# Gap Analysis: Assessing the Impact of Data Centers on Water Stress Conditions in Virginia and Arizona

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# The Overarching Issue: Digital Growth vs Finite Resources

## +133%

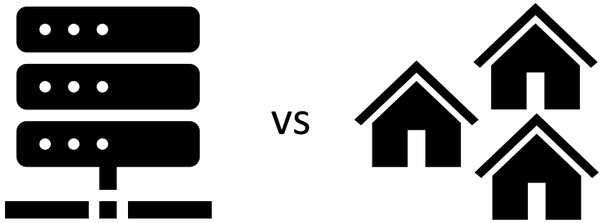
Projected Rise in Electricity Consumption for US Data Centers

(from 183 TWh in 2024 to 426 TWh by 2030)

## 100-1000 MW

Power Capacity of New Hyperscale Data Centers

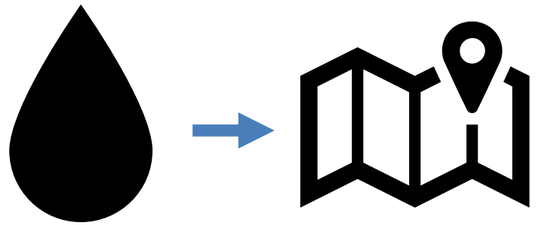
(Equivalent to 80,000 – 800,000 homes)




## 0.3%

Of the total US Water Withdrawals go towards Data Centers

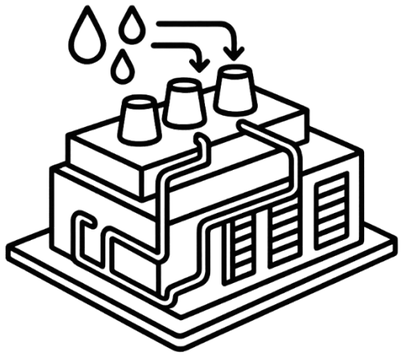
BUT impacts are highly localized and concentrated



Given that data centers are a crucial part of digital infrastructure, the central challenge is how to expand without breaking the localized systems on which they depend.

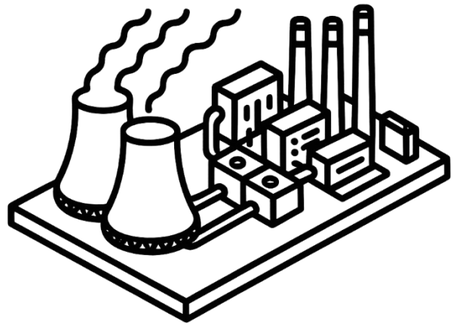
# Water-Energy-AI Nexus

## Direct Water Use: On-site Cooling



Visible water footprint through evaporative needs and other on-site water withdrawals

## Indirect Water Use: Electricity Grid

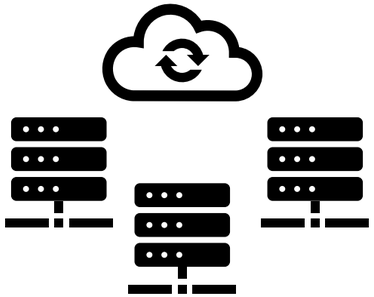


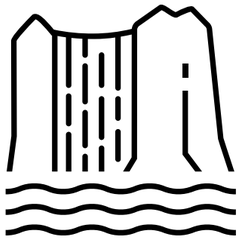
On average, US thermoelectric power plants require 15 gallons of water per kWh.
For a 100 MW data center, indirect water use can go up to 13.1 billion gallons per year

Evaluating “Water-Smart” data centers by only focusing on on-site water use can overlook the massive off-site water burden carried by power plants.

# Issues with current Data center “Hubs”

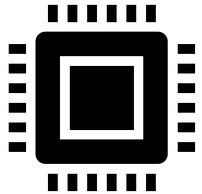
## Virginia: Data Center Alley

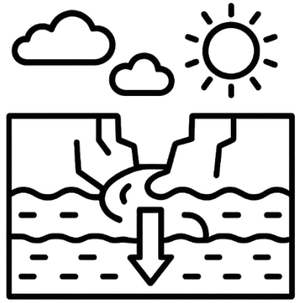




- Historically water-abundant, humid climate and riparian water rights
- World’s largest concentration of digital infrastructure, heavy reliance on shared municipal infrastructure

## Arizona: Silicon Desert





- Arid desert environment, prior appropriation doctrine
- Rapidly growing ‘Cloud and Chip’ industry with heavy reliance on groundwater and overallocated rivers

