BC ESG • Operational Resilience Architecture

Dry-Site Risk Quick Card: Data Centers in Dry Places (Physical-Risk & Water Assessment)

Current version — Nov 1, 2026. Update history: https://bcesg.org/data-center-water-scarcity-physical-risk/
Target: High-Density GPU Siting (40–100+ kW/rack) • Mass-Bait Standard

EXECUTIVE CORE: THE DENSITY-BASIN COLLISION

AI build-out rack densities have escalated from historical 10–15 kW to **40–100+ kW for GPU clusters**. Every kilowatt arrives as heat that historically evaporated water. Facilities sited for cheap power and tax incentives cluster in contested basins (**US Sun Belt, southern Europe, northern India, parts of East Asia**). Cooling depends on resources hosts cannot guarantee during drought.

THE HAZARD SET: SITING, PATHWAYS & FINANCIAL EXPRESSIONS

Hazard	Root Driver	Impact Pathway	Financial Expression
Extreme heat	Rising ambient temperatures; urban heat islands	Evaporative cooling efficiency falls with wet-bulb temperature; mechanical chillers carry the load	PUE deteriorates; energy costs spike; thermal throttling in the tail
Water scarcity & drought	Precipitation shifts; aquifer depletion	Municipal curtailment; industrial water prices rise	Forced reduction in cooling withdrawal; dry-cooling retrofits; tanker logistics in extremis
Flood & inundation	Extreme rainfall; riverine and coastal surge	Substations flood; fuel deliveries for backup generators are cut	Long outages; asset damage; insurance repricing (stranded assets)
Grid stress & wildfire	Peak demand colliding with heat; transmission fire risk	Load shedding; public-safety shutoffs	Generator hours accumulate — Scope 1 diesel, fuel-supply exposure, permit pressure

THE ASSESSMENT METHOD: THREE SEQUENTIAL PASSES

Pass 1: Geospatial Exposure Mapping

- **Downscaled CMIP6:** Run facility lat/long against CMIP6 under **SSP2-4.5** and **SSP5-8.5** at **2030, 2040, and 2050** horizons.
- **Trajectory Screening:** Temperature, wet-bulb projections, flood designations, and basin-level water stress.
- **Per-Asset Taxonomy:** Classify every site into Low | Medium | High | Critical.
- **Rule:** Assess per building, never portfolio averages (averages conceal critical basin risks).

Pass 2: Thermal & Electrical Sensitivity

- **The Failure Band:** Stress cooling against the **28–32°C wet-bulb band** where evaporative systems fail to hold ASHRAE envelopes unaided.
- **Mechanical Crossover:** Calculate exact ambient condition triggering full mechanical support.
- **PUE & Power Spike:** Quantify PUE deterioration and sudden kW load surge.
- **Grid Coincidence:** Audit utility contract capacity against peak afternoon grid stress when all users peak.

Pass 3: Redundancy & Vulnerability Scoring

- **Electrical & UPS:** Grade N+1 / N+2 depth and dual utility feeds.
- **Fuel Autonomy:** On-site fuel storage for **48–72 hours** continuous generation.
- **Physical Defense:** Substation flood barriers and critical equipment elevation.
- **Water Redundancy:** Routinely underweighted: second water source, on-site storage buffer, and reclaimed-water optionality.

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CORE PRINCIPLE: MEASURE STRESS, NOT JUST VOLUME

A litre consumed in a wet basin and a litre consumed in a stressed basin are different facts; volumetric reporting treats them as identical. Operators must evaluate basin stress, trade-offs against energy, lifecycle footprints, and local statutory withdrawal priority.

