notice and follow-up characterization provides a mechanism for timely information transfer. The agreement may also assign responsibility for concentrate, sludge, spent media, crystallized solids, and hauled residuals in keeping with the customer and utility's wastewater treatment responsibilities. Even if a data center adopts a minimum- or zero-liquid-discharge design there will be a need to address wastewater management including the need for authorized management of commissioning water, cleaning waste, outages, and emergency bypasses.

10.8 Metering, Reporting, Audit, and Confidentiality

Measurement provisions establish the data needed to verify both service and compliance. Permanent meters should cover each external supply, major on-site source, cooling makeup, blowdown, recovered water production, wastewater discharge, and authorized bypass. Agreement provisions for metering address meter ownership, location, accuracy class, installation, access, calibration, maintenance, telemetry, data retention, and the method for estimating use during meter failure (AWWA 2021). Utility billing meters will control billing unless the governing rules provide otherwise, while process meters support reconciliation of the approved water and constituent balances.

Reports should distinguish withdrawals, purchases, source substitution, consumptive use, liquid discharge, pollutant loads, reclaimed flow, energy associated with water treatment, chemical consumption, and solid residuals. The agreement should define reporting frequency, electronic format, responsible signatory, certification language, correction procedures, and escalation thresholds. It should provide reasonable utility access to source records, calibration certificates, laboratory reports, operating logs, and relevant control-system summaries, subject to safety and security protocols. The USEPA industrial-user guidance illustrates how monitoring, reporting, inspection access, transfer, termination, and standard conditions can be assembled into an enforceable control mechanism (USEPA 2012).

Confidentiality provisions must align with public-records law, regulatory disclosure duties, and the utility's need to communicate material impacts. The developer should identify the specific information it considers confidential and provide the legal basis for protection. Security-sensitive diagrams, network details, and operational procedures can be segregated from public planning data where lawful, but claims of security sensitivity do not prevent disclosure of service commitments, public costs, aggregate water

use, discharge compliance, or governing-body decisions when disclosure is required. The agreement does not promise blanket confidentiality that the public entity lacks the authority to provide. The agreement can (subject to state and federal law) incorporate procedures for record requests, consultation, redaction, and responsibility for seeking judicial protection.

10.9 Change Control, Technology Transition, and Reassessment

The agreement should define a material change by its effect on utility service rather than by a single generic percentage. Material changes may include an added building or phase, accelerated schedule, higher computing load, change in cooling technology or operating sequence, new water source, changed COC, new treatment process or chemical, altered wastewater flow or load, new emergency-discharge pathway, interconnection of parcels, change in redundancy, or sustained departure from the approved demand envelope. Both the customer and utility will want reasonable and dependable scheduling. The utility will need notice early enough for it to update any needed hydraulic, capacity, water-quality, financial, or regulatory analyses before implementation. Similarly, the customer's planned changes are dependent on timely review and an agreement on proceeding.

Elements to outline in describing review processes include what information is required, who bears review and infrastructure costs, how long the utility has to respond after receiving a complete submittal, and whether interim operation is allowed. A change that reduces water demand should still receive review if it changes wastewater strength, return flows, revenue recovery, reclaimed water economics, or the useful life of dedicated infrastructure. Implementation of changes in technology or operating practice that demonstrably satisfy performance objectives and regulatory requirements embedded in existing agreements may require close coordination with the utility as it adapts to changes in water demand and effluent streams. Experience in the electric sector reinforces the value of staged revalidation as forecasts and technologies evolve for large load utility customers (Navarro and Knoll 2026).

Where future conversion from potable to reclaimed water, blowdown recovery, direct liquid cooling, or MLD is contemplated, including a decision gate in the agreement rather than an unconditional promise can be a useful construct. In such situations, the gate identifies feasibility studies, water-quality testing, infrastructure readiness, regulatory approvals, commissioning criteria, cost allocation, backup arrangements, and the service-amendment process needed before conversion. This approach preserves flexibility while avoiding technical baselines that count an aspirational technology pathway as a present capacity or financial offset.

10.10 Intergovernmental Coordination and Community Benefit Agreements

A water or wastewater utility controls only a few facets of facility siting agreements. Other considerations include land use ordinances, tax incentives, electric service, transportation, emergency response, and economic-development commitments. Consequently, a development agreement will identify the responsible city, county, utility, development authority, and regulatory bodies, and should prevent one entity's approval from being represented as another entity's service commitment. Local legal authority and public process must be evaluated before transferring responsibility for a provision from one jurisdiction to another (Grimm, Green Nylen, and Kiparsky 2026). Intergovernmental procedures are an

avenue to address sharing of technical information, sequencing of approvals, governing-body presentations, public communication, and resolution of inconsistent conditions. The utility should retain independent authority over water and wastewater related capacity, rates, engineering, pretreatment, and operations within its jurisdiction.

A Community Benefit Agreement (CBA) may address local hiring, workforce development, neighborhood investment, transparency, environmental measures, tax or incentive conditions, and other community priorities. It is adjacent to, but does not replace, the utility service or development agreement. The City of Lancaster's data center materials illustrate the use of a CBA within a broader public approval process (City of Lancaster, Pennsylvania 2025). If a community-benefit commitment depends on water use, reclaimed water conversion, infrastructure timing, or public funding, the relevant documents should use consistent definitions, milestones, verification methods, and remedies.

A CBA may define developer contributions for treatment capacity, transmission, storage, reclaimed water infrastructure, monitoring, or source water protection when those commitments fall within the parties' authority. Environmental provisions may address groundwater, surface water, wastewater discharge, noise, heat, or air-quality concerns. Workforce and community-investment provisions remain financially and legally distinct from utility cost recovery, preventing an incentive or community payment from obscuring the cost of water and wastewater service.

