



Here's a condensed technical report that combines the key information into a single document suitable for municipal planning or decision-making.

Wastewater Considerations for Data Centers and Municipal Lagoon Treatment Systems

Introduction

As the number and size of data centers continue to grow, municipalities are increasingly evaluating the potential impacts these facilities may have on wastewater treatment infrastructure. While data centers generally produce relatively little process wastewater compared to traditional manufacturing industries, larger facilities that use water-based cooling systems can generate industrial wastewater that may affect municipal treatment plants, particularly lagoon systems.

The primary wastewater concern is not sanitary wastewater generated by employees, but wastewater associated with cooling systems and water treatment operations.

Types of Data Centers and Wastewater Characteristics

The quantity and composition of wastewater are driven primarily by facility size and cooling technology rather than ownership or business model.

Data Center Type	Typical Wastewater	Relative Municipal Impact
Micro	Primarily domestic wastewater	Very Low
Edge	Domestic wastewater; minimal maintenance water	Very Low
Enterprise	Domestic wastewater; limited cooling tower blowdown	Low
Managed Services	Similar to enterprise or colocation facilities	Low to Moderate
Colocation	Domestic wastewater, cooling tower blowdown, reverse osmosis reject water	Moderate
Cloud	Large cooling tower blowdown, reverse osmosis reject water, boiler blowdown	High
Hyperscale	Significant cooling-related wastewater and treatment chemicals	Very High
AI	Very large cooling tower blowdown, liquid cooling maintenance water, reverse osmosis reject water	Highest



Small data centers often function much like commercial office buildings, while hyperscale and AI facilities may generate substantial industrial wastewater because of their extensive cooling systems.

Cooling Tower Blowdown

Cooling tower blowdown is the principal industrial wastewater stream generated by many large data centers.

Cooling towers remove heat through evaporation. As water evaporates, dissolved minerals remain behind and become increasingly concentrated. To prevent scale formation, corrosion, and reduced cooling efficiency, a portion of the concentrated water is periodically or continuously discharged. This discharge is known as **cooling tower blowdown**.

Typical constituents include:

- Elevated total dissolved solids (TDS)
- Chloride
- Sulfate
- Calcium and magnesium
- Silica
- Corrosion inhibitors
- Biocides
- Residual chlorine or bromine
- Trace metals

Unlike sanitary wastewater, cooling tower blowdown contains relatively little organic material but elevated concentrations of dissolved minerals and cooling-water treatment chemicals.

Effects on Municipal Wastewater Systems

Municipal wastewater treatment plants can generally accommodate data center wastewater when properly managed; however, cooling tower blowdown presents several operational concerns.

Elevated Dissolved Salts

Cooling tower blowdown contains high concentrations of dissolved minerals that are not removed by conventional biological treatment. These salts pass through the treatment process and may:

- Increase effluent salinity.
- Reduce reclaimed water quality.
- Accumulate over time, particularly where evaporation is significant.

Biological Inhibition



Cooling systems commonly use biocides to control bacterial growth.

Examples include:

- Chlorine
- Bromine
- Glutaraldehyde
- Isothiazolinones
- DBNPA

Residual concentrations can inhibit the microorganisms responsible for wastewater treatment, reducing treatment efficiency and slowing recovery following an upset.

pH Variations

Cooling water may have elevated or depressed pH depending on treatment chemistry. Extreme pH can interfere with biological treatment and may require neutralization before discharge.

Metals

Corrosion within cooling systems may introduce copper, zinc, nickel, and iron. While typically present in low concentrations, these metals can accumulate in wastewater sludge over time.

Hydraulic Loading

Large intermittent releases of cooling tower blowdown can create hydraulic and chemical shock loading. Gradual discharge is generally preferred.

Additional Industrial Wastewater Sources

Large data centers may also generate wastewater from:

- Reverse osmosis (RO) reject water
- Boiler blowdown
- Water softener regeneration
- Cooling system cleaning
- Equipment maintenance
- Heat exchanger flushing

These waste streams are generally characterized by elevated dissolved solids, low organic content, and water treatment chemicals.

Lagoon System Considerations

Lagoon wastewater treatment systems are more sensitive to industrial wastewater than mechanical treatment plants because they rely on naturally occurring bacteria, algae, and long detention times.

Potential impacts include:

- Reduced biological activity from residual biocides.
- Accumulation of dissolved salts because lagoons do not remove TDS.
- Elevated effluent conductivity.
- Long-term accumulation of metals in lagoon sediments.
- Slower recovery from treatment upsets caused by concentrated industrial discharges.

