



 Sustainability & Operational Excellence

Expect the Unexpected: Avoiding Late-Stage Surprises in Water Projects through System-Level Data Analysis

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Outline

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 - Solution
 - Case Study 1
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 - Case Study 3
 - Key Takeaways
- Change Drivers
 - The Problem
 - Preliminary Solution
 - Surprise Risks and Implications
 - Response and Optimized Solution

The Problem

Aggressive Water Reclaim Goals

Changing Factory Loads

New Processes

New GHG Abatement

Wastewater Compliance Limits

Resource Constraints

**Past Experience
Does Not Apply**

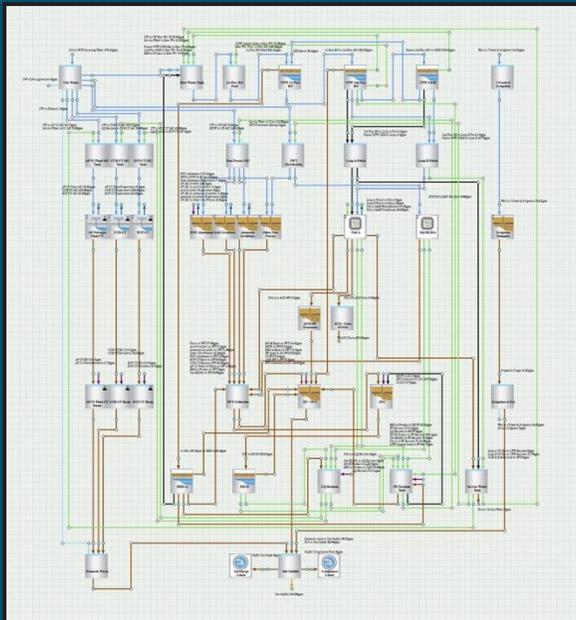


**Future States
are Unknown**

**Path to Reclaim
Goals is
Unknown**

The Solution

Total Site Water View: Flows, Chemistries and Capacities for All Systems



Strategy
development and
testing to achieve
reclaim goals

Validates
(or invalidates)
many
assumptions

Reveals risks before
making final reclaim
commitments and
costly investment

Case 1- Change Drivers

Change Drivers:

Aggressive Water Reclaim Goals

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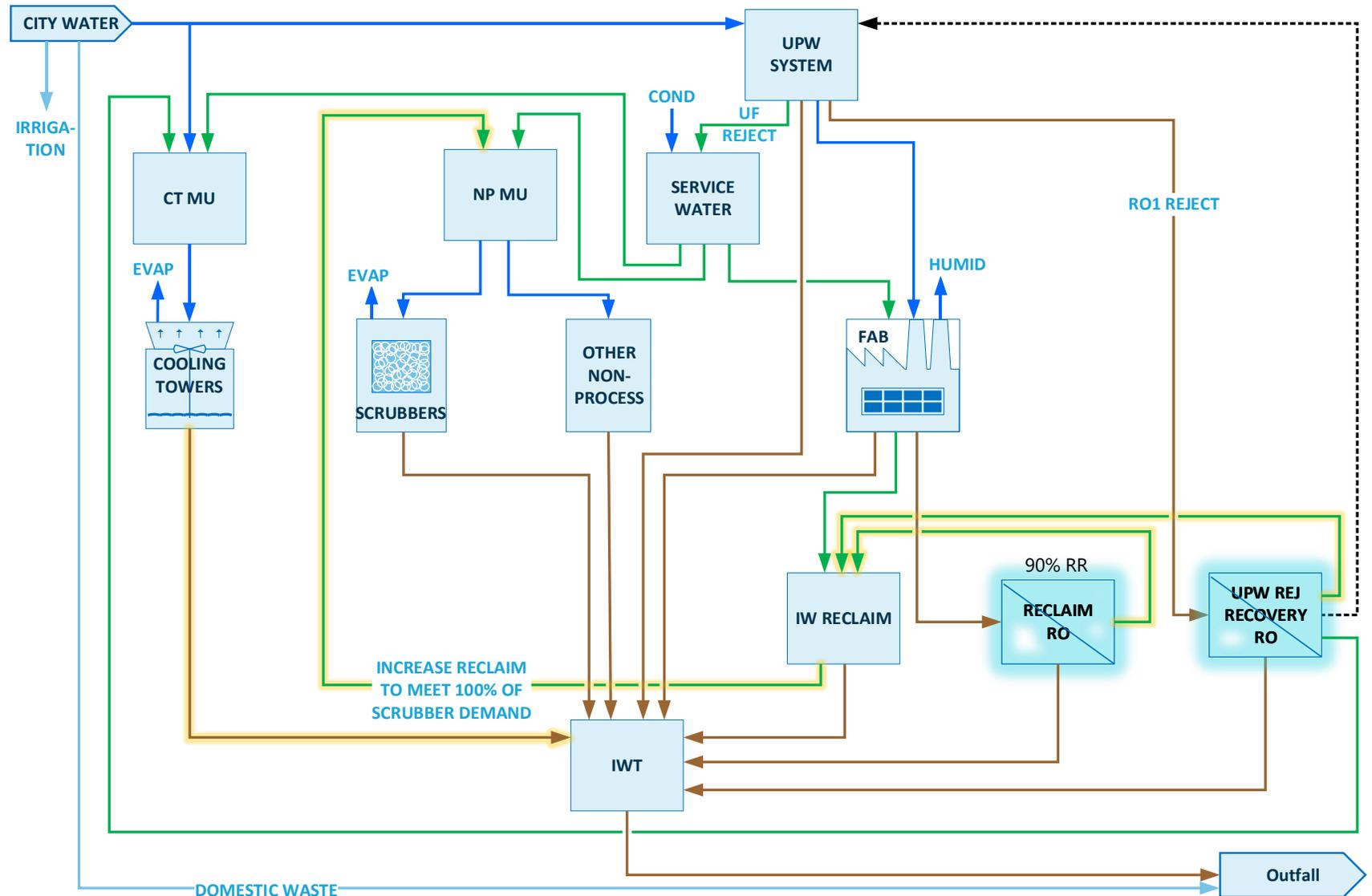
Case 1- The Problem

Reducing future UPW flows would also decrease the site's water Reclaim %

KPI	Baseline Average	Future Average	Indicator
Total Incoming City Water, Normalized	X	0.85 X	
Reclaim %	X	0.88 X	

Case 1- Preliminary Solution

- Two new reclaim RO systems
 - New UPW Reject Recovery RO
 - New Reclaim RO with 90% recovery rate