As described previously in this section, provisions not directly included in the water and wastewater service agreements could potentially be included in a CBA:

- **Water-demand limits.** An annual, monthly, peak-day, or peak-hour cap on potable water use; potentially differentiated by cooling season, facility phase, or ambient temperature conditions.
- **Water-source requirements.** Commitments to use reclaimed/non-potable water, closed-loop or low-water cooling, on-site reuse, or another specified supply source where feasible.
- **Wastewater flow and strength limits.** Maximum discharge volumes; limits on temperature, TDS, chemicals, or other constituents; pretreatment requirements; and restrictions on discharges associated with cooling-water blowdown or treatment systems.
- **Capacity reservation and phasing.** Conditions under which the utility reserves water-production, transmission, collection, treatment capacity and when that capacity can be released if the campus is delayed or does not develop as represented.
- **Developer-funded capital improvements.** Funding for upsizing mains, pump stations, storage, reclaimed water facilities, sewer interceptors, treatment upgrades, or source-development projects that are needed because of the data center.
- **Drought and emergency curtailment.** A defined service-priority hierarchy, curtailment triggers, mandatory conservation actions, backup cooling provisions, and conditions under which potable water can be reduced or suspended.
- **Metering, reporting, and transparency.** Separate meters; regular reporting of water withdrawals, wastewater discharges, reuse volumes, and water-use effectiveness; audit access; and potentially public reporting.
- **Security and reliability commitments.** Redundant connections, on-site storage, backflow prevention, emergency response coordination, fire-flow provisions, and utility access requirements.
- **Authorized funding commitments** for project-driven or shared community water and wastewater improvements.

- **Environmental monitoring commitments** for defined groundwater, surface water, wastewater, heat, noise, or air-quality indicators.
- **Conditional reclaimed water conversion milestones** tied to supply availability, water quality, infrastructure readiness, and regulatory approval.

11 Regulatory Framework and Emerging Policy

The regulatory framework establishes the conditions under which utilities can supply water, accept wastewater, and support reclaimed water use which both directly and indirectly impacts data center development. Understanding these conditions is essential to translating technical feasibility into an authorized and implementable service arrangement. This section reviews the U.S. federal, state, tribal, and local requirements relevant to water supply, discharge control, reuse, and project approval. It explains how regulatory obligations vary with the facility's location, water source, cooling configuration, treatment processes, and discharge pathway.

This review provides the foundation for regulatory screening questions, an approval matrix, and coordination procedures. It helps users identify applicable requirements, responsible authorities, necessary technical documentation, and dependencies among approvals. Connecting these requirements to demand projections, wastewater characterization, infrastructure planning, and service agreements allows utilities to identify constraints before committing capacity or funding.

Emerging policy is equally relevant because changes in water-use reporting, resource planning, efficiency expectations, and public disclosure can affect the information needed to evaluate a project. Distinguishing enforceable requirements from proposed measures and voluntary guidance helps users understand both current obligations and potential future changes. Recording each measure's jurisdiction, legal status, effective date, and source provides a basis for reassessment as policies evolve. This section, therefore, supports practical guidance that remains adaptable to local authority and changing requirements while promoting consistent, transparent project evaluation.

11.1 Federal Regulatory Framework

Currently, no current federal regulatory constructs are in place to specifically govern data center development and operations. Data center development, like other commercial enterprises, must comply with applicable regulatory requirements. The principal federal programs and related state oversight specific to water include the following (USEPA 2012):

- **Safe Drinking Water Act (SDWA):** Establishes federal requirements for public water systems and finished water quality.
- **Clean Water Act (CWA):** Regulates pollutant discharges to waters of the U.S. through the NPDES program and establishes the federal pretreatment framework for indirect discharges to POTWs.
    - **NPDES permitting**: A point-source discharge to waters of the U.S. requires applicable NPDES authorization. A POTW also evaluates whether an industrial discharge to its collection system could affect treatment performance, biosolids management, receiving water, or the utility's permit conditions.
    - **Industrial Pretreatment Program (40 CFR Part 403):** Establishes general and specific prohibitions, categorical standards where applicable, and requirements for approved POTW pretreatment programs. As the “Control Authority” the utility operating the POTW receiving the data center's wastewater effluent determines industrial-user status, applicable local limits, and required control mechanisms (USEPA 2026a; USEPA 2012).

11.1.1 Drinking Water, Source Development, and Cooling Intakes

SDWA establishes federal requirements for public water systems and authorizes the USEPA and approved primacy agencies to implement drinking water programs. If a data center develops its own potable water supply, then it must comply with SDWA requirements as a public water system (PWS). When a data center receives potable water from a community water system (CWS), the utility operating the CWS is responsible for compliance with SDWA, while the customer is responsible for premise plumbing, private treatment, and facility operations under applicable state and local rules. SDWA does not directly regulate the allocation of water in the U.S.

11.1.2 Direct Discharge, Indirect Discharge, and Stormwater

A facility that directly withdraws surface water for cooling is subject to Applicability Review under CWA section 316(b) (40 CFR Part 125, Subpart I). The governing requirement, if any, depends on the facility category, intake design capacity, cooling-water use, source water, and permitting status. The review covers intake location, design, construction, capacity, and measures needed to minimize adverse environmental effects; it does not arise merely because the project operates a cooling tower (USEPA 2026c).

A direct discharge from a data center or associated treatment system may require an individual or general NPDES permit containing technology-based limits, water-quality-based limits, monitoring, reporting, and other conditions (USEPA 2026d). The analysis turns on the actual pathway and receiving water, not the project label. Cooling-tower blowdown, membrane concentrate, equipment-cleaning wastewater, hydrostatic-test water, dewatering water, and emergency releases can present different permitting questions.

Wastewater routed to a POTW remains subject to the National Pretreatment Program, 40 CFR Part 403, the receiving utility's sewer-use ordinance, local limits, and any industrial-user control mechanism (USEPA 2017; USEPA 2012). Low flow does not establish acceptability. A concentrated stream can interfere with POTW treatment, pass through the POTW to receiving waters, impair residuals management, create worker hazards, or affect the utility's NPDES permit. The Control Authority determines characterization, sampling, pretreatment, discharge scheduling, notification, and authorization. Significant Industrial Users status and categorical coverage require project-specific determinations (USEPA, 2004).

Stormwater permitting can apply to a campus phase or a common plan of development, even when individual parcels fall below the governing disturbance threshold. Operational stormwater requirements depend on industrial activity, material exposure, and the applicable permit program. Erosion control, pollution-prevention planning, inspection, stabilization, and long-term drainage need coordination across separately phased parcels and off-site utility work.

11.1.3 Federal Environmental Review and Ancillary Programs

The National Environmental Policy Act (NEPA) applies when a federal agency undertakes, funds, permits, or otherwise authorizes an action that creates the statutory federal nexus. A privately financed data center on private land does not enter federal environmental review solely because of its size. Federal land, financing, approvals, or permits can create the nexus, and the responsible agency determines the review level and scope. A number of states have their own environmental impact assessment process statutes akin to NEPA. These state assessments may apply independent of the federal statute’s applicability.