# Virginia: Existing Data Centers

## 300+ Facilities

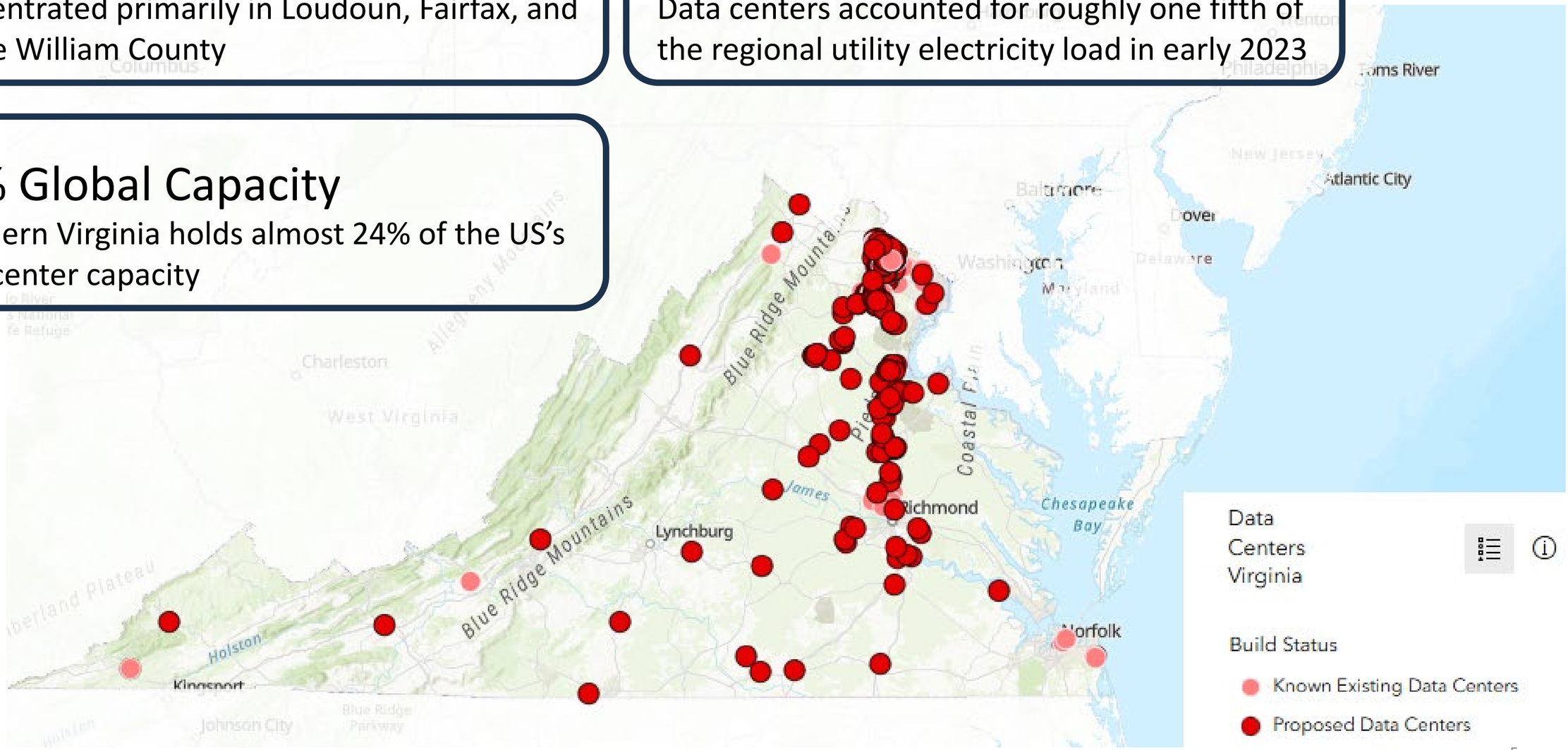
Concentrated primarily in Loudoun, Fairfax, and Prince William County

## 21% of Utility Load

Data centers accounted for roughly one fifth of the regional utility electricity load in early 2023

## 13% Global Capacity

Northern Virginia holds almost 24% of the US's data center capacity



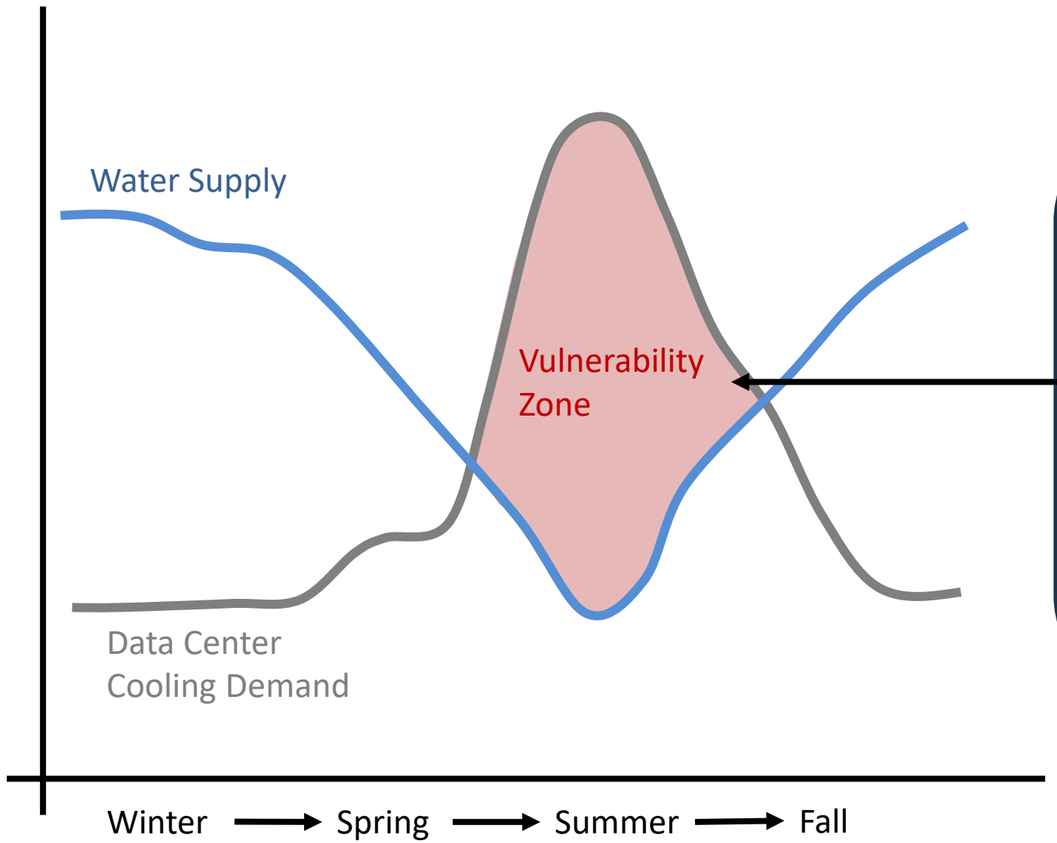
# Vulnerabilities in Virginia

## 86% Increase

Data center water use in Virginia increased from 1.1 billion gallons in 2019 to 2.1 billion gallons in 2023

## Skewed Use

11 facilities, each used over 50 million gallons annually, whereas a single facility used 243 million gallons in a year (10% of the state sector total)




## The Shared Risk

During the massive heatwaves or droughts, evaporative cooling demands can directly compete with the public water supplies, especially in watersheds where many facilities are clustered