Case 1 – Surprise Risks

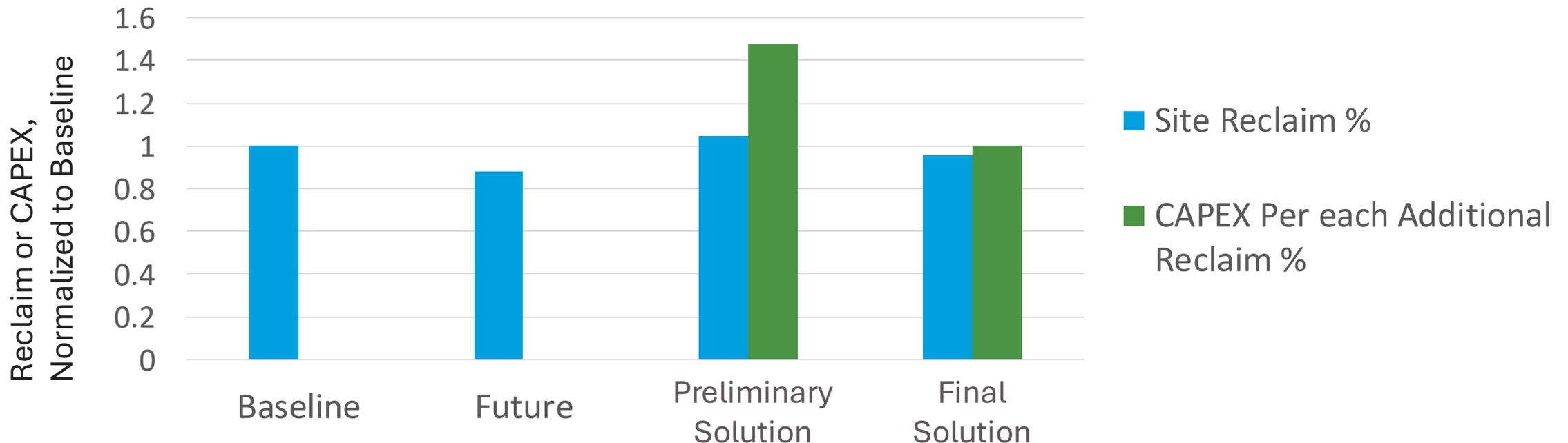


Parameter	Expected Quality	Unexpected, Actual Result	Risk	Implications
Oxidizers	< 10 ppm H ₂ O ₂	> 20 ppm H ₂ O ₂	Unsustainable RO membrane damage	Increased pretreatment required
Particles	SDI < 3	SDI > 6	Unsustainable RO fouling	Increased particle removal required pre-RO
TDS	Low concentrations of hardness and silica	Moderate concentrations of hardness and silica	Unsustainable RO scaling	Increased pretreatment and reduced recovery rate
Metals	Non-detectable	Above RO design guidelines	RO fouling	Investigate further

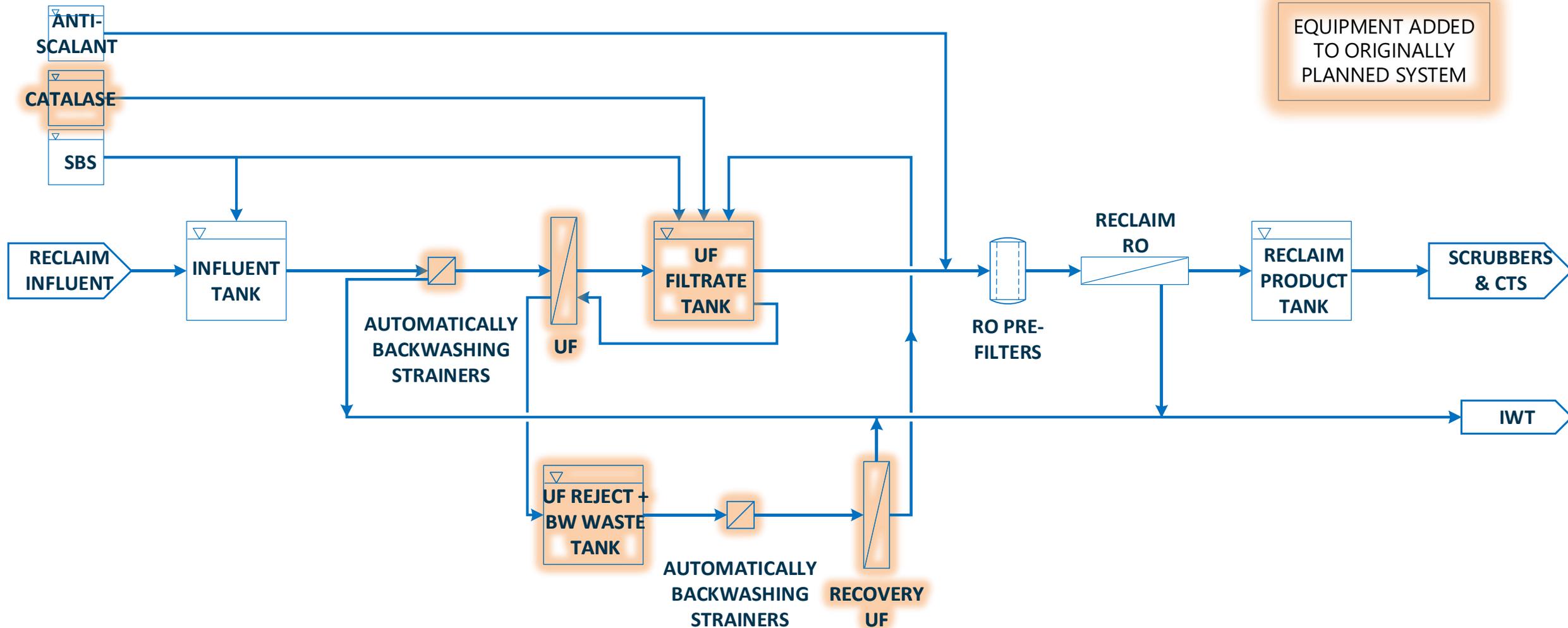
Case 1 – Optimize the Solution

- Planned more robust pretreatment, planned lower recovery rate based on space and funding available. Made a strategic decision based on data.