A discharge of dredged or fill material into jurisdictional waters, including qualifying wetlands, can require CWA section 404 authorization (40 CFR Part 230). Campus grading, utility crossings, intake or outfall structures, access roads, substations, and off-site water or sewer extensions can trigger review even when the principal building pad avoids aquatic resources. Early delineation and alternatives analysis reduce the risk of a late constraint on the site plan or infrastructure route (USEPA 2026e).

Chemical inventories and emergency-planning duties can arise under the Emergency Planning and Community Right-to-Know Act when on-site chemicals meet applicable conditions and thresholds. Cooling-water chemicals, treatment reagents, fuels, batteries, and other stored materials receive screening under the governing federal, state, and local programs (USEPA 2025). Treatment residuals, spent chemicals, cleaning wastes, and contaminated media also require a hazardous-waste determination under the applicable Resource Conservation and Recovery Act program. States can impose additional or more stringent requirements (USEPA 2026f).

11.2 State Regulatory Framework

State law governs many questions that determine project feasibility, including water rights, withdrawal permits, consumptive-use authorization, utility service authority, reclaimed water standards, environmental review, and reporting thresholds. Appropriative, riparian, groundwater, and interstate allocation regimes create different requirements, and reclaimed water approval depends on state rules, source quality, treatment, end use, and site-specific controls. Early coordination with the relevant state and tribal agencies clarifies the governing pathway and prevents a local service discussion from being mistaken for regulatory approval (USEPA 2026g). State-level requirements may include:

- **Water rights and allocation:** Appropriative, riparian, groundwater, and interstate allocation rules may require a new authorization, transfer, change petition, or demonstration of available supply.
- **Large-water-user requirements:** State-specific withdrawal, registration, reporting, conservation, and environmental-review requirements may apply when defined thresholds or impact criteria are met.
- **Reclaimed water standards:** State rules define approved sources and end uses, treatment and disinfection criteria, monitoring, storage, setbacks, cross-connection controls, and operator responsibilities; cooling-tower use requires confirmation under the applicable program.
- **Water-use permits:** Groundwater or surface-water withdrawals may require consumptive use, well construction, source development, or related environmental authorization.
- **Backflow prevention and cross-connection control:** State rules and local ordinances govern plumbing controls to prevent cross-connections between piping that contains substances that could contaminant the potable water supplies through an unintended reversal of water flow (i.e., a backflow event).

11.2.1 Water Rights, Withdrawals, and Reuse

State water law controls many of the most consequential questions associated with water supply. The governing entity may use prior appropriation, riparian rights, regulated riparian permitting, correlative groundwater rights, reasonable-use doctrines, groundwater-management areas, or combinations of these approaches. Interstate compacts, Tribal reserved rights, adjudications, minimum-flow rules, drought orders, and basin-specific restrictions can further constrain availability. A utility's withdrawal permit does

not necessarily authorize every increase in customer demand, new point of use, source substitution, interbasin transfer, or seasonal operating pattern (Federal Judicial Center n.d.).

Reclaimed water requirements remain primarily state-driven and vary as a function of intended end use. Requirements may limit what wastewater streams are available sources, determine required treatment levels, constrain end uses, determine applicable operator training and certification, specify compliance monitoring regimes, and guide other aspects of reuse practice. USEPA's REUSExplorer provides a useful index of state water reuse regulations (USEPA 2026g). Municipal reclaimed water, on-site sanitary reuse, stormwater capture, condensate, and blowdown recovery may entail engaging multiple agencies including those that regulate wastewater treatment/discharge, administer public health codes, and oversee water rights. Permitting of reuse strategies does not necessarily resolve related ownership, return-flow effects, or concentrate disposal considerations.

11.2.2 Environmental Review, Land Use, and Utility Authority

State environmental-review statutes, wetland and water-quality certifications, air permits, dam-safety rules, cultural-resource requirements, species protections, and public-health regulations can add review beyond federal law. Local zoning and development codes can govern setbacks, height, noise, backup generators, hazardous-material storage, landscaping, heat rejection, construction hours, and off-site utility routes. Conditions imposed through land-use review require coordination with utility and environmental permits, so separate approvals do not establish inconsistent operating assumptions.

Cooling-tower risk management illustrates the difference between technical guidance and law. Centers for Disease Control and Prevention (CDC) guidance and the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 188 provide recognized practices, but their legal status depends on jurisdictional adoption or incorporation into a code, permit, license, or contract (CDC 2025; ASHRAE 2021). The project record states whether a cited standard is legally incorporated, contractually required, or voluntarily applied.

Water and wastewater utilities impose service conditions through adopted rates, rules, ordinances, pretreatment authority, permits, and development or service agreements. The controlling instruments define the approved source, service envelope, metering, monitoring, discharge authorization, drought response, cross-connection protection, reporting, inspection access, cost recovery, enforcement, and material-change process. Confidentiality provisions cannot override public-record, open-meeting, permit-notice, or regulatory-reporting duties.

12 Community Engagement and Transparency

12.1 Importance of Proactive Communication

It is good practice for water utilities to engage with their leadership and the communities they serve early on in the development of high-interest projects. In the case of data centers, where public opposition has often been fierce, failure to engage early and with transparency can lead to delay or redesign. Communities should be informed about water demand, drought response, wastewater effects, infrastructure financing, or enforceable commitments. Early disclosure of decision-relevant facts allows utility leadership and the community to evaluate these issues before positions harden (Grimm, Green Nylen, and Kiparsky 2026, 65).

Effective communication explains what is known, what remains uncertain, how the utility evaluates risk, and when binding decisions will occur. Early engagement, accurate information, and continued dialogue improve public understanding and give decision-makers time to respond as appropriate to concerns.

12.1.1 Governance Objectives and Decision Boundaries

Engagement functions as part of utility governance and due diligence. A credible process gives affected parties timely access to decision-relevant information, identifies the questions on which public input can influence the outcome, records how that input was evaluated, and maintains accountability after service begins.

At the outset, the utility identifies the purpose of engagement, decisions under review, the decisionmaker for each issue, applicable legal process, and opportunities for public influence. The utility may control water and wastewater service, rates, capacity allocation, pretreatment, infrastructure acceptance, and operating requirements, while planning agencies, elected bodies, regulators, electric utilities, or economic-development entities control other elements. A decision map should direct comments to the responsible entity.

