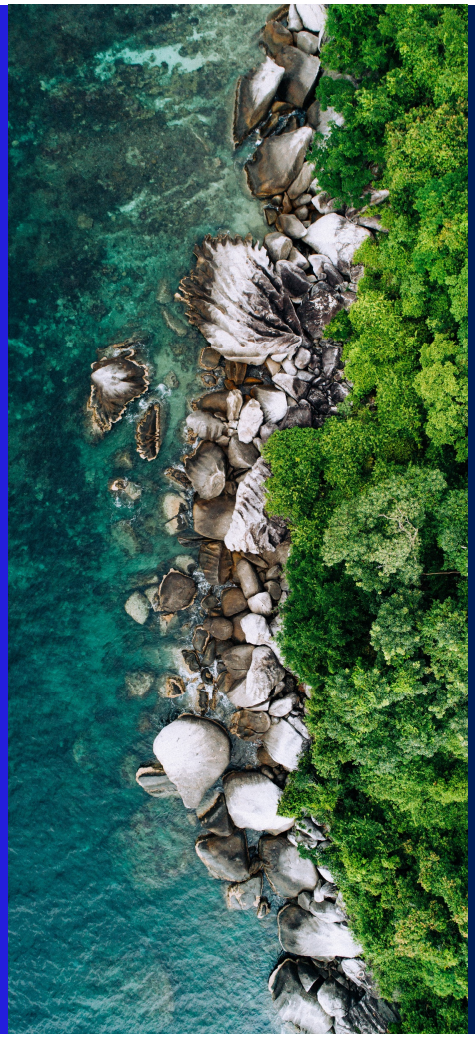
Jacobs Challenging today. Reinventing tomorrow.

Water for Industry: Transformation Beyond COVID-19

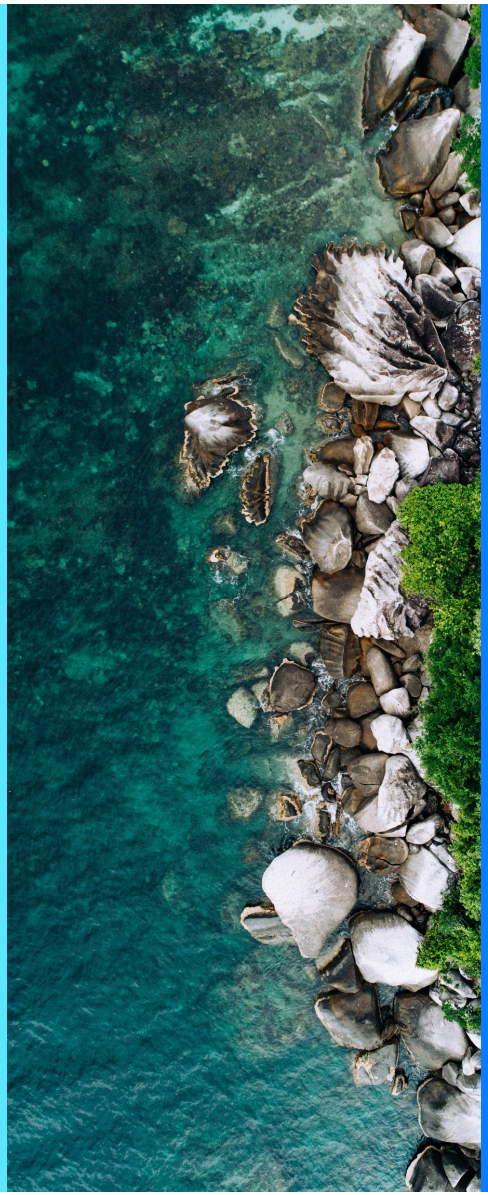


In the kNOW Webinar Series

Apr 22, 2021

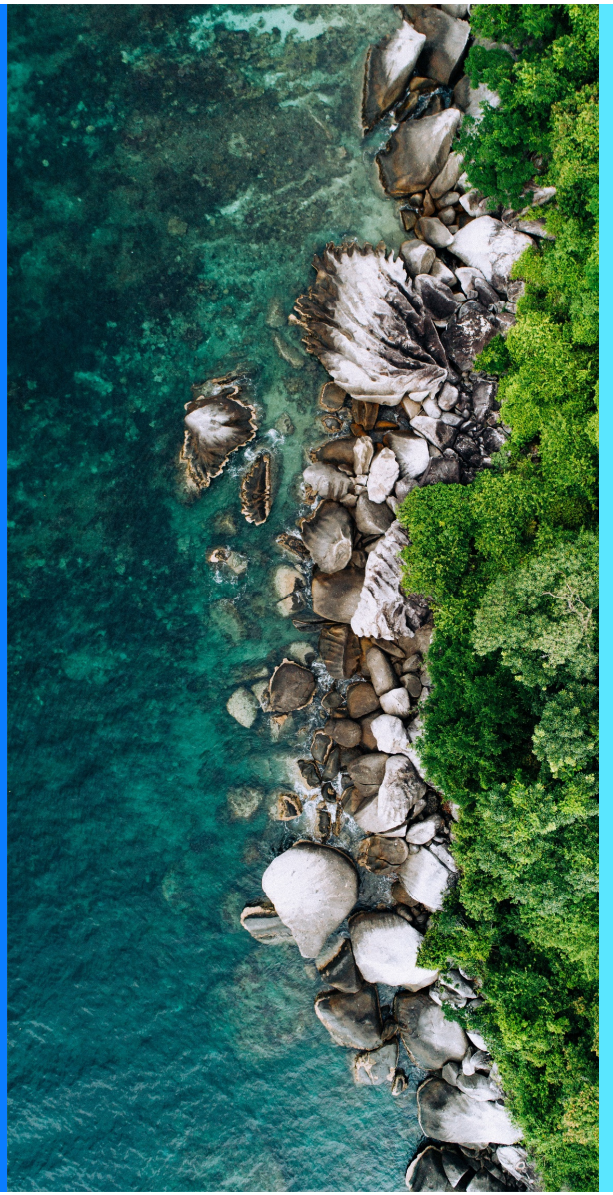
Agenda

- **Introduction**
- **Life Sciences**
  - Market Summary
  - How Water Used
- **Data Centers**
  - Market Summary
  - How Water Used
- **Forest Products**
  - Market Summary
  - How Water Used
- **Water Efficiency Strategy**
- **Question and Answer**



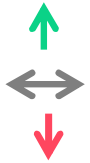
Jacobs Presenters

- **Robert Thompson (Jacobs: Houston, TX USA)**
  Water Solutions and Technology, Global Director
- **Joe Rozza (Jacobs: Atlanta, GA USA)**
  Director, Sustainability & Resilience
- **Carlo Bonicelli (Jacobs: Milan, Italy)**
  Regional Solutions Leader, Europe | Industrial Water
- **Chandra Mysore (Jacobs, Atlanta, GA USA)**
  Regional Solutions Leader, US South
  | Drinking Water & Reuse