Option	Product Flow	CAPEX	Annual OPEX
Final Solution	X	X	X
Preliminary Solution	1.6 X	1.8 X	1.2 X



Case 1 - Optimized Solution



Case 2- Change Drivers

Change Drivers:

Aggressive Water Reclaim Goals

Changing Factory Loads

New Processes

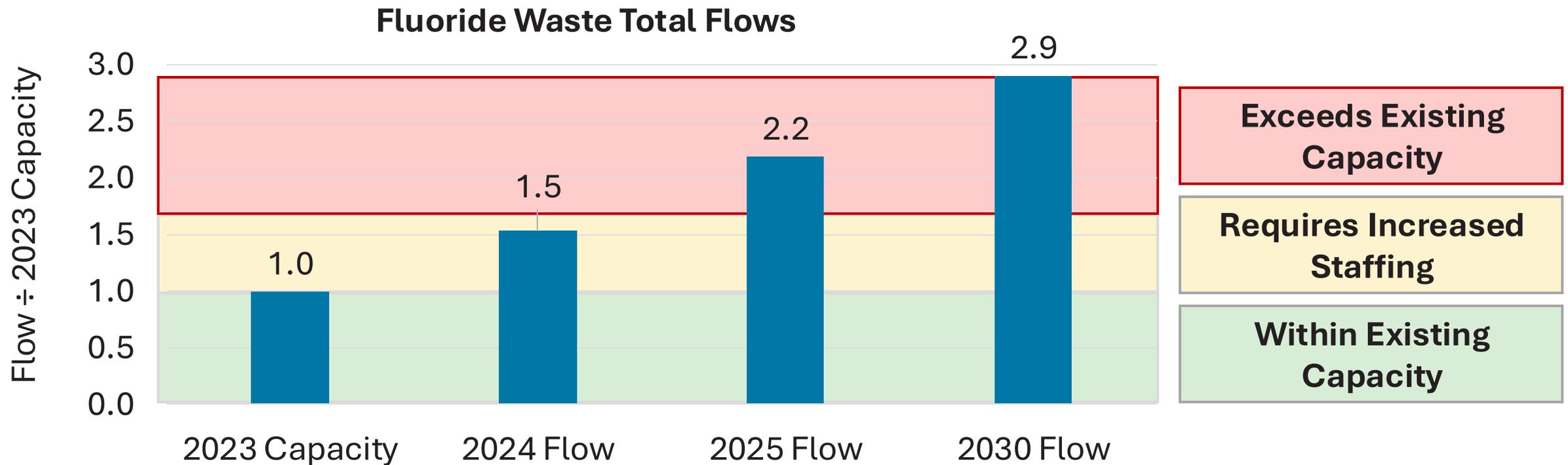
New GHG Abatement

Wastewater Compliance Limits

Resource Constraints

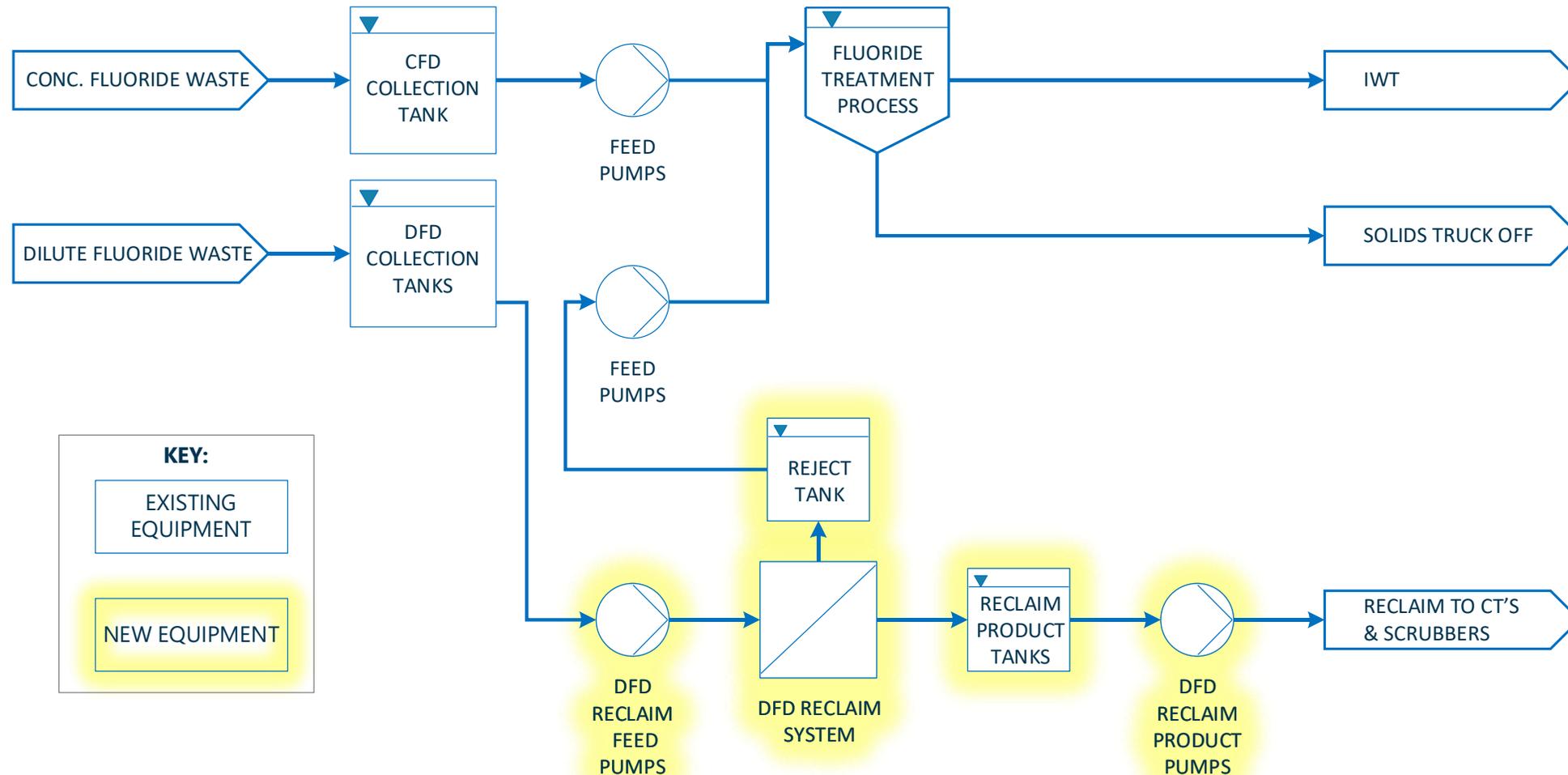
Case 2 – The Problem

Planned GHG abatement blowdown flows would exceed existing fluoride waste treatment system capacity.