# Arizona: Existing Data Centers

## 160+ Facilities

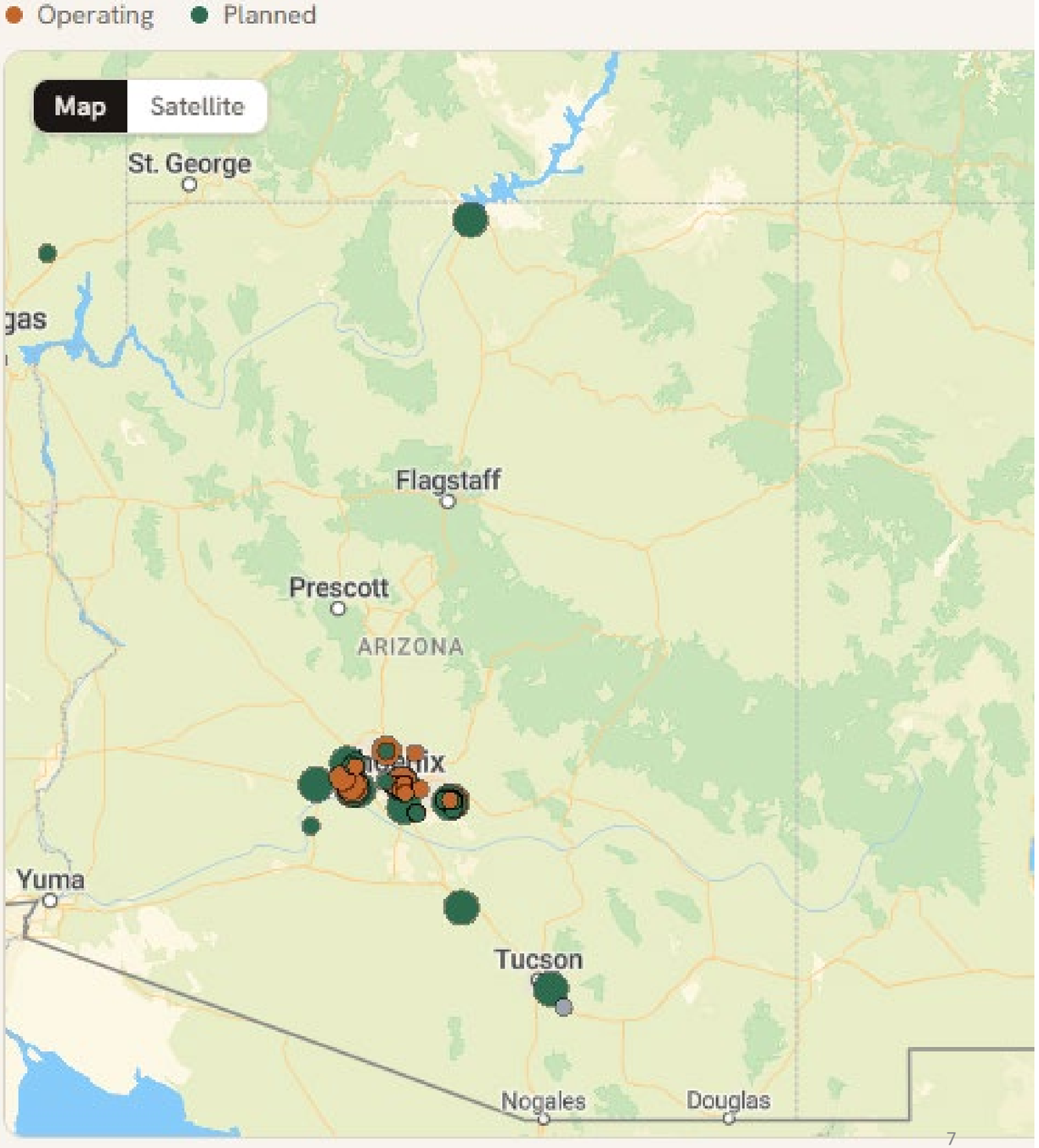
Concentrated primarily near Phoenix Active Management Area (AMA)

## 602 MW in 2024

Phoenix AMA saw a 67% year-to-year increase in operating capacity

## Water Source Shift

Reliance on municipal supplies, reclaimed wastewater, and groundwater withdrawals



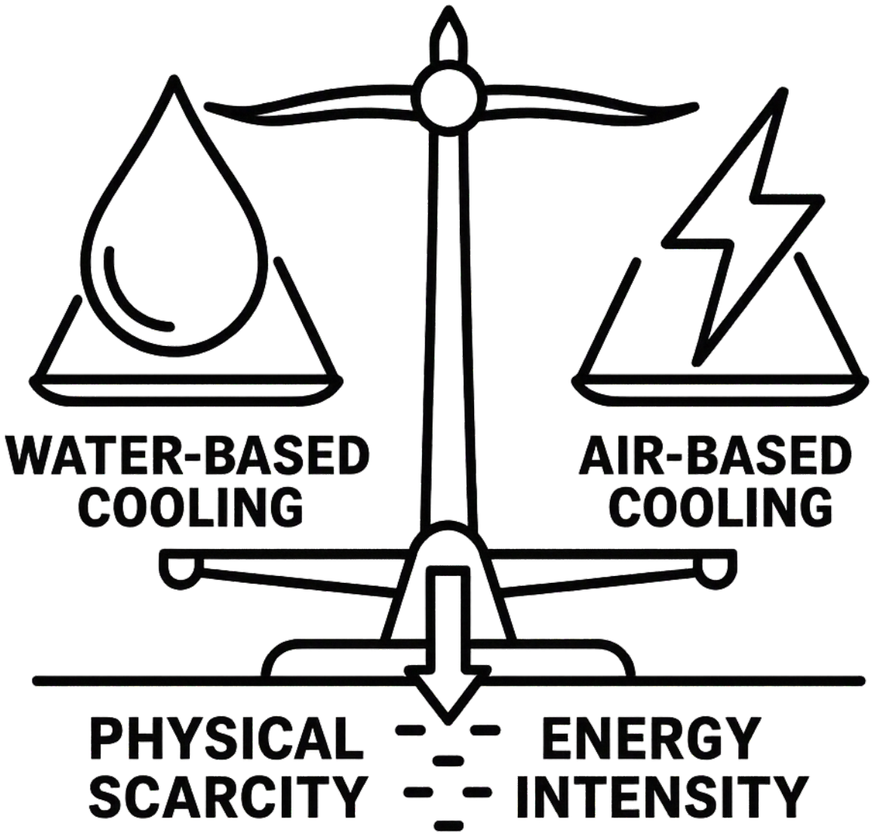
# Vulnerabilities in Arizona

## Groundwater

Arizona relies on finite groundwater and the structurally constrained Colorado River. Most available surface water is legally overallocated.