Summary of Covid-19 Impacts by Market

- Life Sciences / Pharmaceuticals ↑
- Electronics / Data Centers ↑
- Forest Products ↑
- Food / Beverage ↔
- Manufacturing / Consumer Products ↔
- Chemicals ↔
- Power ↓
- Mining ↓
- Oil / Gas (upstream / downstream) ↓



Covid-19 Impact

Convergence of Impacts with Water Issues

- Water Scarcity
- Increasing Environmental Regulations
- Aging Infrastructure

In less than 3 months, a major international city will likely run out of water

By Paul P. Murphy, CNN
Updated 2:35 PM EST, Wed January 31, 2018

https://www.cnn.com/2018/01/24/africa/cape-town-water-crisis-trnd

Rapid growth of India's Chennai threatened by water shortages

PUBLISHED TUE, AUG 6 2019•2:03 AM EDT

AP

SHARE

https://www.cnbc.com/2019/08/06/rapid-growth-of-indias-chennai-threatened-by-water-shortages.html

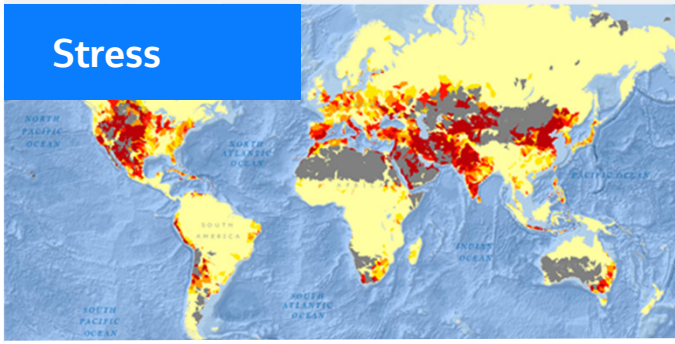
US West Prepares for Possible 1st Water Shortage Declaration

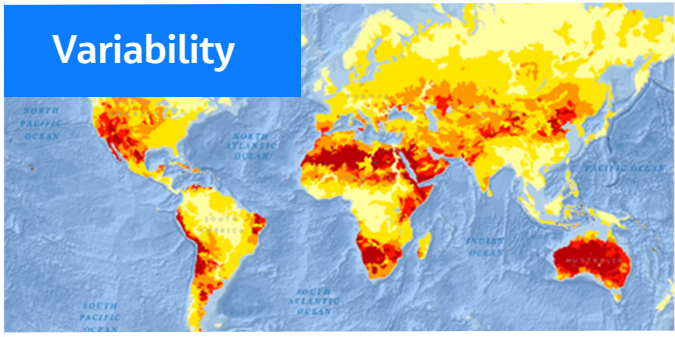
U.S. water officials are projecting the man-made lakes that store water used throughout the American West will fall to historically low levels and trigger an official shortage declaration for the first time.

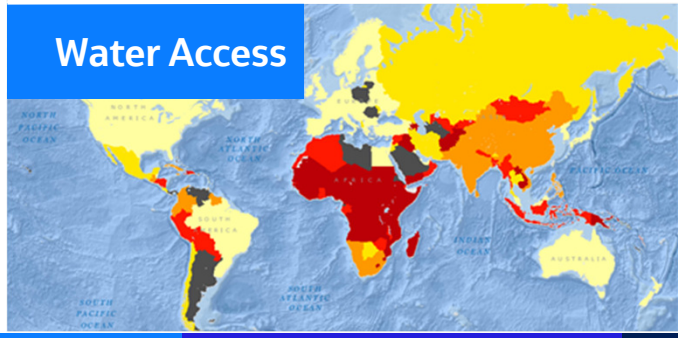
By Associated Press | April 17, 2021, at 12:25 p.m.

https://www.usnews.com/news/politics/articles/2021-04-17/us-west-prepares-for-possible-1st-water-shortage-declaration

World Resources Institute/Aqueduct Data







Market Highlight:
Life Sciences

Life Sciences – Market Overview

Steady Growth, Accelerated by Covid-19

- Drivers:
  - Aging population/Expanding middle class
  - Covid-19
  - Biopharmaceuticals
  - Drug patent expirations
  - Pharmacopeia standards (USP, EP, JP,…)
- East Asia / Pacific, Europe, North America dominant for production
- Role of large contract manufacturers (CMOs)

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Water Use

- **Potable water**
  - sanitary water (bathrooms, sinks,…)
  - canteen
  - chemical synthesis
  - early stages of cleaning of pharma manufacturing equipment
- **Purified Water**
  - preparation of medicines (no sterile and apyrogenic)
  - final rinse of equipment in the manufacture of non-parenteral products.
- **Water for Injection**
  - Manufacturing of sterile pharmaceutical products for parenteral administration / other pharma products where endotoxin content must be controlled.
  - final rinsing of primary (in contact with the final product) packaging materials
- **Industrial water (e.g. treated groundwater)**
  - Cooling Tower make up
  - Cooling
  - Boiler
  - Irrigation

Water treatment – recent key drivers

- Pharmaceuticals in the Environmental (PIE), an emerging water issue
- Single use reactors result in major water use reduction

Water Treatment - Case Study #1

Location: Europe / Biopharmaceutical

Facility assessment to identify risks and criticality

↓

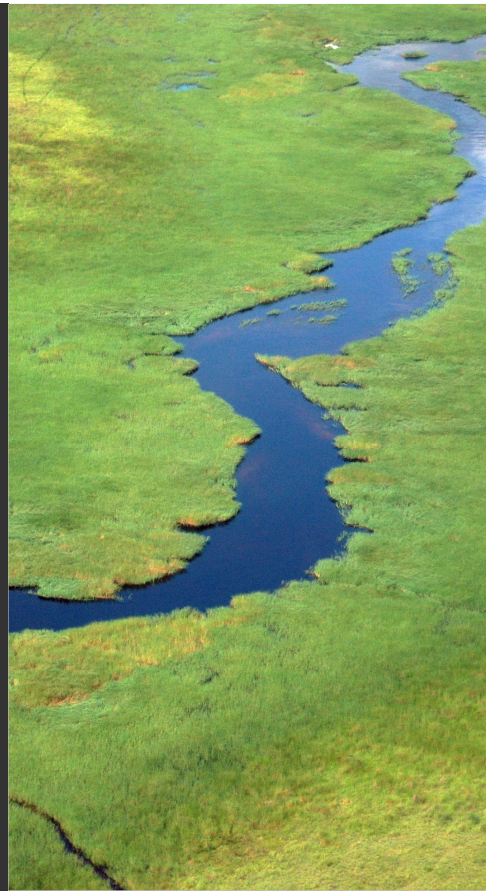
Water consumption next to capped value of allowed by municipality