The decision map separates information exchange from formal adjudication (Reed 2008, 2417-2431). A public workshop can improve understanding and gather concerns, but it does not replace a rate hearing, environmental review, permit proceeding, procurement process, or governing-board action required by law. Likewise, a developer open house does not substitute for utility-led disclosure or an official public record. The engagement plan identifies which forums create a formal record, which are advisory, and which provide information only.

Public expectations generally reflect the project's current stage of development. Communications should distinguish an inquiry from a complete application, a planning estimate from a validated demand, a conditional capacity indication from a service commitment, and a proposed mitigation measure from an enforceable obligation. Engagement does not guarantee consensus or approval, but it can improve the information available to decisionmakers, reveal local knowledge and implementation risks, clarify competing values, and strengthen the legitimacy of a well-documented decision (National Research Council 2008).

12.1.2 Stakeholder Identification and Procedural Fairness

A stakeholder assessment identifies the organizations, communities, and individuals who may be affected by a project, including those not typically included on standard contact lists. It considers current utility customers; nearby residents; communities that share the same water source, watershed, or downstream system; neighboring utilities; Tribal governments, where applicable; businesses; agricultural users; schools; health care institutions; environmental and affordability advocates; labor groups; emergency managers; and people who may face barriers to participating in the process. The assessment defines its geographic area based on how far project impacts could extend—not simply by the project site or utility service boundary.

Engagement should begin early enough for local information and community priorities to affect alternatives, conditions, phasing, or mitigation. Environmental decision research finds greater value when participation begins before key choices are made, includes relevant interests, uses appropriate knowledge, and connects input to the decision process (National Research Council 2008). A late meeting focused solely on explaining the preferred alternative offers little opportunity to improve the decision, even when it satisfies a notice requirement.

Procedural fairness has practical importance even when participants may disagree with the outcome. The process provides a genuine opportunity for participants to be heard, applies review criteria consistently, explains evidence and legal authority, treats participants respectfully, and reports how material concerns affected the analysis.

12.2 Community Engagement Strategy

A community engagement strategy gives customers and decisionmakers a clear view of the utility's review process, evidence, authority, and unresolved questions. The utility can explain water availability, infrastructure needs, wastewater controls, cost recovery, drought response, and service conditions while distinguishing its responsibilities from land-use, tax, energy, and economic-development decisions. Consistent communication supports informed participation without promising approval or service before technical and financial conditions are satisfied.

The information released depends on local law, project maturity, confidentiality protections, and community concerns. A useful communication plan addresses the recurring topics below and identifies which facts are preliminary, verified, contractually committed, confidential, or unavailable.

Utility messaging should address:

- The utility's authority over water supply, wastewater service, rates, infrastructure, and pretreatment, compared with other entities' authority over land use, zoning, energy service, incentives, and economic development.
- How projected average, peak, seasonal, drought, and emergency demands affect water sources, treatment, transmission, storage, and wastewater systems, together with the measures available to maintain reliable service.
- How project-driven infrastructure, operating costs, and financial risks are allocated, funded, secured, and reconciled without shifting unsupported costs to existing customers.
- Water-quality protections for supply and discharge, including source compatibility, monitoring, pretreatment, discharge limits, residuals management, and cross-connection control.

- How the utility verifies and enforces compliance with service agreements, operating requirements, permits, tariffs, and applicable law.
- How the utility responds when the data center misses milestones, exceeds authorized demand or discharge conditions, fails to maintain security, or otherwise breaches an enforceable obligation.

12.2.1 Staged Disclosure and Information Governance

The utility may find it helpful to maintain a common project fact base and update it as information matures. The record identifies the sponsor and responsible legal entity; location and phases; cooling approach; water sources; average-day, maximum-day, seasonal, commissioning, drought, and emergency demands; consumptive use; wastewater flow and characteristics; reuse assumptions; infrastructure; cost recovery; permits; milestones; and contacts. Each release carries a date, version, source, and status label.

Status labels make uncertainty visible. Useful categories include: requested, developer-estimated, utility-validated, conditionally reserved, contractually committed, constructed, commissioned, and measured. Ranges and scenarios provide more information than a single precise forecast when cooling design, IT load, climate, water quality, or phase timing remains undetermined. The record explains the assumptions and conditions that change the estimate, and the next validation point.

Local disclosure distinguishes withdrawal from consumption, average use from peak demand, potable water from reclaimed or other sources, routine demand from drought or emergency demand, and gross treatment recovery from net reduction in external supply. WUE can supplement this information, but does not replace site-specific volumes, source reliability, or seasonal context (Privette, Barros, and Cai 2026, e2025AV002140).

Transparency must operate within lawful limits. The utility should identify public-record duties, trade-secret protections, critical-infrastructure security, cybersecurity, procurement restrictions, and privacy requirements before receiving sensitive material. When full release is not authorized, the record can often provide aggregated ranges, redacted documents, nonconfidential summaries, the category withheld, and the basis for withholding it. Blanket confidentiality labels do not replace legal review.

12.2.2 Accessible Participation and Response to Comments

The engagement method should match the decision, audience, and actual opportunity for influence. Webpages, fact sheets, dashboards, notices, briefings, surveys, interviews, office hours, workshops, advisory groups, hearings, and governing-board meetings may serve different purposes. USEPA guidance distinguishes informing, consulting, involving, collaborating, and empowering, and emphasizes clear expectations about the influence available at each level (USEPA 2026h). A project can use several levels at different stages while retaining lawful decision authority.

Participation design should account for language, disability, transportation, work schedules, childcare, internet access, technical literacy, and historical experience with public institutions, consistent with applicable law and policy. Meetings should occur at varied times and in accessible formats. Plain-language summaries should accompany technical documents, and maps, demand profiles, and scenario comparisons explain relationships that are difficult to convey through narrative alone.

A single hearing rarely reaches the full range of affected interests. Broad notice may be combined with targeted outreach and small-group discussion, followed by placement of the resulting information in one transparent record. Direct outreach should not give selected participants hidden decision authority.

Participant selection, advisory roles, meeting notes, submitted materials, and areas of agreement or disagreement should be documented.