## Cooling Trade-off

Community pushback is forcing planners to abandon evaporative cooling in favor of zero-water air-cooling systems.




## Indirect Penalty

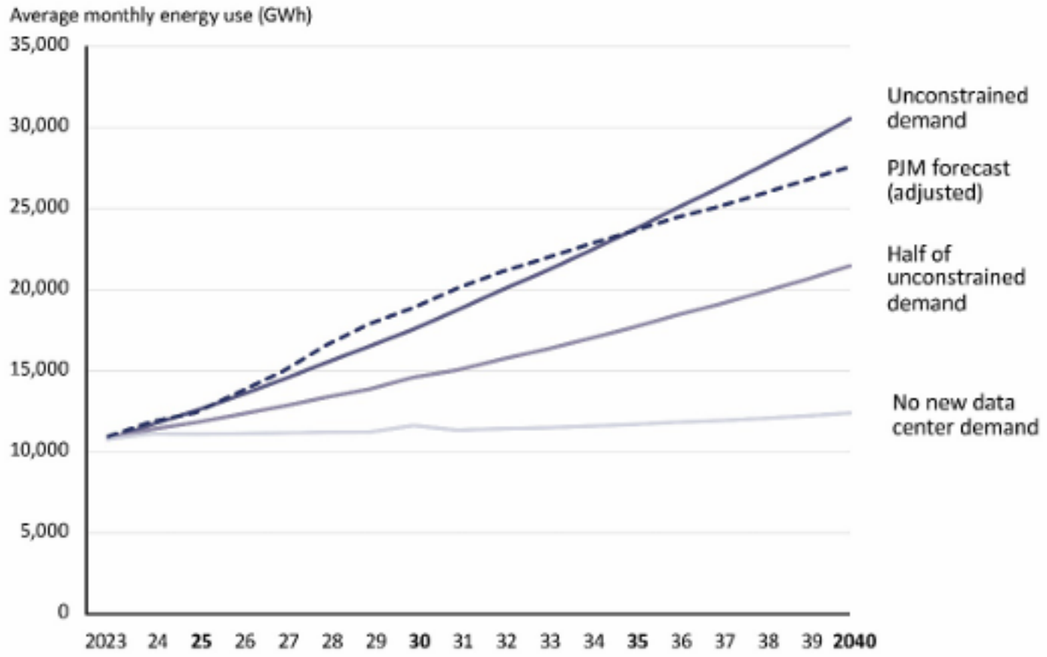
Air-cooled facilities consume significantly more electricity. This indirect water footprint could increase water stress by 17-32% in peak periods.

# Data Center Water Use in Context

| Metric<br>(BGY: Billion gallons per year) | Virginia | Arizona |
|---|---|---|
| Data center (DC) direct water use | 2.1 BGY<br>(<0.5% of total statewide withdrawals) | 0.905 BGY<br>(<0.1% of total statewide withdrawals) |
| DC indirect water use | 400-500 BGY | 2.9 BGY (data only for Phoenix) |
| Agricultural water use | 9.7 BGY | 1271 BGY |
| Thermoelectric withdrawals | 1700 BGY | 122 BGY |
| DC direct water use vs Agriculture | DC/Agriculture: 0.22 ratio | DC/Agriculture: 0.0007 ratio |
| DC direct water use vs Thermoelectric | DC/Thermoelectric: 0.001 ratio | DC/Thermoelectric: 0.007 ratio |
| DC total water use vs Agriculture | DC/Agriculture: 41.45-54.62 ratio | DC/Agriculture: 0.003 ratio |
| DC total water use vs Thermoelectric | DC/Thermoelectric: 0.23-0.29 ratio | DC/Thermoelectric: 0.031 ratio |
| Dominant water use sector | Thermoelectric Power Generation | Agriculture |

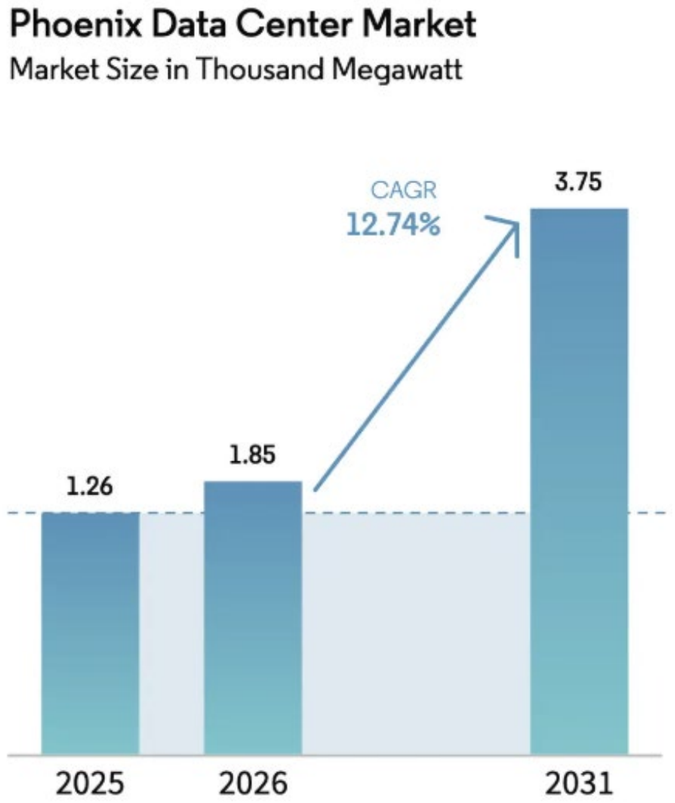
# Planned Data Centers in Virginia and Arizona

## Virginia




SOURCE: JLARC staff consultant analysis.
NOTE: A detailed note is provided for this figure in Chapter 3.