↓

Mitigation strategy: water consumption reduction

↓

Concept study to face the requirement: PW production Reverse Osmosis brine reuse as Industrial water, Cooling Tower make up treatment to increase COCs, stormwater treatment and recovery



Water Treatment - Case Study #2

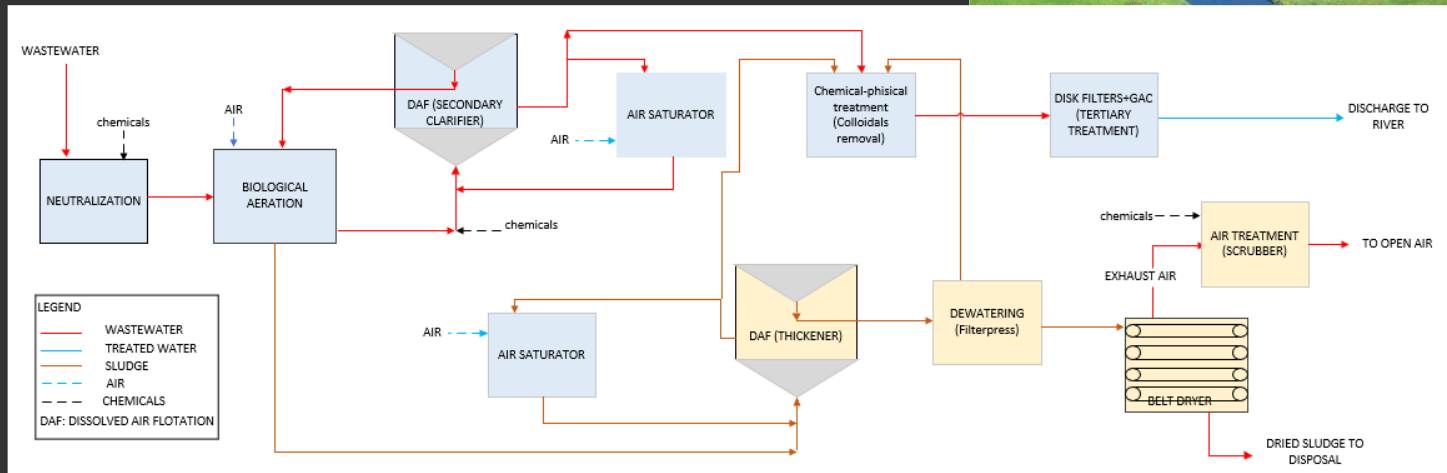
Location: Europe / Diagnostic Products

Production expansion

Production Detailed Design

Wastewater treatment plant to be revamped (+ 200 m3/h, total flow rate: 500 m3/h)

Feasibility+
Dewatering / drying pilot testing
Basic Design+
Tendering Package



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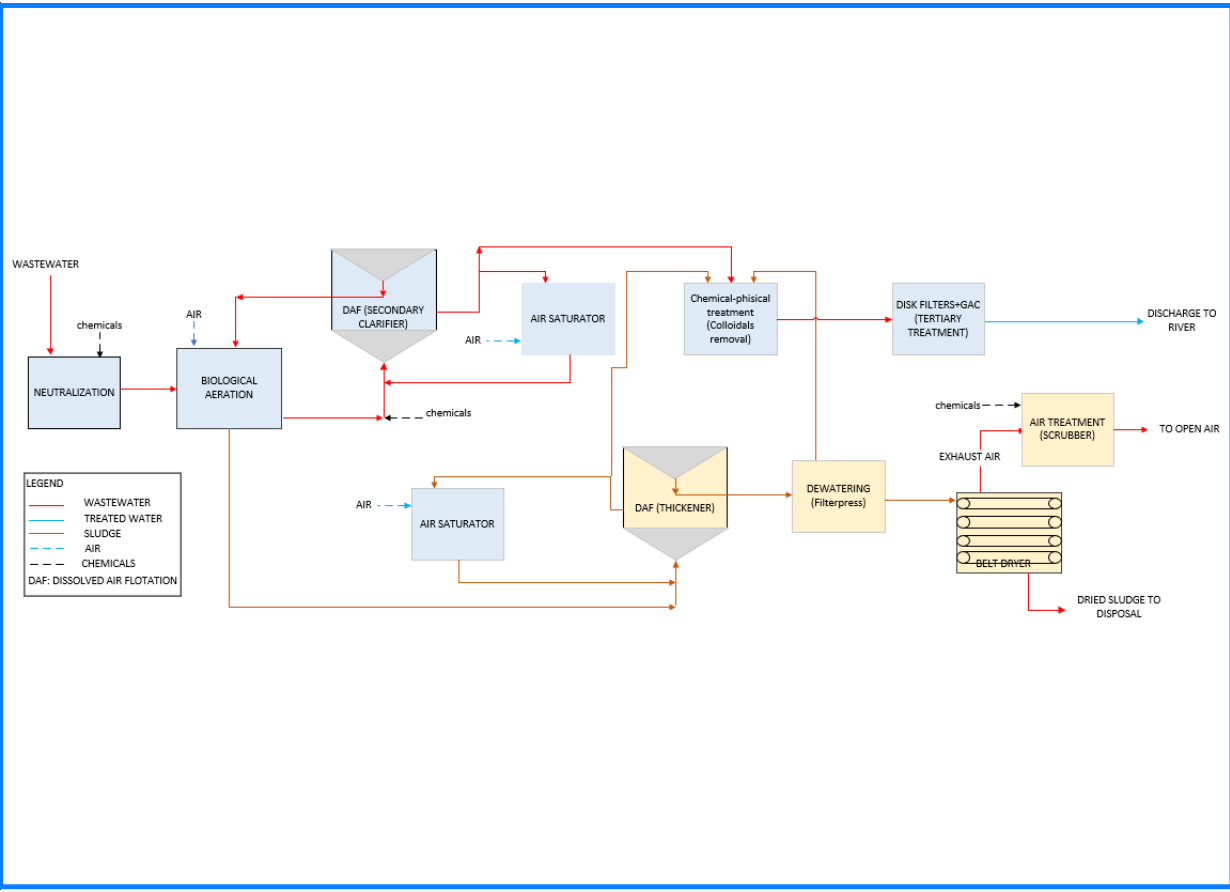
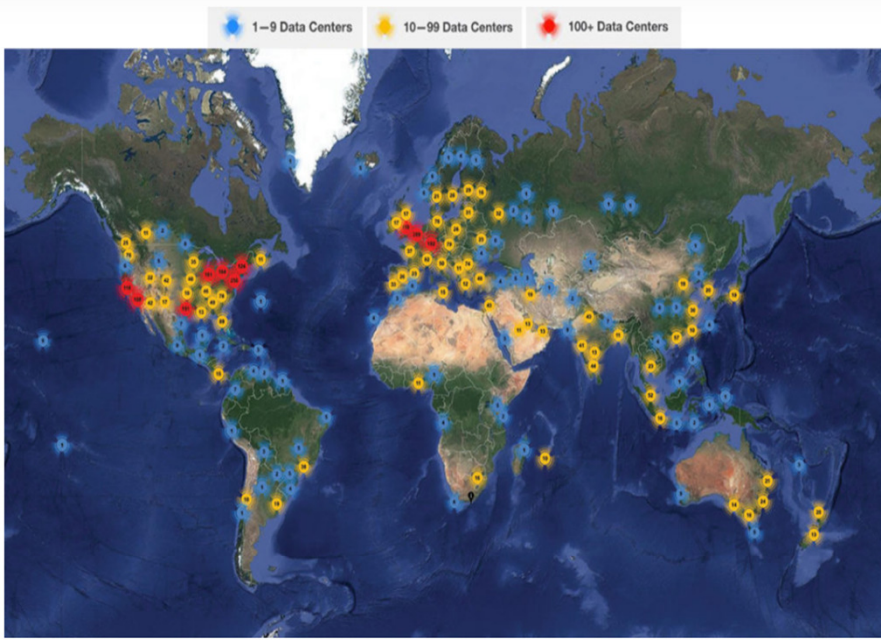