The greatest concern for lagoon systems is maintaining a stable biological environment.

Industrial Pretreatment

Industrial pretreatment is a combination of monitoring, operational controls, and, when necessary, on-site treatment designed to protect municipal wastewater treatment systems.

Pretreatment programs are regulated under:

- The Clean Water Act
- EPA General Pretreatment Regulations (40 CFR Part 403)
- State environmental regulations
- Local sewer use ordinances

Pretreatment programs commonly require:

- Wastewater characterization.
- Industrial discharge permits.
- Flow monitoring.
- Routine sampling.
- pH monitoring.
- Conductivity and TDS monitoring.
- Metals monitoring.
- Operational controls to prevent harmful discharges.

Where necessary, facilities may install:

- Equalization tanks.
- Neutralization systems.
- Dechlorination equipment.
- Oil-water separators.

- Metals removal systems.

For data centers, pretreatment most often focuses on controlling cooling-water chemistry rather than treating highly contaminated industrial wastewater.

Considerations for Municipal Lagoon Systems

Municipalities operating lagoon treatment systems should evaluate proposed data centers based on:

- Facility size and electrical demand.
- Cooling technology (air-cooled versus water-cooled).
- Estimated cooling tower blowdown volume.
- Water treatment chemicals used.
- Frequency of maintenance discharges.
- Potential impacts on salinity and biological treatment.
- Availability of pretreatment and monitoring.

Small air-cooled facilities generally pose little risk beyond ordinary sanitary wastewater.

Large cloud, hyperscale, and AI data centers that rely on evaporative cooling may require industrial discharge permits, pretreatment measures, and ongoing monitoring to ensure compatibility with lagoon treatment systems.

Conclusion

The potential wastewater impacts of data centers are largely determined by their cooling systems rather than their ownership model. Micro, edge, and many enterprise facilities generate wastewater comparable to that of commercial office buildings and typically present minimal concerns.

Conversely, cloud, hyperscale, and AI data centers may generate substantial volumes of cooling tower blowdown containing elevated dissolved salts, corrosion inhibitors, biocides, and trace metals. While these waste streams are generally less complex than those from traditional industrial facilities, they can affect municipal wastewater treatment—particularly lagoon systems that depend on stable biological processes and do not remove dissolved salts.

Careful planning, industrial pretreatment, monitoring, and coordination between the municipality and the data center operator can help ensure that wastewater discharges remain compatible with existing treatment infrastructure while supporting future economic development.

how would their treated waste effect plants grown with land application of treated wastewater from a lagoon system



This is an excellent question because **land application systems are often more vulnerable to long-term accumulation of constituents than the lagoon itself**. If a municipality irrigates crops, forage, turf, or other vegetation with treated lagoon effluent, the primary concern from data center wastewater is **the gradual buildup of salts and certain trace constituents in the soil**, rather than acute toxicity.

How Land Application Systems Work

In a land application system, treated lagoon effluent is applied to agricultural fields or other vegetated areas where:

- Plants utilize nitrogen, phosphorus, and water.
- Soil provides additional filtration and treatment.
- Microorganisms further break down organic matter.
- Water either infiltrates to groundwater or is taken up by plants through evapotranspiration.

Because **dissolved salts are not removed by lagoon treatment**, they remain in the irrigation water and are repeatedly applied to the soil.

Potential Effects on Plants

1. Salinity (Primary Concern)

Cooling tower blowdown contains elevated **Total Dissolved Solids (TDS)**, including:

- Sodium
- Chloride
- Sulfate
- Calcium
- Magnesium

These salts pass through the lagoon largely unchanged.

Repeated irrigation with high-salinity water can:

- Reduce seed germination.
- Slow plant growth.
- Reduce crop yields.
- Cause leaf burn (especially from chloride).
- Make it more difficult for roots to absorb water (osmotic stress).

Plants may appear drought-stressed even when soil moisture is adequate because the salts reduce the availability of water to roots.



2. Sodium Hazard

Sodium deserves special attention because it affects **soil structure**, not just plants.

Excess sodium can:

- Cause soil particles to disperse.
- Reduce soil permeability and infiltration.
- Create surface crusting.
- Limit root penetration.
- Increase runoff.

Over time, sodium can make soils less productive and more difficult to manage.

For this reason, municipalities often evaluate the **Sodium Adsorption Ratio (SAR)** of reclaimed wastewater used for irrigation.