12.2.3 Communicating Technical, Financial, and Operational Risk

Water supply communication should cover legal and physical source availability, drought stages, climate and seasonal assumptions, treatment and conveyance capacity, storage, fire flow, redundancy, and effects on other customers. It should distinguish withdrawal from consumption and explain how evaporation, reclaimed water substitution, on-site recovery, and altered return flow affect the broader system. The same explanation should state whether a data center receives the same drought restrictions and surcharges as other customers or operates under different adopted terms, together with the cost and reliability basis for any distinction.

Wastewater communication should address flow, pollutant concentration, mass loading, variability, pretreatment, monitoring, residuals, upset conditions, and unauthorized discharge. A low flow can still create material risk when a concentrated or intermittent stream interferes with treatment, residuals management, worker safety, or permit compliance. Public information should describe the control and accountability framework without exposing operational details that compromise security.

Financial communication should separate utility cost recovery from economic-development incentives and community investments. The record should identify project-driven capital and operating costs, allocation, developer contributions, security, minimum payments, reserved capacity, debt exposure, and residual utility risk. Claims regarding net fiscal benefit or cost for water services should be rooted in the analyses described in Section 9. Transparent communication of embedded assumptions will be important both for utility leadership and the interested public.

12.2.4 Community Benefit Agreements

As noted in Section 10, CBAs may contain a wide range of provisions, many of which extend beyond provision of water services. Such agreements may entail an ongoing obligation for public transparency throughout the life of an economic-development agreement (Government Finance Officers Association 2018).

When CBAs result in a regular public report or dashboard, the utility should be prepared to both (1) review the CBA to ensure measures it is responsible for occur at a frequency proportionate to project scale and risk and (2) maintain tracking and reporting adequate to meet its reporting obligations. Relevant measures include water delivered by source, average and peak demand, reclaimed water use, consumptive use, wastewater flow and selected compliance indicators, drought actions, infrastructure milestones, and material deviations from the approved plan. Over time it may become necessary to explain whether apparent trends reflect actual operations or changes in accounting practice.

If the CBA prescribes a unique issue-resolution pathway other than normal utility and governmental processes, then the CBA should clearly identify appropriate points of contact, an acknowledgment timeframe, expectations for technical investigation, escalation routes, and notice of resolution. Such provisions can improve public transparency by providing informational updates, an accessible administrative channel, and a record of recurring concerns. They do not replace regulatory appeal, public-record request, emergency report, or legal remedy administration.

13 Utility Questionnaire and Response Analysis

13.1 Questionnaire Introduction

Data center development requires water and wastewater utilities to make planning decisions based on local supply conditions, infrastructure capacity, cooling configurations, and project timelines. Utilities are often required to evaluate significant service requests before developers finalize facility designs, operational requirements, or construction schedules. Understanding how utilities gather information, assess uncertainty, and establish service conditions is essential for developing practical guidance. This section analyzes utility perspectives on these challenges and links their experiences and anticipated needs to the report's technical methods, planning tools, and project-review checklist.

The questionnaire outreach engaged 44 utilities of varying system sizes, geographic regions, and experience levels with data center development. Customized questions addressed issues specific to each utility, such as demand forecasting, capacity allocation, water quality, wastewater management, reuse, infrastructure funding, and service agreements. The questionnaire, distributed between March and August 2026, was supplemented by follow-up discussions and a review of published information. Responses were categorized by decision context, risks and constraints, tools or actions, required data inputs, and factors influencing the transferability of practices. This methodology established a structured foundation for identifying recurring concerns while preserving the context necessary to interpret individual responses.

Detailed feedback from five utility cases demonstrates the breadth of considerations involved. East Bay Municipal Utility District (EBMUD) discussed staged information requests, development phasing, conservation measures, and financial arrangements. Southern Nevada Water Authority and Las Vegas Valley Water District emphasized consumptive-use restrictions, return-flow accounting, and coordination between water and energy planning. Sacramento Area Sewer District (SacSewer) identified salinity, source-control participation, seasonal reclaimed water availability, and project-specific collection-system capacity as key review considerations.

Collectively, these perspectives inform the Utility Checklist for Evaluating Data Center Development presented at the end of this section. The checklist translates identified information needs into adaptable questions that address project definition, supply reliability, infrastructure, cooling, alternative water sources, wastewater, financial responsibility, contractual provisions, monitoring, and resilience. Its purpose is to facilitate timely discussions, clarify unresolved assumptions, and guide increasingly detailed evaluations as projects progress.

13.2 Questionnaire Objectives

This questionnaire was designed to capture the experiences and needs of utilities managing data center development, including consideration of relevant tools, policies, checklists, and technical methods. The questionnaire is designed to identify information gaps, common barriers faced, and innovative practices, promoting alignment of solutions with specific conditions facing different CWSs. The questionnaire explores how utilities forecast and allocate capacity for data center loads, address infrastructure and water quality issues, manage cooling-tower blowdown and reuse, and implement financial or contractual measures for cost recovery. It also examines responses to drought, power outages, and public concerns.

Questionnaire respondents include utilities with data centers currently in operation or development, as well as utilities anticipating future data center development within their service areas. Accordingly, the findings reflect a combination of retrospective operational experience and forward-looking expectations. Responses concerning anticipated demands, impacts, policies, or infrastructure needs are based on the information and professional judgment available to respondents at the time of the questionnaire and should not be interpreted as outcomes verified through actual data center operations.

13.3 Questionnaire Methodology

The team created a tailored set of five questions for each utility, resulting in 222 unique questions. The themes explored in the questionnaire were based on AWWA's 2025 report *Cooling the Cloud: Water Utilities in a Data-Driven World* among other sources. The 44 utilities were selected to represent a range of system sizes, geographic regions, and experience with nearby data center development. The questionnaire was distributed by email between March and August 2026, with each utility receiving five questions and a deadline for responses. The team supplemented information gathered from the questionnaire with follow-up phone interviews and a literature review. Responses were coded by theme into a literature response matrix. Each question was coded into five categories: decision context, risks and constraints, tools or actions used, required data inputs, and transferability conditions. This approach enabled aggregation of common themes and identification of evidence gaps. Utility feedback was cross-checked with published cases and expert sources for verification. Figure 4 shows the workflow of the utility questionnaire in more detail.