Market Highlight:

Data Centers

Data Centers-by the numbers

- Data centers store, manage and disseminate information.
- ~3 million data centers around the US.
  - ~1 data center for every 100 people (US DOE, 2014)
- By end of 2021, numbers are expected to grow to ~7.2 million (Statista, 2021).
- Consumed ~174 billion gallons of water in 2020.
- Account for 1-2% of electricity consumption worldwide.



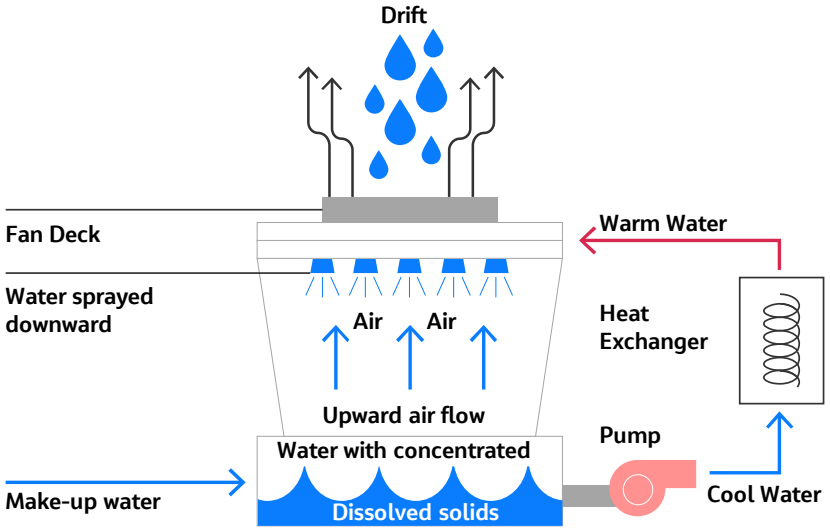
Map courtesy of datacentermap.com

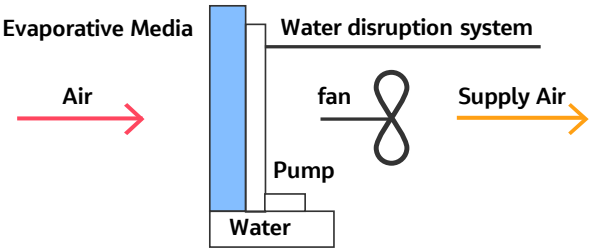
Data Centers: Water-Energy Nexus

- An average data center uses 0.5 gallons of water for cooling for every kWh it consumes
  (US Data Ctr Energy Report, 2016)
- 1-MW data center using traditional cooling methods uses about 6.75 million gallons of water per year
  (Uptime Inst. 2016)
- Water Usage Effectiveness (WUE=L/kWh)) is a key measurement of water performance in data industry *(The Green Grid, 2011)*
  - Includes water used on-site (Source 1) and water needed to produce energy (Source 2)
  - Tradeoffs and accounting between:
    - Different sources of water
      (i.e. reuse/reclaimed water has less embedded energy vs surface water)
    - Embedded energy/water in chemicals used for treatment
      (i.e. more treatment chemicals needed = more energy/water consumed)

Water is a Key for Heat Dissipation from Data Centers

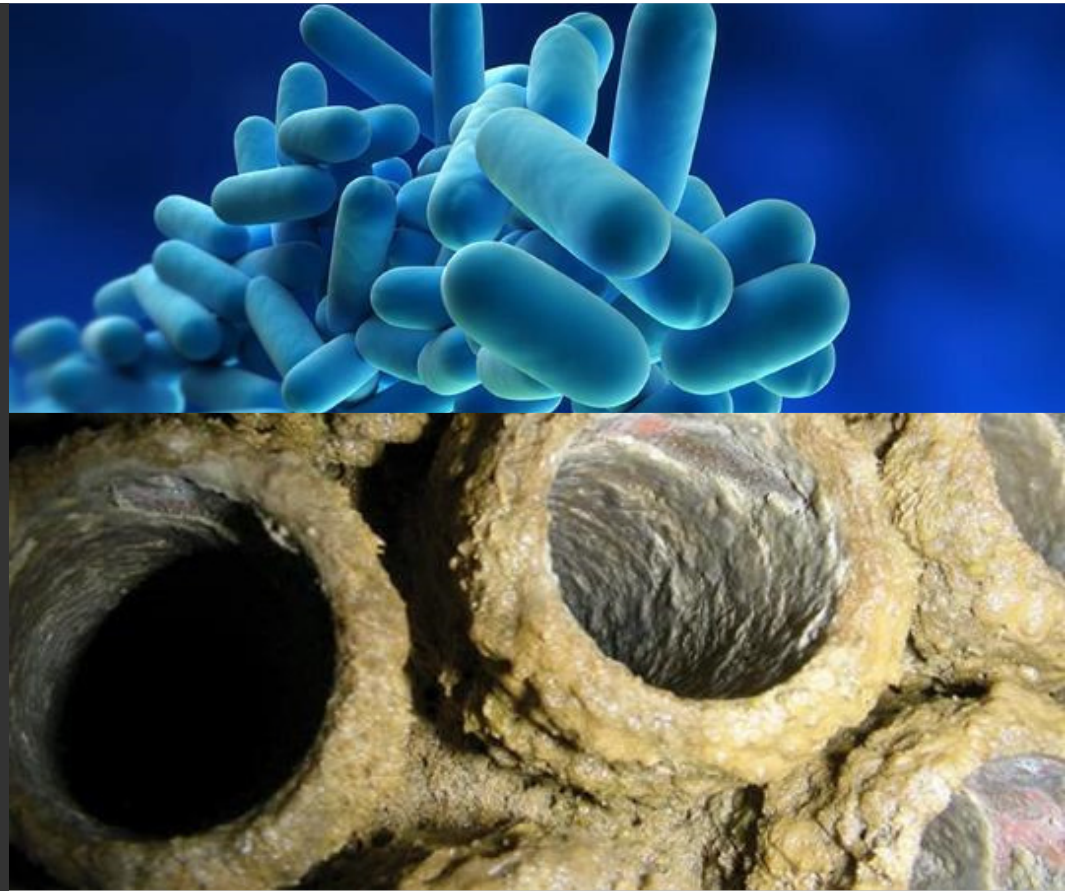
- Cooling Towers-Standard approach for large-scale cooling systems, tried and true method
  - Provide chilled water for cooling through heat exchanger with air or refrigerant on the closed-loop side
- Direct Evaporative Cooling (aka swamp coolers)
  - No cooling towers, water is passed through a cooling media to add humidity and dissipate heat
- Indirect Evaporative Cooling
  - No cooling towers, similar to direct but has a secondary closed air loop for initial heat transfer
- Other variations on direct/indirect evaporative cooling available