3. Chloride Toxicity

Chloride is common in cooling tower blowdown because it concentrates as water evaporates.

Sensitive plants may experience:

- Leaf tip burn.
- Marginal leaf scorch.
- Premature leaf drop.
- Reduced growth.

More salt-tolerant species, such as many grasses, generally tolerate higher chloride concentrations than vegetables or fruit trees.

4. Boron

Some source waters and cooling-water treatment chemicals may contribute boron.

While boron is an essential micronutrient, the range between deficiency and toxicity is narrow.

Sensitive crops can be injured by relatively low boron concentrations.

5. Trace Metals



Cooling systems may contribute very small amounts of:

- Copper
- Zinc
- Nickel
- Iron

At typical concentrations from properly managed data centers, these metals are unlikely to cause immediate plant toxicity. However, because metals do not degrade, they can accumulate in soils over many years, particularly if effluent is applied repeatedly to the same fields.

Long-term monitoring of soil metal concentrations is prudent for land application systems.

6. Corrosion Inhibitors

Cooling-water treatment programs may use compounds such as phosphonates or molybdate-based inhibitors.

Most occur at low concentrations, but their long-term behavior in agricultural soils is still an area of ongoing research. Municipalities may choose to monitor these constituents if industrial cooling-water discharges become a significant portion of the wastewater stream.

7. Biocides

Residual biocides should be largely degraded or diluted before treated effluent reaches land application sites if pretreatment and lagoon treatment are functioning properly.

If significant residual concentrations were present, they could:

- Affect beneficial soil microorganisms.
- Reduce microbial decomposition.
- Alter nutrient cycling.

Under normal operating conditions, this is generally considered a lower risk than salinity.

Effects on Soil

Long-term irrigation with saline water can lead to:

Potential Effect	Result
Salt accumulation	Reduced crop productivity

Potential Effect	Result
Sodium buildup	Poor soil structure
Reduced infiltration	More runoff and ponding
Reduced permeability	Less water reaching plant roots
Higher soil conductivity	Increased stress on salt-sensitive crops

These effects often develop gradually over years rather than appearing immediately.

Crop Sensitivity

Different plants vary widely in their tolerance to saline irrigation water.

Crop Tolerance	Examples
Sensitive	Beans, carrots, onions, strawberries, many fruit trees
Moderately tolerant	Corn, soybeans, wheat, alfalfa
Tolerant	Barley, cotton, Bermuda grass, tall fescue, many native grasses

If reclaimed water is used primarily on forage grasses or turf, the risk from modest increases in salinity is generally lower than for high-value horticultural crops.

Implications for Municipal Lagoon Systems

For municipalities using treated lagoon effluent for irrigation, accepting wastewater from large water-cooled data centers should prompt an evaluation of:

- **Total dissolved solids (TDS)** loading.
- **Electrical conductivity (EC)** of the reclaimed water.
- **Sodium Adsorption Ratio (SAR).**
- **Chloride concentrations.**
- Long-term trends in soil salinity and infiltration.
- Crop salt tolerance.
- Groundwater protection where infiltration is significant.

If these parameters remain within agronomic guidelines, the treated wastewater can often continue to be used successfully. If not, adjustments may include blending with lower-salinity water, reducing application rates, rotating irrigation areas, or selecting more salt-tolerant vegetation.

Relative Risk by Data Center Type

Data Center Type Potential Effect on Land Application

Micro	Negligible
Edge	Negligible
Enterprise	Low
Managed Services	Low to Moderate
Colocation	Moderate
Cloud	Moderate to High
Hyperscale	High
AI	Highest

The greatest long-term concern is **not toxicity to plants from a single irrigation event**, but the **gradual accumulation of dissolved salts—especially sodium and chloride—in the soil**. These constituents are not removed by lagoon treatment and can, over many years, reduce soil productivity and limit the range of crops that can be successfully irrigated.

Considerations for Idaho

For Idaho municipalities, this issue is especially important because many lagoon systems discharge through **land application during the growing season**. In the state's semi-arid climate, evapotranspiration can concentrate salts in the root zone if there is insufficient leaching from rainfall or supplemental irrigation. As a result, municipalities evaluating large cloud, hyperscale, or AI data centers should consider not only the capacity of the lagoon but also the long-term effects of increased salinity on soils, crops, and groundwater. Monitoring **EC, TDS, SAR, chloride, and soil salinity** over time can help ensure that reclaimed water remains suitable for its intended agricultural use.