## Arizona



# Core Problem: The Transparency Gap

## Facility Level Peak Demands

Since facilities seldom report annual aggregates or averages, it is challenging to make inferences of critical summer heatwave peaks that can actually break the system

## Consumptive vs Non-Consumptive

The distinction between water evaporated (lost) vs returned back to the system is rarely tracked

## Energy-Water Nexus

Data linking the facilities' hourly loads to the electricity grid's indirect water footprint are not readily available

Core Insights: Standardized disclosures of facilities' water and electricity demands need to be mandated

# Recommendation 1: Mandate Standardized Disclosure

## Pre-Development Projections

Require phased disclosure of projected water and electricity use linked to siting and permitting decisions

## Peak-day Water Use

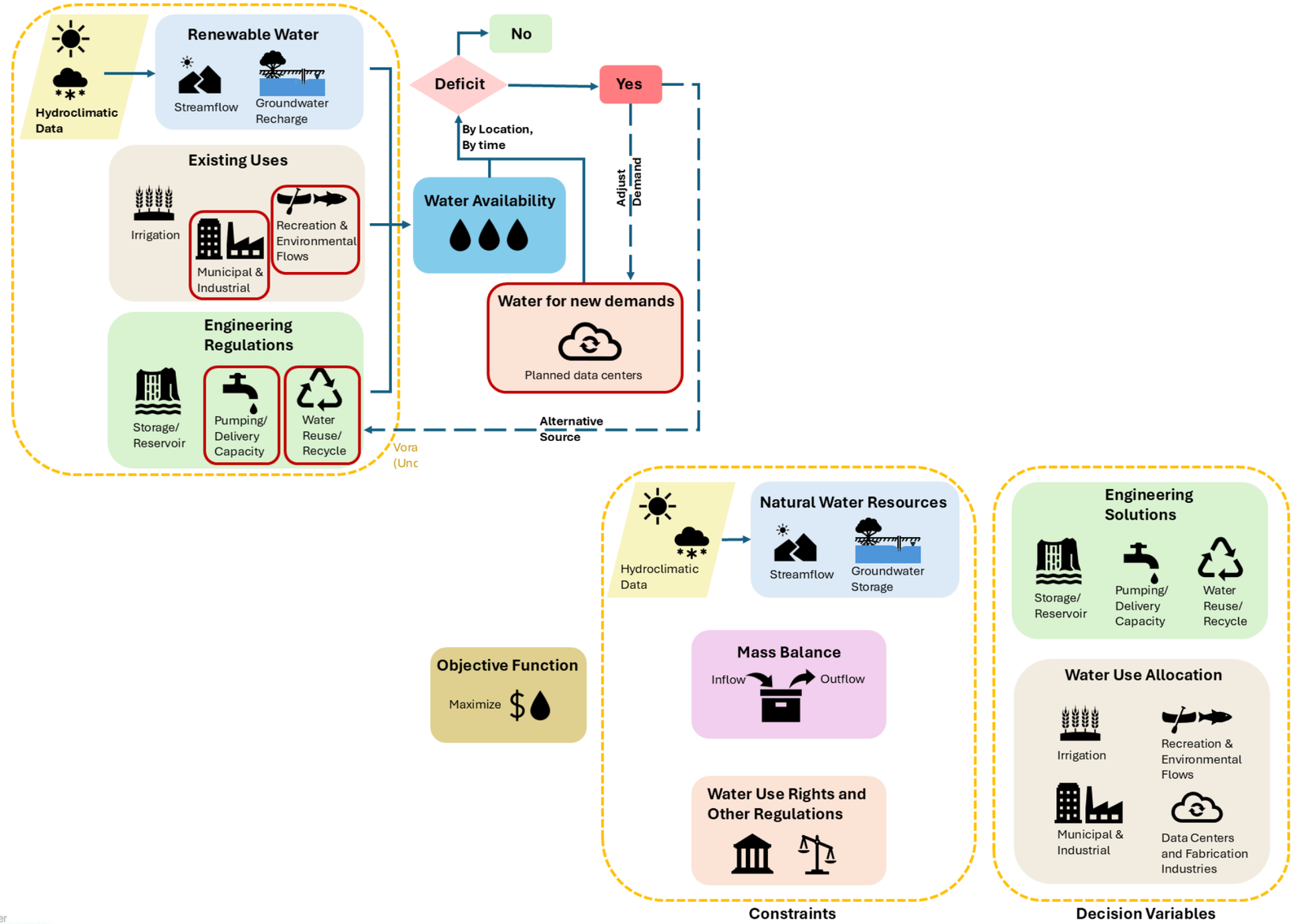
Mandate reporting both annual averages and peak water withdrawal rates

## Indirect Footprint Tracking

Require disclosure of grid electricity sources and their associated water footprint