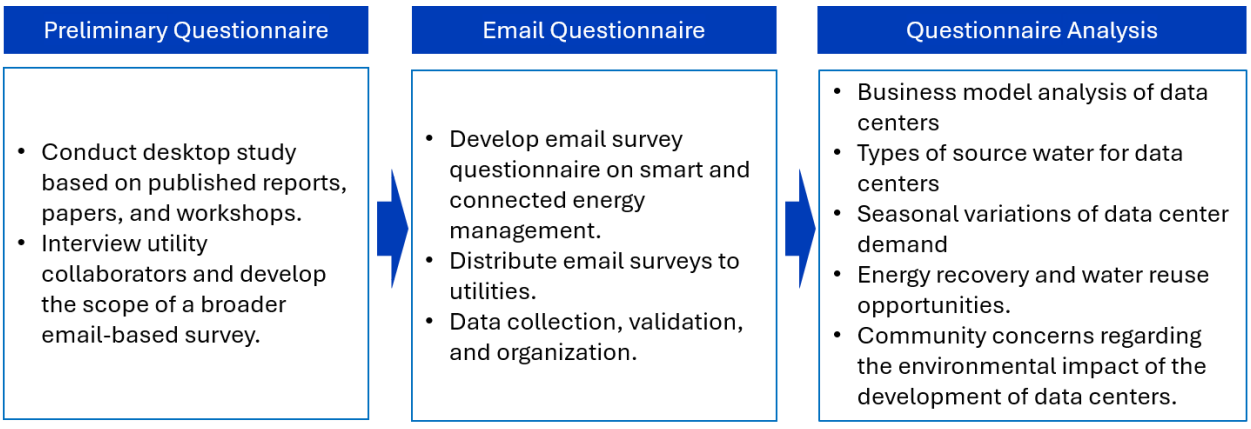


Figure 4 Workflow of Utility Questionnaire

13.4 Questionnaire Topics

The 44 utilities contacted include both large urban systems and smaller cities. Several utilities are located in regions with significant data center growth. The sample over-represents rapidly growing Sunbelt regions and systems engaged in data center planning. The customized questions span eight topics, as shown in Figure 5.

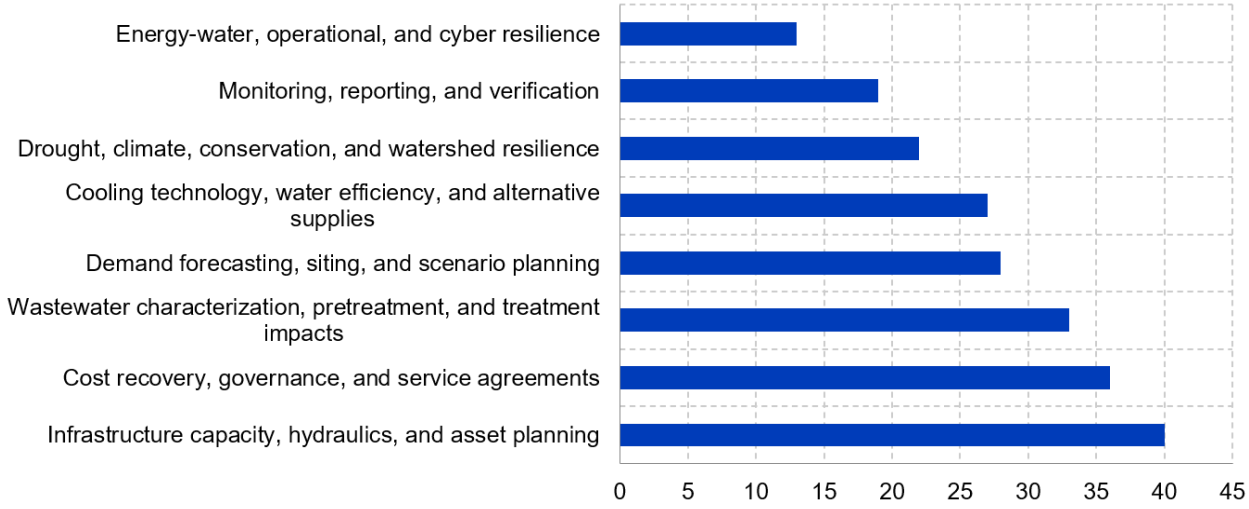


Figure 5 Utility Questionnaire Topics

13.5 Detailed Feedback from Three Utility Cases

The three utility summaries below illustrate how local water resources, infrastructure, operating conditions, and development processes shape the information needed to evaluate data center projects. Their feedback provides practical context for the Utility Checklist for Evaluating Data Center Development, particularly the questions concerning supply reliability, phased demand, wastewater characteristics, infrastructure capacity, financial responsibility, and coordination. The responses describe both established practices and issues that utilities anticipate addressing as projects develop.

The responses also contributed to the iterative development of the questionnaire. As utilities described their experiences and concerns, their feedback helped clarify terminology, identify information gaps, and refine questions for subsequent outreach and follow-up. This process helped focus the questions on decisions relevant to utility planning, including how demand develops over time, what information is available at each project stage, and how responsibilities are allocated between utilities and developers. The evolving questions, in turn, supported the development of more useful data requests, review steps, and decision criteria. The following synthesis presents key feedback points from each utility and explains their relevance to these practical tools.

13.5.1 East Bay Municipal Utility District

The East Bay Municipal Utility District (EBMUD) described a two-stage process for certain large projects in which an initial Water Supply Assessment considers annual average demand, consistency with the Urban Water Management Plan, reliability during normal and drought years, reclaimed water opportunities, and water-use efficiency. The EBMUD Board of Directors must approve the Water Supply Assessment. The second stage is the water service application which provides peak demand, fire-flow requirements, development phasing, and other design information used to size facilities and determine whether new pipelines or major facilities are needed. This sequence illustrates how utilities can organize information requests around the decisions being made at each stage.

EBMUD also described the relationship between phased development and distribution-system water quality. Steady demand may improve turnover within a pressure zone. Conversely, infrastructure sized for future phases that are delayed or never developed may experience longer water residence times and lower disinfectant residuals. The district identified facility sizing, system configuration, and construction phasing as relevant considerations. These were conditional effects dependent on actual demand, system geometry, and the timing of development.

Within a designated Water Reuse Zone, an applicant must use reclaimed water for eligible non-potable uses such as cooling towers, subject to availability. Very large projects, even outside of the Reuse Zone, are evaluated for reclaimed water use. If sufficient reclaimed water is currently not available, an applicant may be subject to future conversion requirements when reclaimed water becomes available, and interim potable service may include a conversion condition. Information about cooling-system compatibility and the potential timing of reclaimed water service would therefore be relevant to both initial design and later modifications.