Water Quality Risks Present Regardless of the Type of Cooling Used

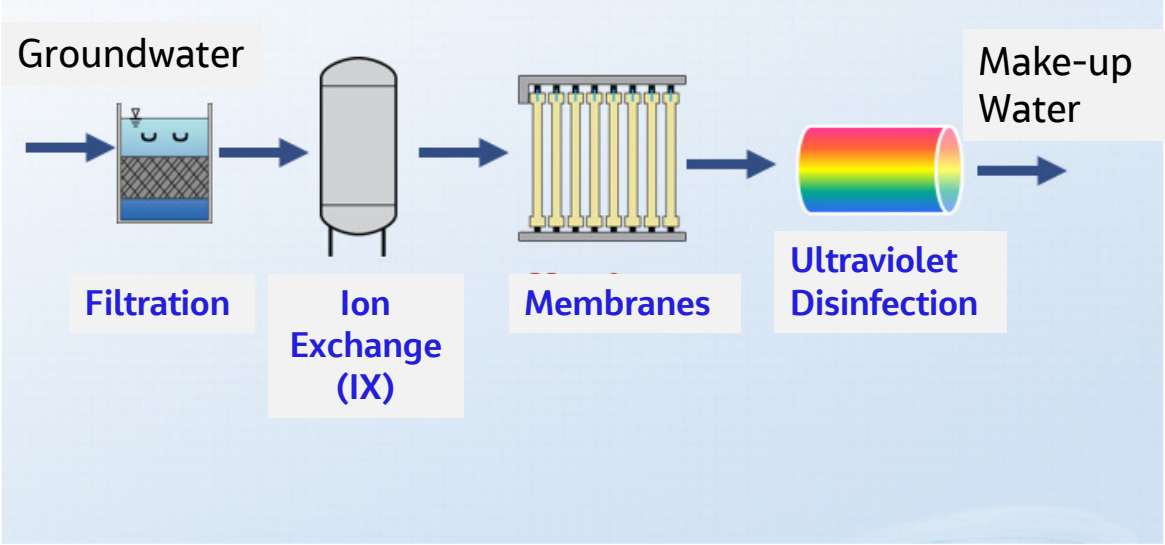
- Legionella
- Other Microbiological
- Total Dissolved Solids (TDS)
- Metals
- Corrosion
- Scaling



Case Studies, Tools / Technologies Discussion

Case Study #1

- Source Water-
  - City's Drinking Water (primary)
  - Groundwater (secondary)
- Design Flow-80,000 gal/day

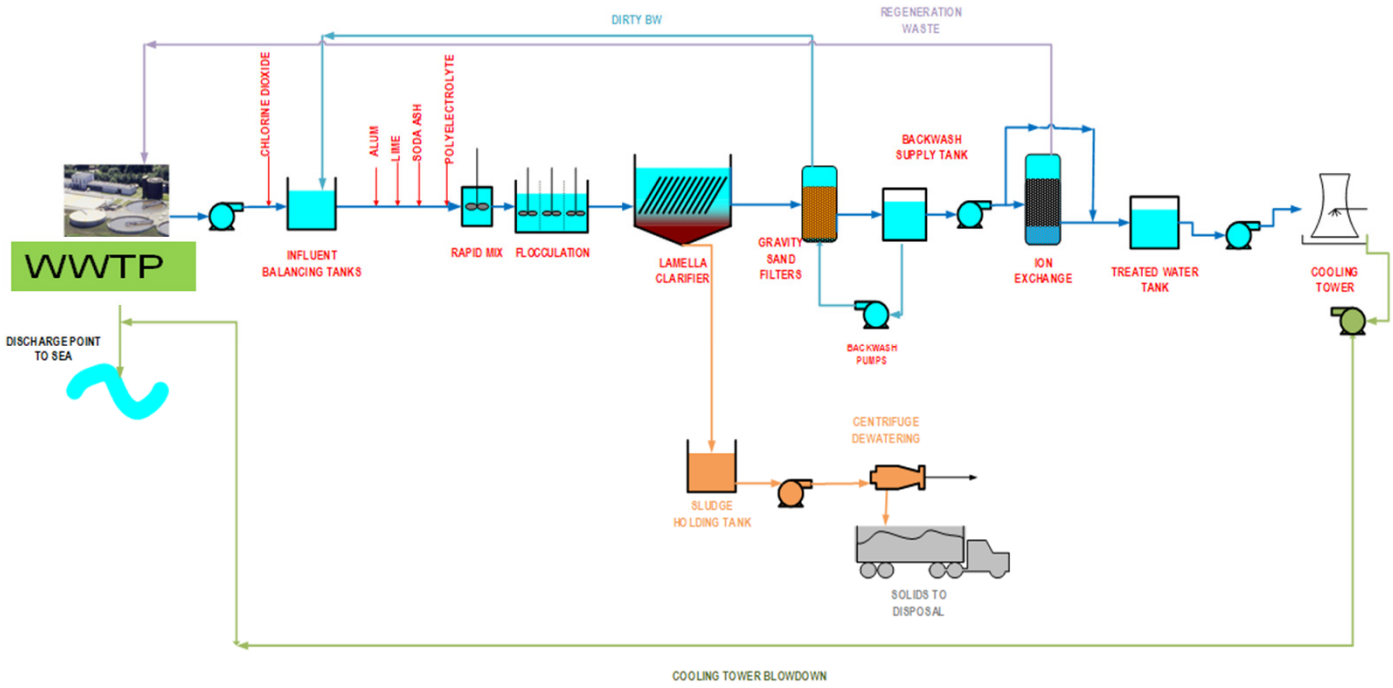


Water Quality Parameter	Make-up Water Quality
pH (su)	6-8
Alkalinity (mg/L)	50-170
Conductivity [µS/cm]	100-550
TDS (mg/L)	<550
Hardness (as CaCO3)	50-170
Silica (ppm)	30
Iron (mg/L)	<0.2
Nitrate (mg/L)	50
Chloride (mg/L)	55
Suspended Solids	< 5

Case Study #2

- Source Water
  - Initially cooled with potable water
  - Expansion needed 5 MGD of cooling water
  - Reclaimed water as a source?
  - Water Quality Challenges
    - TSS
    - Nitrogen, Phosphorous
    - Hardness
    - Metals

  Solution-Complex treatment designed to meet Water Quantity and Quality requirements



Market Highlight:

Forest Products

Printing & Writing

- Printing & Writing Grades Declining Globally
- Printing & Writing Grades Continue to decline in North America
- Newsprint Down Globally >50% past ten years
- Most suppliers either have implemented or are considering product conversion projects to improve viability of existing production capacities.