THE 4-PART WATER STRESS WORKING TOOLKIT

1. WUE vs. PUE Trade-off Dynamics

• **WUE Formula:** Annual water use ÷ IT equipment energy (L/kWh).
• **Performance Frontier:** Evaporative fleets run well above 0.2 L/kWh. The design frontier (dry cooling, closed-loop, direct-to-chip liquid) targets **<0.2 L/kWh** and approaches zero on-site.
• **Coupled Reporting:** Report WUE alongside PUE or not at all. Evaporative cooling spends water to improve PUE; dry cooling spends energy to save water. Optimizing one in secret creates fragile facilities.

2. WRI Aqueduct & WWF Risk Filter

• **Basin Classification:** Baseline water stress: **High (40–80%)** and **Extremely High (>80%)**.
• **Mandatory Mitigation Trigger:** Facilities in Extremely High basins warrant documented mitigation plans regardless of their WUE before adding capacity.
• **Local Hydrology:** Maps seasonal variability, groundwater decline, and regulatory/reputational exposure. Small users in critical basins still face curtailment.

3. ISO 14046 & AWARE Lifecycle Accounting

• **Direct & Indirect Scope:** Life-cycle assessment of direct cooling water and indirect water embedded in purchased electricity.
• **AWARE Characterization:** Scarcity-weights consumption based on regional watershed availability.
• **Catching the Shell Game:** A "zero-water" facility on a coal-heavy or thermal grid has simply moved its water consumption offsite to power plant cooling towers.

4. Source Water Vulnerability Assessment

• **Municipal Audit:** Municipal supplier sustainability, infrastructure age, and aquifer recharge rates.
• **Drought Allocation Hierarchy:** Statutory legal priorities defining who gets cut first during declared emergencies (drinking water > agriculture > industrial cooling).
• **Demand Competition:** Forecasts competing residential growth and agricultural extraction.

UPSTREAM SUPPLY CHAIN & DISCLOSURE ANCHORS

The Upstream Fab & Grid Problem

• **Ultra-Pure Water Concentration:** Advanced semiconductor fabs concentrate in drought basins (**Taiwan 2021 drought** forced emergency water trucking; **Arizona**). A single-point failure is an immediate global server-availability event.
• **Generation Dependency:** Regional grid cooling and hydro reliability in heatwaves.
• **Supply Screen:** Map fabs, cold-plate/PDU nodes, and generation regions through identical hazard screens.

Compliance & Permitting Anchors

• **ESRS E3 & E1:** In-scope EU reporting of water consumption in stressed basins with watershed context; E1 covers physical-risk scenario analysis.
• **IFRS S2:** Financial effects on cash flows and capital allocated to adaptation.
• **TNFD LEAP:** Nature-dependency framing (Locate, Evaluate, Assess, Prepare).
• **Municipal Permits:** Local ordinances restricting potable extraction for cooling enforce mandatory transition to reclaimed/non-potable water feeds.

THE 4-PHASE EXECUTION ROADMAP & HYPERSCALER BENCHMARKS

Phase & Window	Operational Mandate	Technical Actions & Industry Benchmarks
Phase 1 (M1–3) Audit	Geospatial screening & local hydrological audit	Screen 100% owned/leased sites via Aqueduct and downscaled CMIP6; assign Low/Med/High/Critical taxonomy; commission Source Water Vulnerability Assessments for High/Critical sites.
Phase 2 (M4–12) Cooling Transition	Low-water architecture for new high-density builds	Mandate dry cooling, direct-to-chip liquid, rear-door heat exchangers in stressed basins; retrofit evaporative systems with adiabatic assist. Decisions represent 15-year commitments based on basin projections.
Phase 3 (M12–18) Circular Sourcing	Exit potable municipal drinking water	Transition to reclaimed municipal wastewater, industrial greywater, on-site rainwater harvesting. Shields facility in statutory drought allocation battles.
Phase 4 (Ongoing) Replenishment	Volumetric replenishment & public transparency	Watershed restoration (wetlands, aquifer recharge, invasive removal). Match peer benchmarks: **Microsoft water-positive by 2030**, **Google 120% freshwater replenishment**. Pair with near-real-time public usage reporting.