Decision-making

# Recommendation 2: Establish Data Center Planning Boundaries

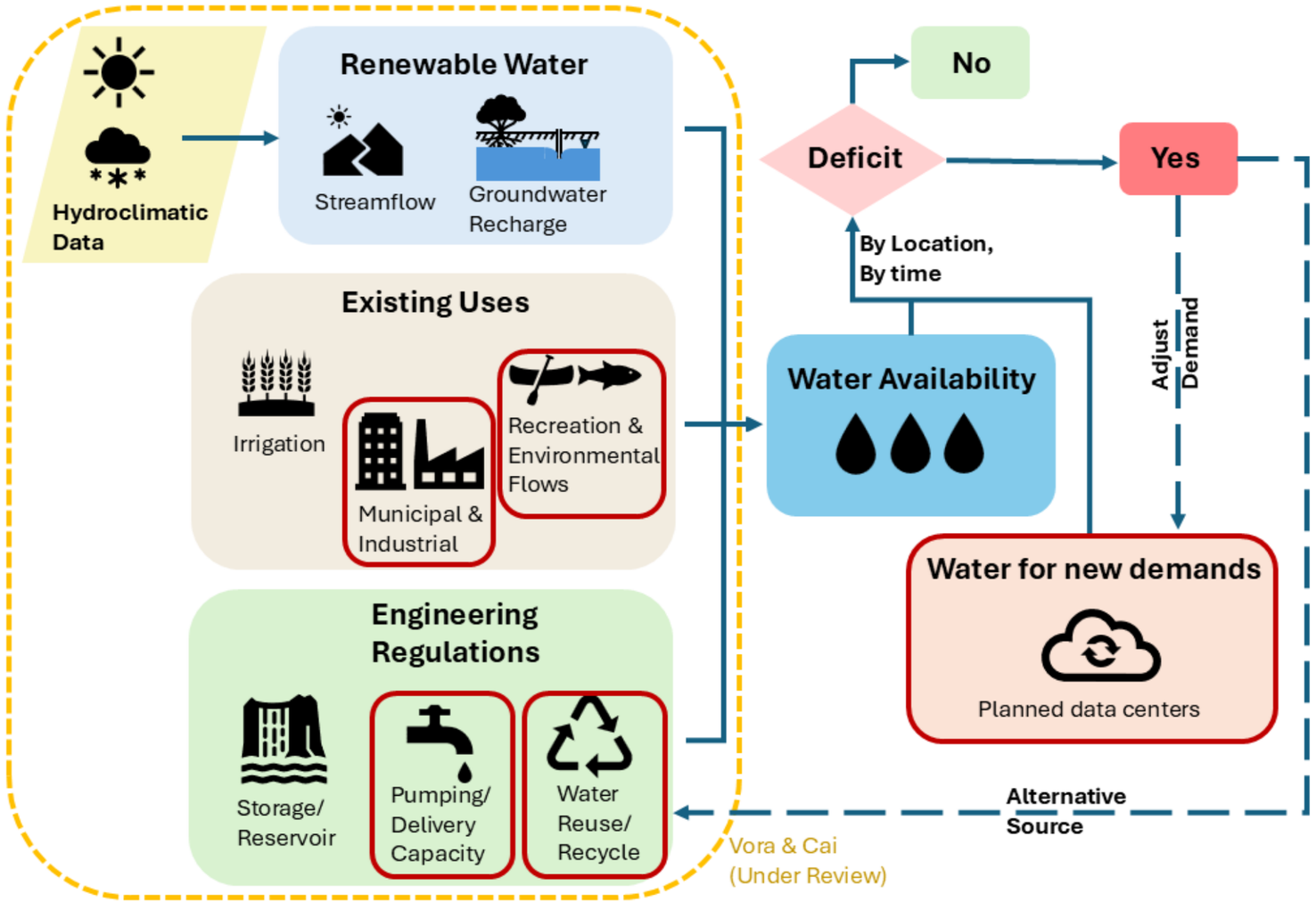



## Move Beyond Statewide Averages

Define Spatial units that reflect realistic combinations of available water, energy access, and land suitability

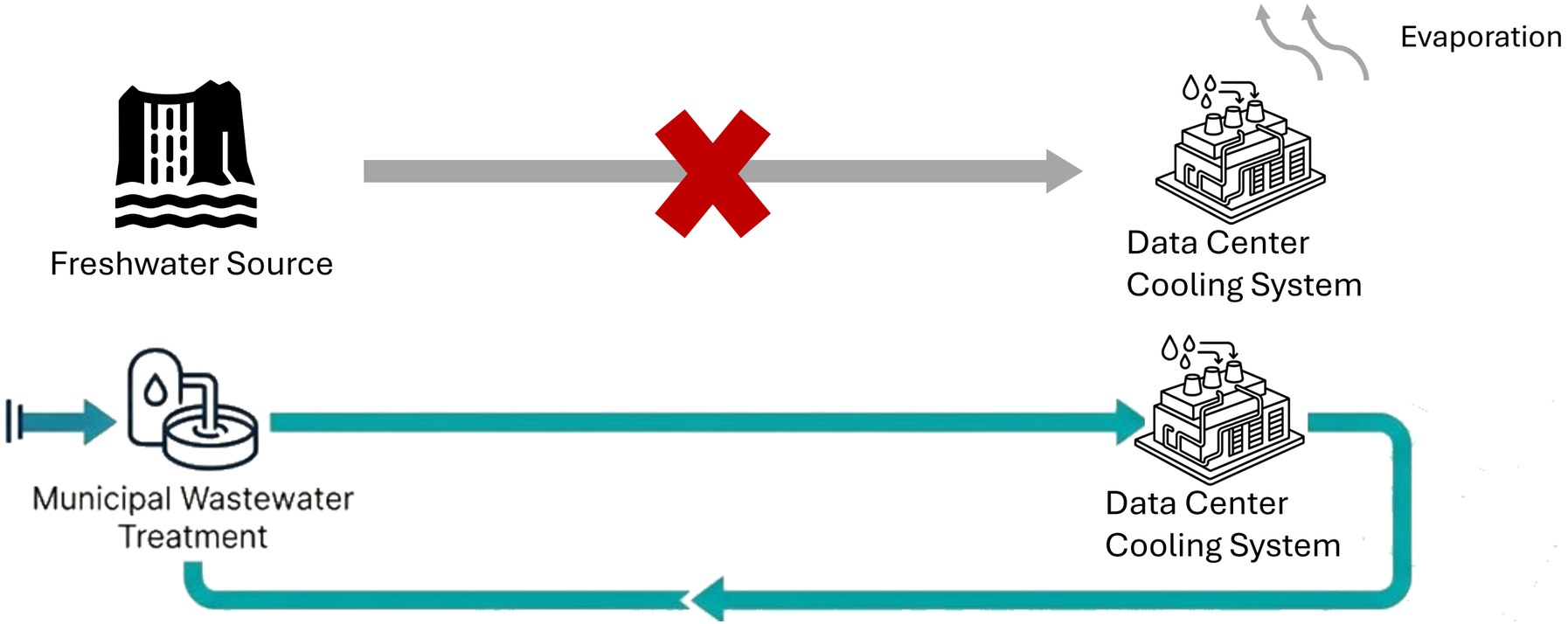
Modeling the impact of data centers for these planning boundaries should be carried out with suitable models, taking into account the existing laws and policies

# Explanation of the model for Virginia




- Determine natural water availability using hydroclimatic data
- Subtract current agricultural/municipal uses and regulatory constraints to find actual, high-resolution availability
- Compare available water against planned data center demands by location and time to identify supply gaps and trigger alternative sourcing or demand adjustments.