EBMUD reported specific water efficiency provisions for cooling towers. This included recirculation, at least five COC for towers not using reclaimed water, conductivity controllers, and makeup and blowdown meters for new towers. These reported provisions illustrate how cooling-system descriptions and metering plans can inform reviews of water demand and efficiency. EBMUD also provided a local example of the operating information addressed by the checklist's cooling and monitoring topics.

The district's response described financial and service arrangements involving advance payments for planning and design, a System Capacity Charge guaranty, proportional allocation of available capacity, and obligations associated with later phases. EBMUD did not identify a standard project-specific drought-reservation contract. The response also referred to general drought rules that prioritize existing customers. These details show how project phasing, infrastructure funding, capacity commitments, and supply conditions can enter the same service discussion.

13.5.2 Southern Nevada Water Authority and Las Vegas Valley Water District

The joint response from Southern Nevada Water Authority (SNWA) and Las Vegas Valley Water District placed cooling-system selection within the region's water-resource policies. The utilities reported that a policy adopted in December 2021 prohibits consumptive cooling, heating, and industrial-process systems in new development. Additionally, the SNWA offers substantial incentives (up to 50% of project cost as of October 2026) to retrofit existing cooling systems to reduce consumptive use. The respondents' description included evaporative cooling and hybrid configurations that use spray or adiabatic assistance. This policy was presented as an established condition affecting project review; the response did not report measured facility outcomes resulting from its implementation.

Return-flow accounting was central to the utilities' explanation of regional water impacts. In the accounting framework they described, evaporation represents a consumptive loss, whether the supplied water is potable or reclaimed, when that water does not return to the Colorado River system. Consequently, identifying an alternative water source does not, by itself, establish the effect on regional consumption. Information about water delivered, evaporated, retained, and returned provides the context needed to interpret a facility's and the region’s water balance.

The response also described a design review that considers demanding operating conditions. Relevant information included separate water uses, full-buildout demand, peak AI workloads or maximum rack density, and cooling performance during a multi-day ambient-temperature event of at least 120 degrees Fahrenheit without consumptive cooling. Initial filling of a closed loop was treated as nonrecurring, where the water remains in the loop or returns to the system. These distinctions help explain why project definition and peak-condition information are important alongside annual demand estimates.

Before service begins, the utilities described verification of nonconsumptive operation, metering of material water uses, accounting for delivered and returned water, and review of additives and chemical discharges. The response also identified developer funding for necessary infrastructure upgrades through applicable connection, capacity, or rate mechanisms. These practices connect the checklist's questions about cooling configuration, monitoring, wastewater, and financial responsibility.

The joint response emphasized coordination among water, wastewater, economic-development, public-works, energy, and land-use functions before siting and final design. The respondents also recognized that dry cooling could increase the importance of peak-summer electricity availability. Demand response, storage, renewable supply, batteries, development phasing, and emergency operations were identified as related considerations. The feedback illustrates how water-service discussions can intersect with electricity planning and regional emergency coordination.

13.5.3 Sacramento Area Sewer District

Sacramento Area Sewer District (SacSewer) emphasized early involvement of source-control staff in reviewing data center proposals. Its response considered both the discharge from an individual facility and the combined effects of multiple facilities. A project may appear manageable when evaluated independently, while contributing to a broader salinity concern as development progresses. This anticipated planning issue makes proposed facility locations, discharge characteristics, and development schedules relevant to assessments extending beyond a single site.

The district identified electrical conductivity, TDS, and biocides as priority wastewater parameters. The response linked these concerns to an electrical-conductivity limit in the receiving water permit, an operating objective of avoiding salinity increases above background, and the potential sensitivity of biological nutrient removal to large chemical releases. These were reported features of the district's permit and treatment context. The response did not establish the magnitude of any data center contribution to those conditions.

SacSewer described reclaimed water feasibility as dependent on several connected factors, including pipeline proximity, seasonal availability, cooling-system compatibility, supplemental treatment, storage, backup supply, and permitting. Existing agricultural and urban uses were reported to consume most of the available supply during summer, with potential availability for data centers concentrated in fall, winter, and spring. The district also noted that an earlier cooling-tower reuse project encountered an air-quality permitting issue. At the time of the response, Title 22 reporting information reviewed by the respondent

did not specifically identify data center use, leaving questions about the applicable pathway unresolved in the response.

For collection-system planning, SacSewer reported using models that account for existing and future capacity. SacSewer also noted that standard acreage-based planning factors do not specifically represent large water-use data centers. Project-specific discharge estimates would therefore provide a more useful basis for evaluating a proposed connection and identifying possible improvements. The district indicated that applicants would fund system upgrades associated with their projects.

The response identified several potential service and charging options, including wastewater reuse, salinity reduction or pretreatment. Fees are set by the Ordinance. The appropriate fee would depend on the individual site's discharge characteristics and whether they qualify for the pretreatment program. In the context of the checklist, SacSewer's feedback links wastewater characterization and alternative water feasibility with infrastructure needs and financial responsibility.

13.6 Utility Checklist for Evaluating Data Center Development

Participating water systems reported that obtaining key project information early in data center development is important for water and wastewater infrastructure planning. Information about proposed facilities, operating requirements, and development schedules provides a basis for assessing potential service needs and coordinating reviews before capacity commitments or major infrastructure investments. The information available, and the level of detail needed for evaluation, vary with project maturity, local system conditions, and the services requested. Table 8 summarizes relevant information needs through example questions that utilities can incorporate into their project-review processes.

The information identified through utility feedback includes projected electrical load, cooling and heat-rejection configurations, water sources, and anticipated water demand throughout phased development. Demand estimates can describe average-day, maximum-day, instantaneous peak, and seasonal conditions, together with cooling-tower makeup and blowdown, on-site storage, and proposed water reuse. Wastewater information includes expected discharge volumes, composition, and timing, along with any proposed treatment before discharge. Construction milestones, requested service dates, anticipated infrastructure improvements, and proposed financial responsibilities provide additional context for evaluating the relationship between development schedules and utility planning.