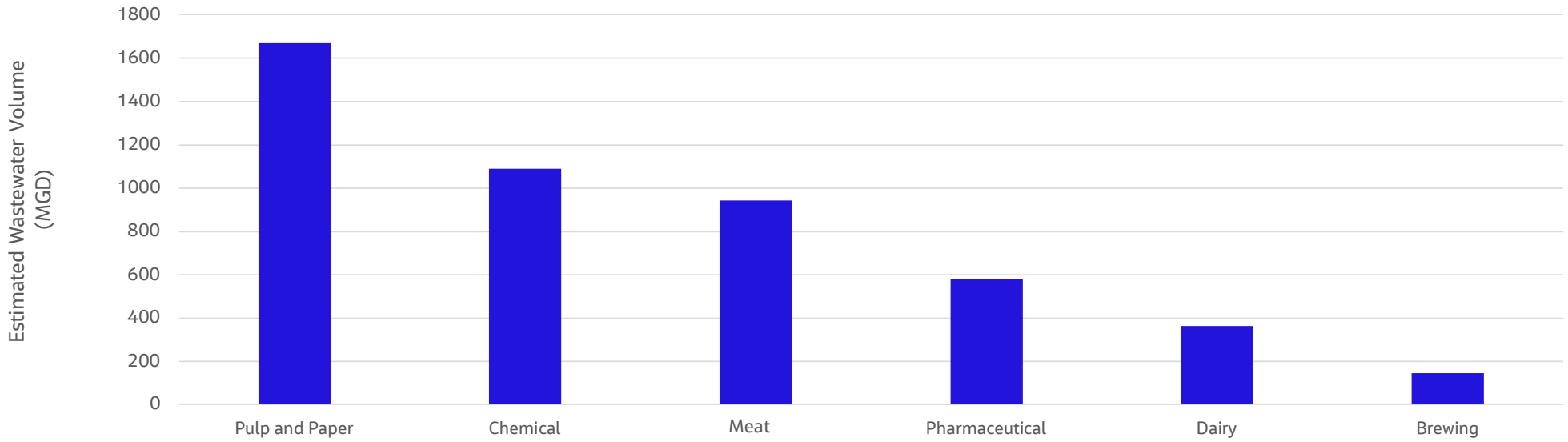
Containerboard

- Containerboard is over half of global P&P market
- Containerboard is expected to continue growing
- Containerboard demand increasing due to on-line retailing at ~3% per year
- Increased demand for “Eco-Friendly” sustainable packaging and plastic replacements

Tissue

- Tissue remains strong (COVID-19 strong rise in 2020-21 demand)
- Tissue imports growing, significant portion US Market
- Tissue overall expected U.S. market growth

Pulp and Paper Water Discharge

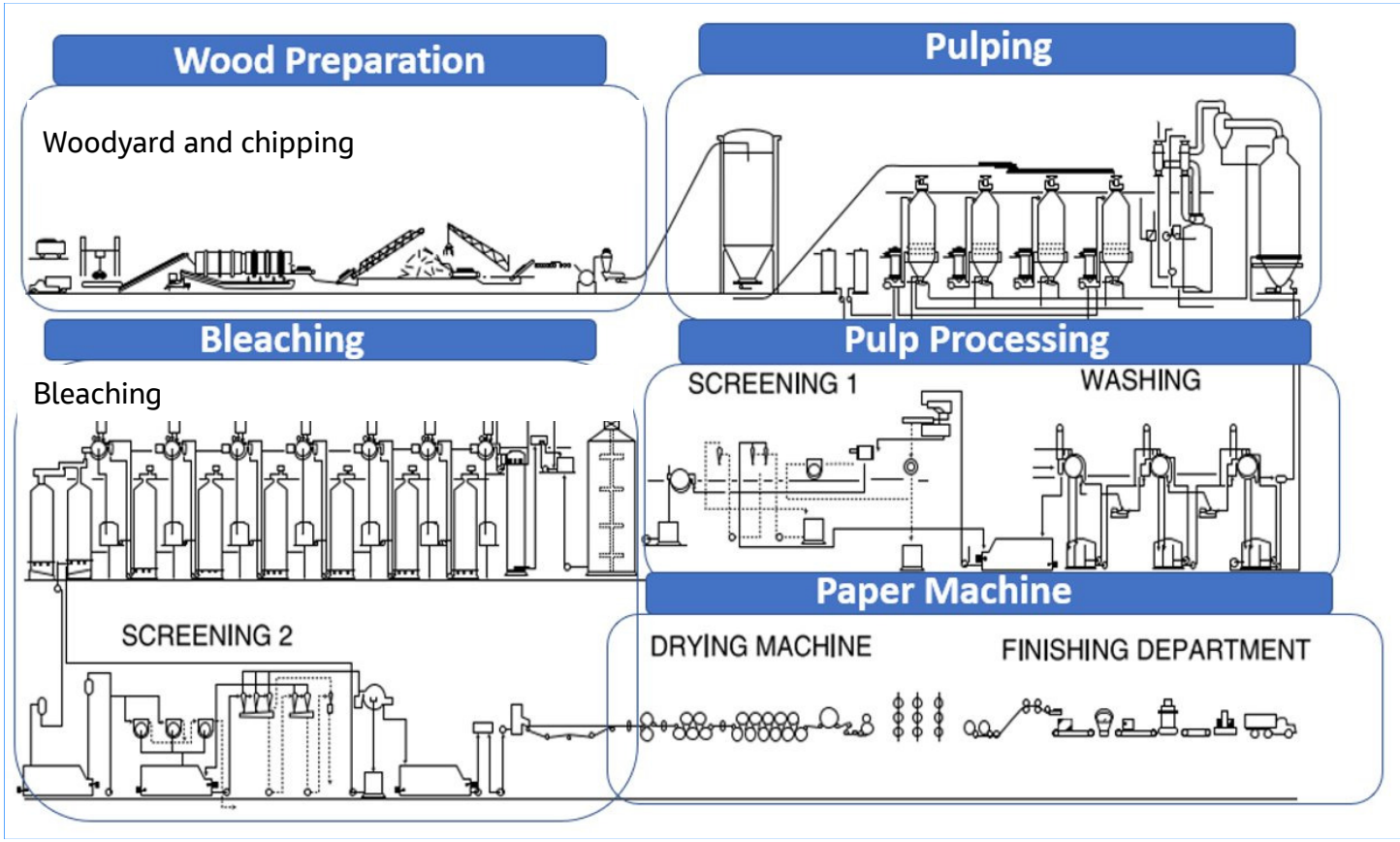


U.S. and European facilities

Pulp and paper industry generated the largest quantities of wastewater in comparison with the other industries