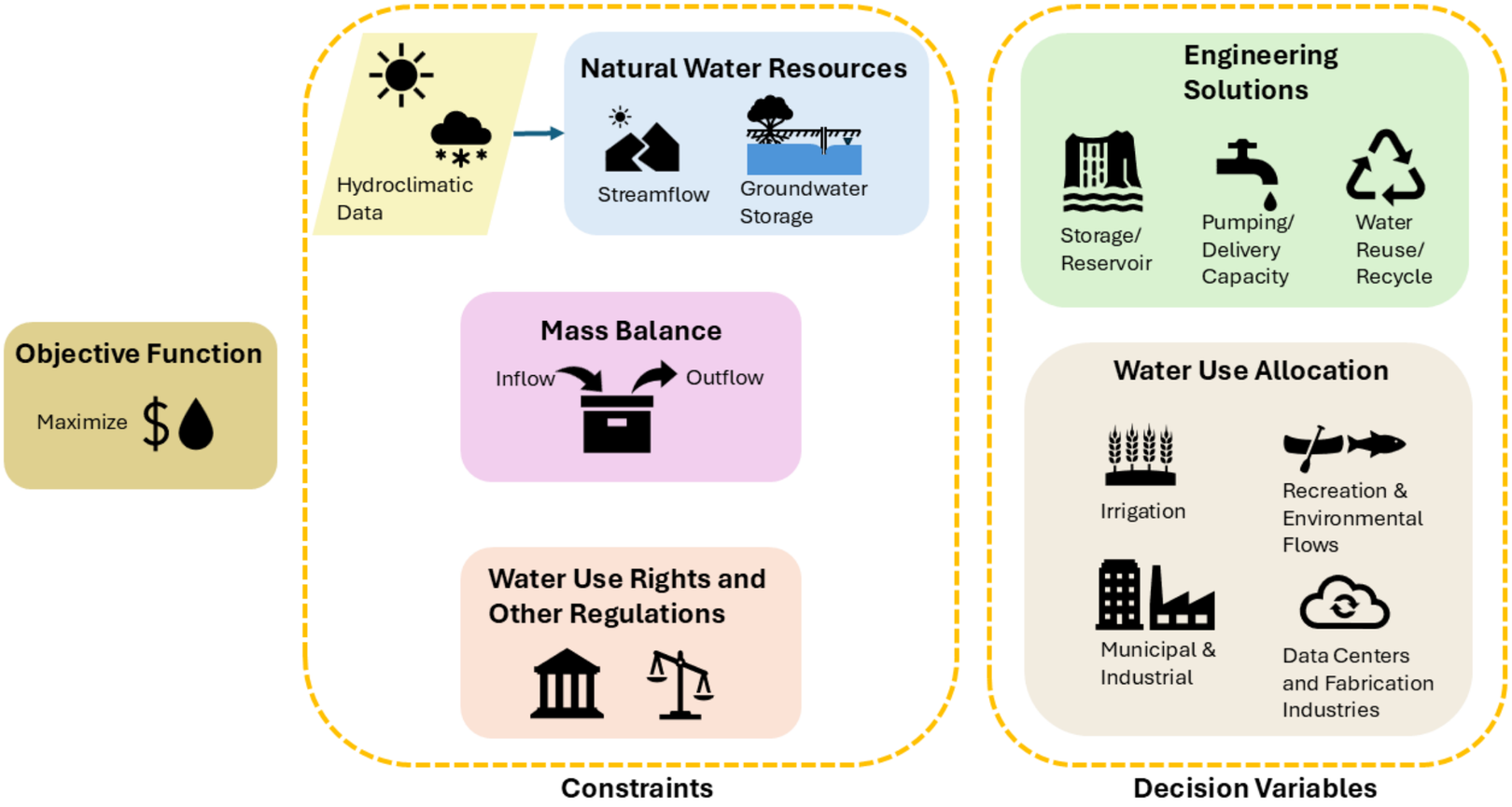
# Reclaimed delivery can offset freshwater withdrawals but require immense infrastructure




In Loudoun County,  out of 900 million gallons of total demand, reclaimed water delivery to data centers reached 736 million gallons in 2024

Reclamation systems can protect freshwater sources, but require municipalities to build and maintain heavy and specialized pipe networks