Utilities can obtain this information through several approaches, including a checklist to guide conversations, a questionnaire completed by the developer, existing service-application forms, technical meetings, or submissions at agreed project milestones. The choice of approach depends on the utility's established procedures, available resources, and the complexity of the proposed development. Initial discussions may rely on preliminary estimates and identify assumptions or unresolved questions. Subsequent exchanges can refine those estimates and document changes in cooling configuration, project size, construction timing, or operating requirements as development progresses.

The checklist connects the information needs identified through utility engagement to practical questions for evaluating individual projects. It can help organize discussions among developers and utility planning, engineering, operations, finance, and legal staff; identify information gaps; and clarify where additional evaluation is needed. The resulting information supports consideration of capacity, infrastructure, cost

recovery, service agreements, and resilience. The questions in Table 8 are illustrative and adaptable to local circumstances, with their use and timing determined through each utility's review process.

Table 8 Utility Checklist Questions for Evaluating Data Center Development

Topic	Checklist Questions
Project Definition	What is planned, and when will each phase open? How much power and water will each phase need?
Source Water Capacity	Is enough water available during normal operations, peak demand, drought, and emergencies? What backup supplies are available?
Distribution and Storage	Can the pipes, pumps, and tanks provide enough flow and pressure, including for firefighting? Will water quality be maintained?
Cooling and Water Efficiency	How will the facility be cooled? How much water will cooling use and discharge? Can it use less water safely?
Alternative Water Supplies	Can reclaimed water or on-site sources reduce drinking water demand? What treatment, storage, or piping would be needed?
Wastewater and Pretreatment	What wastewater will the facility discharge? Can the sewer system and treatment plant handle it? Is treatment needed before discharge?
Financial Protection	Who will pay for new infrastructure? How will existing customers be protected if the project is delayed, changes, or closes?
Contractual Provisions	Does the agreement explain what happens if demand or schedules change? Does it cover service limits, emergencies, reporting, and closure?
Monitoring and Verification	How will water use, wastewater volume, and quality be measured? Who will compare results with forecasts and agreed limits?
Resilience and Coordination	Who will coordinate planning and emergency response? What is the plan for outages, drought, cyber incidents, and public communication?
Community Engagement	Has a stakeholder engagement plan been developed? How and when will the utility communicate about the project?

14 Considerations for Resilient Water Utility Management

The following considerations provide a structured path for a water or wastewater utility to evaluate a data center proposal. The process is stage-gated but iterative: technical, financial, legal, and engagement activities may proceed in parallel, while each service or investment commitment remains contingent on the evidence and approvals required for that stage. Utilities are strongly encouraged to develop a community communication plan, in conjunction with the considerations listed below. It may be prudent to provide regular public reporting on data center water use, wastewater discharge compliance, and infrastructure cost recovery. Additionally, engaging community stakeholders through public meetings, utility newsletters, and online dashboards is recommended.

Require a Project-Specific Water Balance

Obtain a project-specific water balance prepared under the responsible professional's applicable licensure requirements before making a binding service commitment. The balance defines average-day, maximum-day, instantaneous peak, seasonal, commissioning, emergency, and phased-buildout demand; wastewater streams and mass loading; consumptive use; storage; and reuse. Industry benchmarks may support initial screening but do not replace project-specific analysis (AWWA 2025a).

Conduct a Comprehensive Infrastructure Capacity Assessment

Evaluate source, treatment, storage, pumping, distribution, fire-flow, wastewater collection, and wastewater treatment capacity using calibrated models and phase-specific forecasts. Identify constraints, operating limits, upgrades, schedule dependencies, and cost responsibility before authorizing the corresponding service phase (AWWA 2017a).

Develop a Cost-of-Service Analysis and SDC Calculation

Complete a cost-of-service and financing analysis that distinguishes customer-specific facilities, shared capacity, operating costs, renewal, reliability, financing, and uncertainty. Apply system-development or capacity charges only where authorized and supported by the adopted methodology; use direct funding, customer advances, recurring rates, or contractual security as appropriate. Document the allocation of costs and benefits and any exposure retained by existing customers (AWWA 2017b; AWWA 2025b; AWWA 2014).

Execute a Formal Development Agreement

Determine whether adopted tariffs and standard service documents address the project's phasing, capacity, facilities, funding, security, monitoring, wastewater, change-control, and termination risks. Add a development, special-service, or coordinated set of agreements when project-specific obligations remain. Utility counsel confirms consistency with governing law, adopted rates and rules, procurement requirements, permits, and governing-body authority before execution (Grimm, Green Nylen, and Kiparsky 2026, 65).

Establish Wastewater Pretreatment and Discharge Controls

The Control Authority determines industrial-user status and the applicable pretreatment control mechanism under 40 CFR Part 403, the approved pretreatment program, and local law. Before discharge, establish the necessary baseline characterization, limits or best management practices, sampling, reporting, access, spill control, emergency notification, and enforcement provisions (USEPA 2026b; USEPA 2026a; USEPA 2012).

Promote and Incentivize Water Use Efficiency

Encourage project-specific efficiency and performance commitments from the approved water balance, climate, cooling configuration, source quality, reliability needs, and lifecycle tradeoffs. Review cooling system evaluation of dry, hybrid, evaporative, direct-liquid, reclaimed water, and on-site-recovery options to ensure analysis was conducted using a common basis. Any incentives offered for greater efficiency should conform to legal authorities and document cost or public benefit rather than relying on a universal WUE threshold. Material cooling or water-system changes should trigger notice and technical review (USDOE 2019; USDOE 2026).

Protect Rate Fairness and Financial Sustainability

Align customer contributions, recurring rates, minimum-payment obligations, and financial security with the costs and risks attributable to the project. Size security to the utility's outstanding exposure and reduce it as risk is retired. Reassess rates, capacity, and security at defined phase gates or material-change triggers rather than through an unsupported universal annual review. Power-sector large-load guidance offers transferable staging and security concepts, but does not establish water-rate authority (Navarro and Knoll 2026; Energy Systems Integration Group Large Loads Task Force 2025; Cohen, Beyer, and Shwisberg 2026).

Implement a Public Communication and Transparency Program

Develop a communication plan early enough to inform the service and public-approval process. Report verified water use, wastewater compliance, infrastructure commitments, and cost allocation at a frequency and level of detail consistent with public-records law, permit requirements, security needs, and lawful confidentiality protections. Use accessible engagement channels and consider a CBA when it advances defined community objectives without replacing utility rates, permits, or service agreements (Grimm, Green Nylen, and Kiparsky 2026, 65).

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