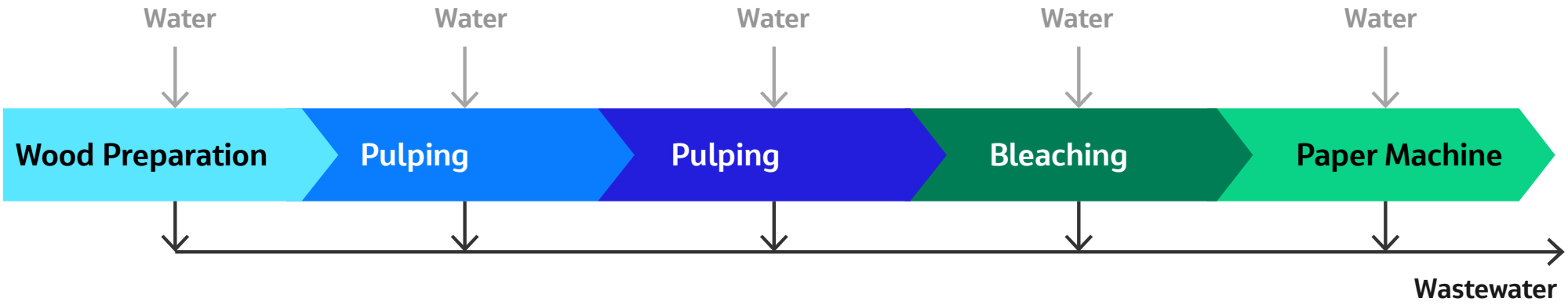
Reference: Calculating the Value of Pulp and Paper's Industrial Wastewater http://www.naylornetwork.com/ppi-otw/articles/index-v2.asp?aid=319802&issueID=42749

Pulp and Paper General Process



Reference: Calculating the Value of Pulp and Paper's Industrial Wastewater http://www.naylornetwork.com/ppi-otw/articles/index-v2.asp?aid=319802&issueID=42749

Pulp and Paper General Process and Water Use



Process	Water Use	Percentage	Effluent Characteristics
Wood Preparation	Water Used for Wood Handling	15%	Solids, BOD, color
Pulping	Chip Digester and Liquor Evaporator Condensate	5%	Concentrated BOD, reduced sulfur compounds
Pulp Processing	Pulp screening, thickening and cleaning	40%	Large volume of water with suspended solids, and significant BOD
Bleaching	Bleach Plant washer filtrate	5%	BOD, color, chlorinated organic compounds
Paper Machine	Water Flow	35%	Solids

Reference: Water Requirements of Selected Industries | Water Use and Wastewater Treatment in Papermills

Case Studies, Tools / Technologies Discussion

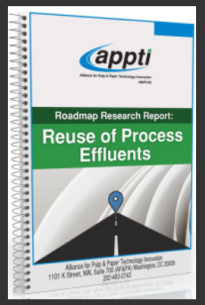
- Paper Mill, US Southeast
  - Foaming, sludge bulking
  - Low DO
  - Process Modeling and State Point Clarifier Analysis
  - Primary clarifier solids removal increase to improve secondary treatment processes
  - Additional gravity thickener for solids handling

Case Studies, Tools / Technologies Discussion

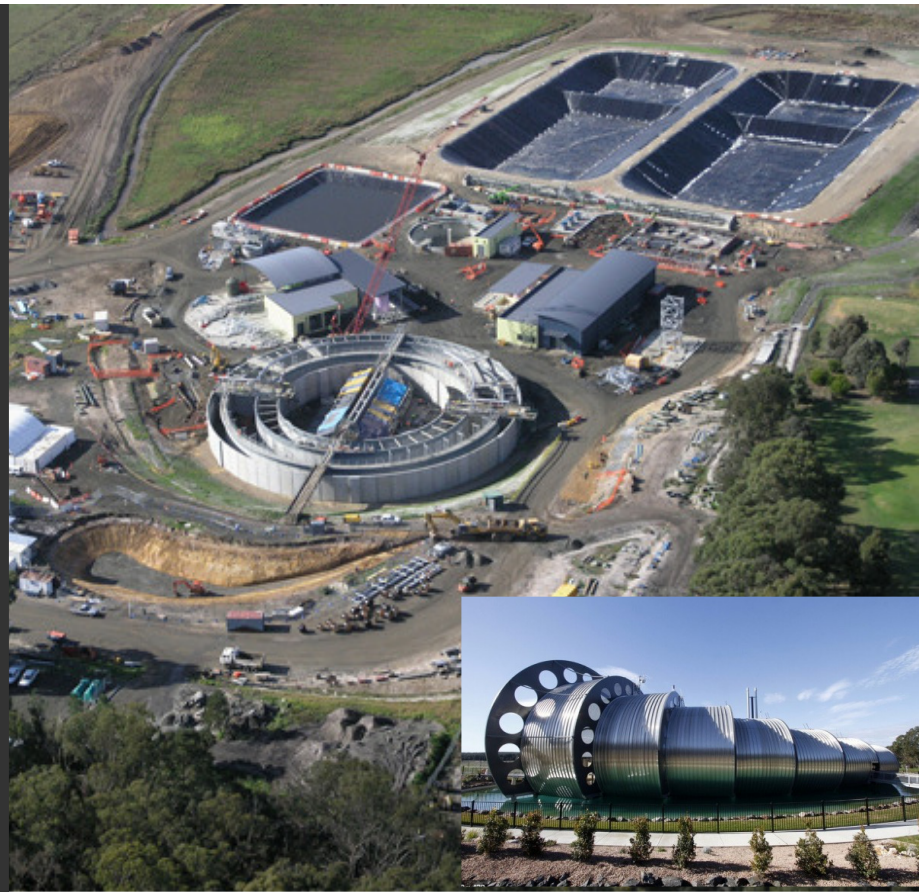
- Gippsland Water Factory , Australia
  - Early adoption of advanced processes

MUNIPAL	PRIMARY	MEMBRANE BIOREACTORS	REVERSE OSMOSIS
INDUSTRIAL	ANAEROBIC		

  - Recycled water, supply to paper mill
  - Major research topic



Alliance for Pulp and Paper Technology Innovation
https://www.appti.org/technology-roadmaps-downloads.html