# Explanation of the model for Arizona

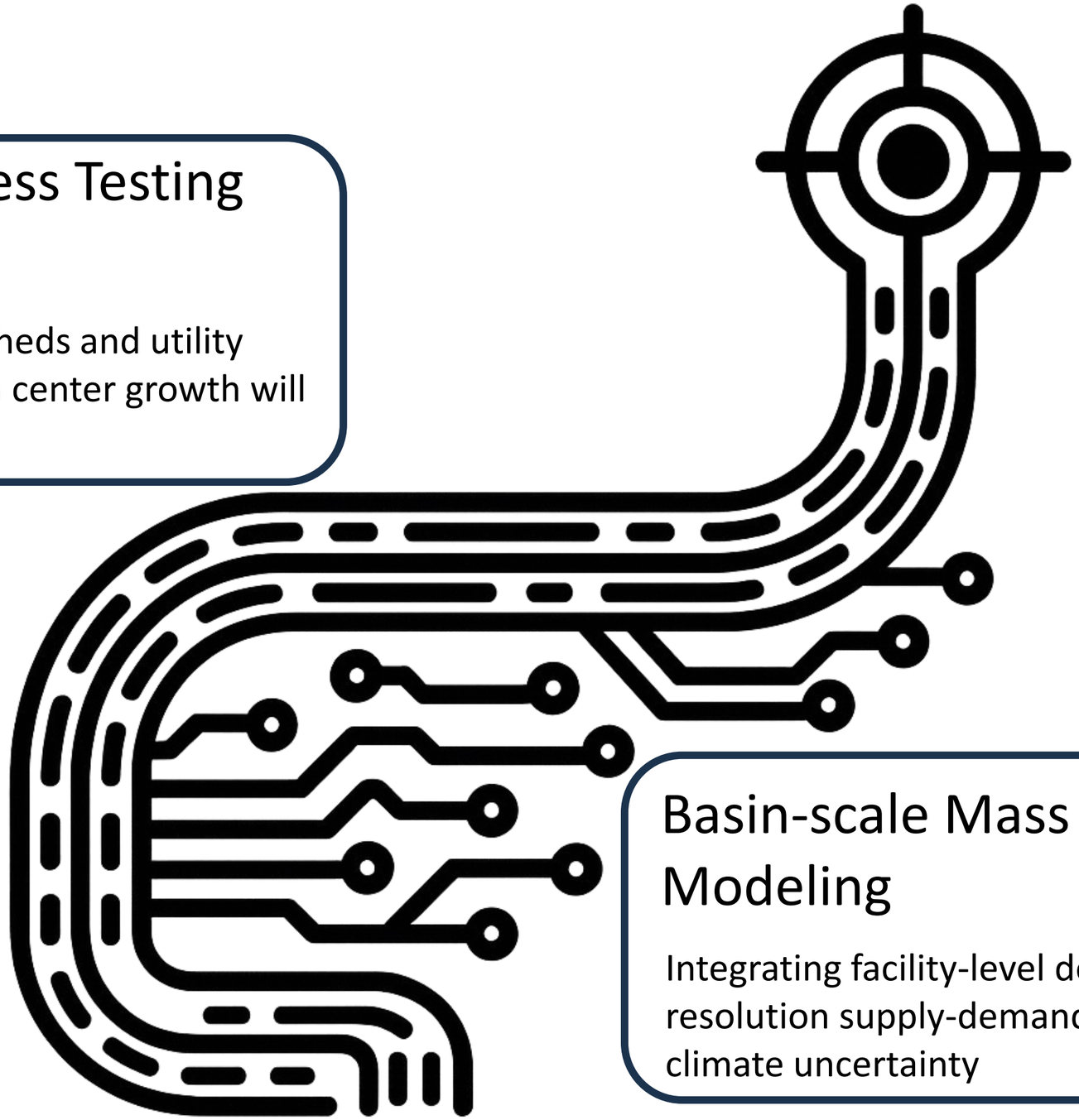



- Since resources are already overallocated, the model emphasizes water reallocation
- The model maximizes watershed-wide benefit function while accounting for environmental, legal, and structural constraints
- The output highlights water rights transfers to balance the water supply and demands

# Future Analysis

## Infrastructure Stress Testing

Identifying specific watersheds and utility systems where future data center growth will break current capacity



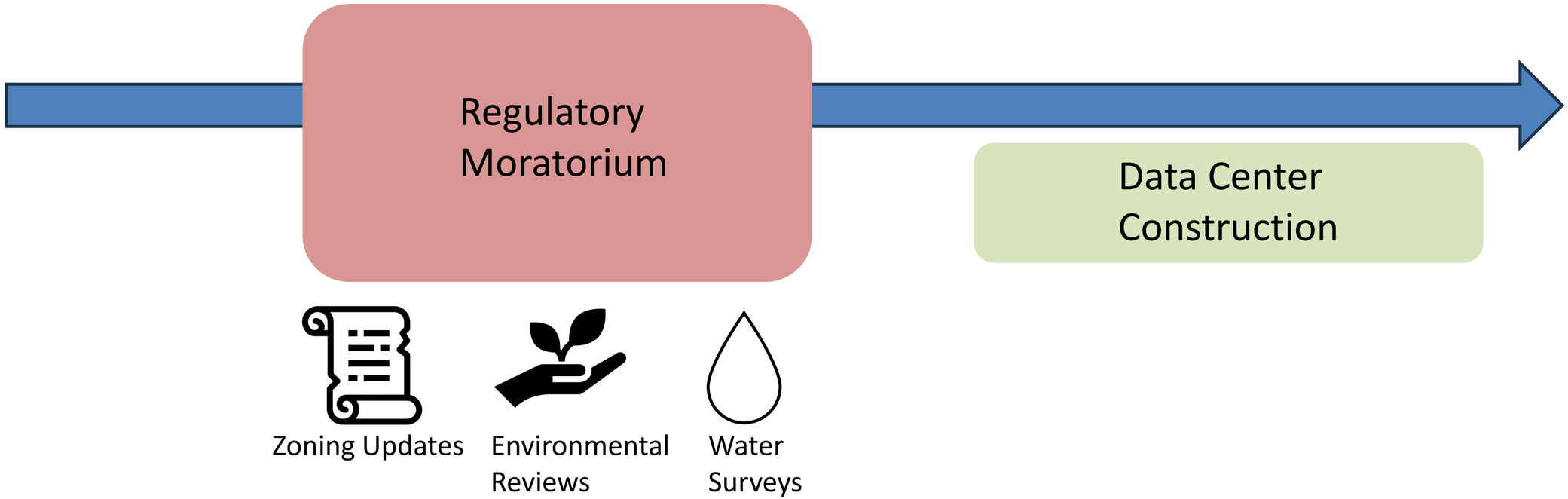
## Resilient Water Governance

The Ultimate Goal

## Basin-scale Mass Balance Modeling

Integrating facility-level demands into high-resolution supply-demand projections under climate uncertainty

# Regulatory moratorium can buy critical time to update municipal zoning




Champaign County is weighing the option of a one-year pause on the construction of large data centers (Source: Mahomet Daily)

A moratorium is a strategic layer to ensure that municipal zones, water rights, and infrastructure plans are modernized before large water users arrive

# Thank You!

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