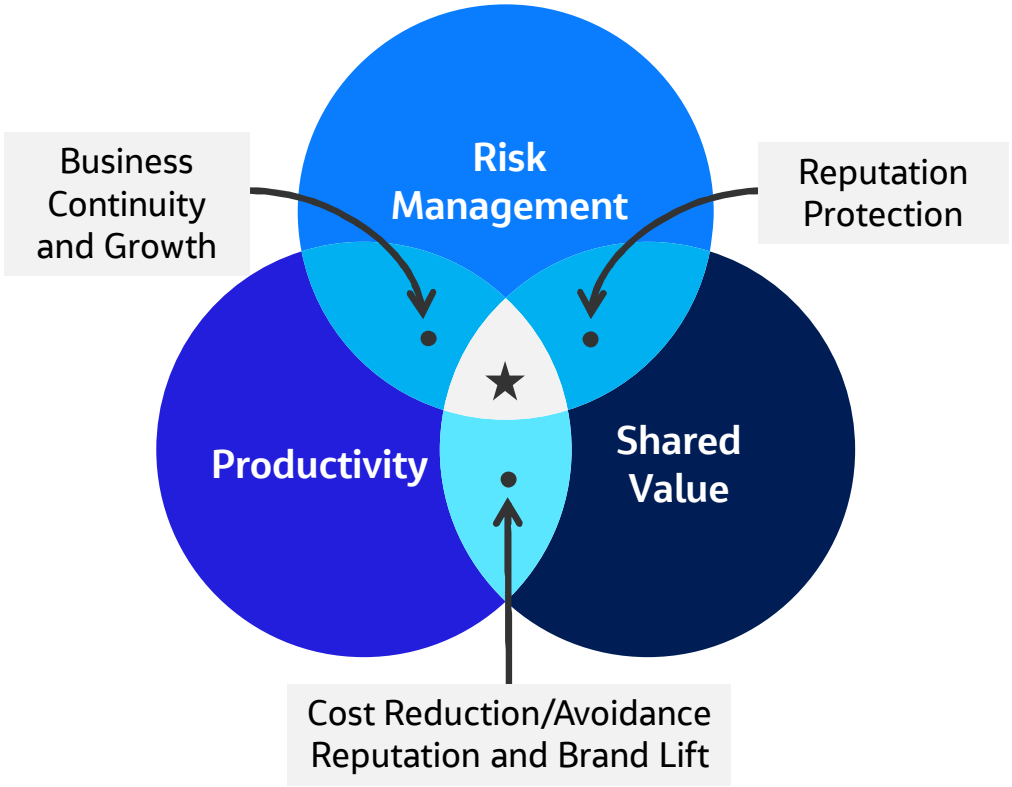


Water Efficiency Strategy

Strategic Water Stewardship

Increasing Productivity, Reducing Risks and Creating Shared Value

Developing the Business Case For Water Technology Investments
Thinking Beyond Financial ROI



Risk Management

- Operational
  - Supply Reliability/Business Continuity
  - Regulatory/Legal
- Reputation and Brand
  - Local/Social Risks: Community and Local Government
  - Local issues that scale to national/international (media)

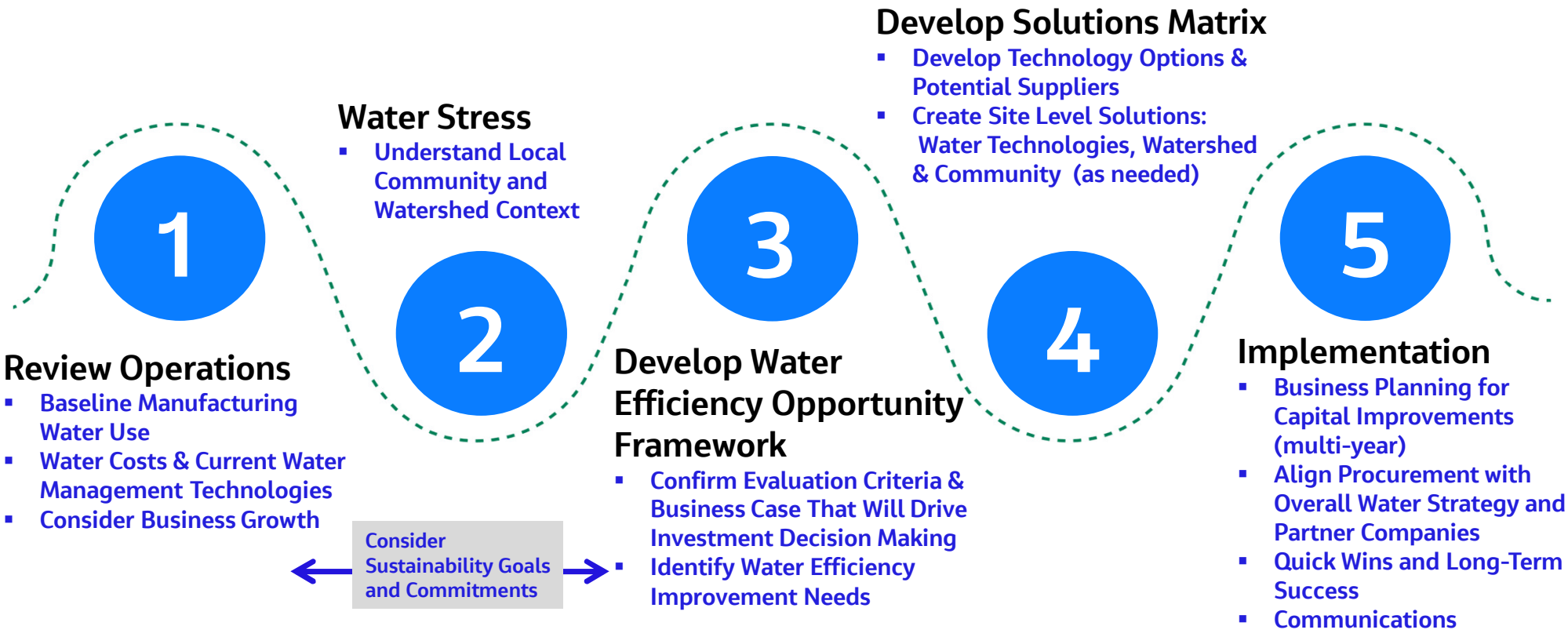
Productivity

- Financial: Cost Savings and Avoidance
- Market: Competitive Advantage (Customers/Consumers)
- Reputation and Brand Lift (“intangible value”)

Shared Value

- Reduces risks and increases productivity while creating social, environmental and/or economic co-benefits
- Local relevance is critical

Strategy & Planning to Guide Technology Selection and Deployment



Question / Answer

Thank You

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