Case 2 – Preliminary Solution

An RO system to concentrate the feedwater, reducing its flow rate

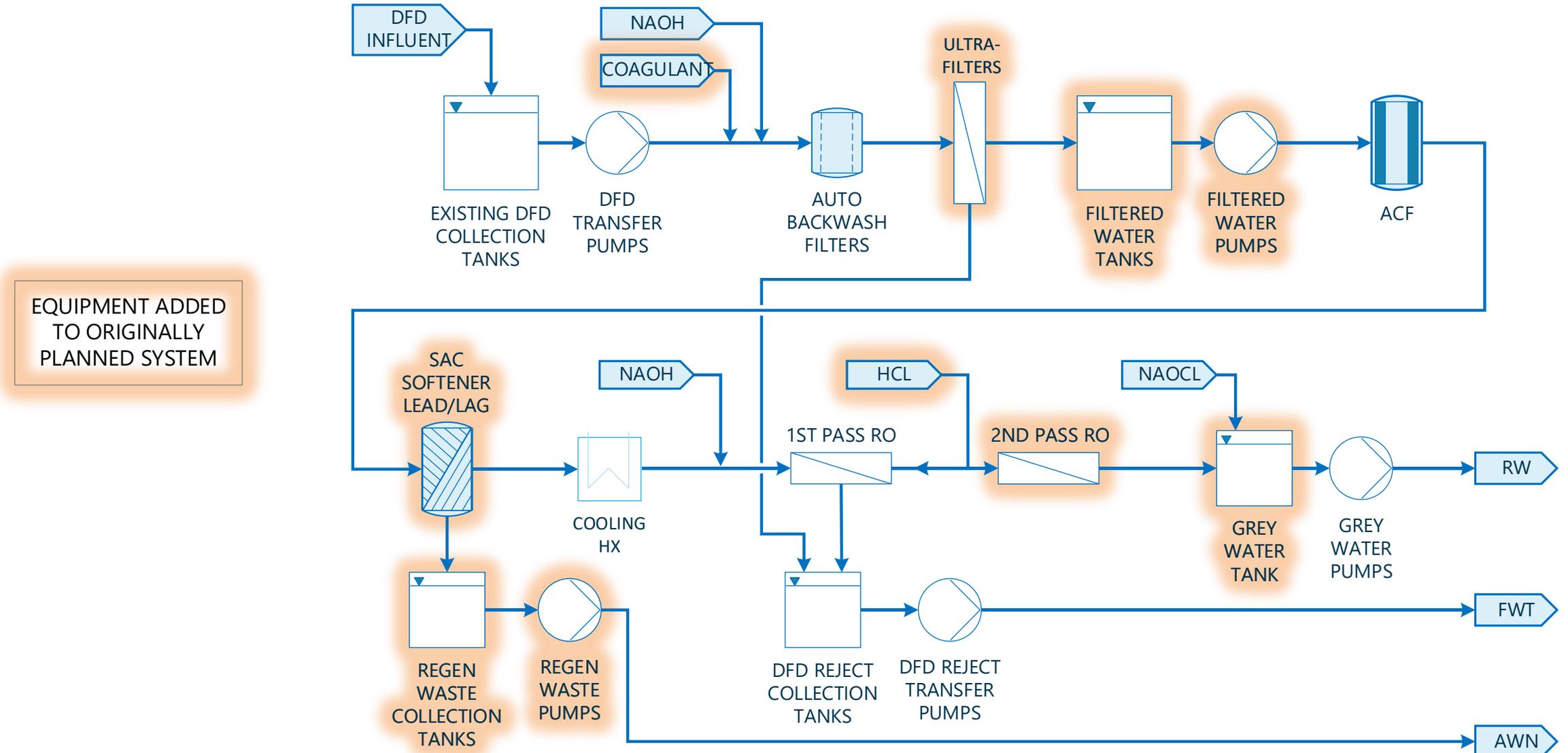


Case 2 – Surprise Risks



Parameter	Expected	Unexpected, Actual Result	Risk	Implications
Silica	Minimal	Near Saturation	RO Scaling	RO operating pH > 9 required
Hardness	Negligible	Non-negligible due to high pH requirement	RO Scaling	Softening required
Particles and TOC	SDI < 3	SDI > 6	Unsustainable RO fouling	Increased particle & TOC removal required pre-RO
Reclaim Overflow	Negligible water wasted	Significant amount of reclaimed water to drain, seasonally	Missed opportunity	Increase reclaimed water storage capacity

Case 2 – Adjusted PFD



Case 2 – Optimized Solution

Not
Feasible!



Optimized Solution:

Targeted upgrades to existing FWT system

	Preliminary Solution	Option A - Increase Reliability of Existing System	Option B - Expand Capacity of Existing System
CAPEX	6 X	X	1.7 X
Footprint	4,500 sqft for building + 1,400 sqft for outdoor tanks	Within existing system footprint	400 sqft for outdoor canopy
Personnel Required	0.5 FTE	4 FTE	4 FTE
Lead Time	19 – 22 months	2-3 months	4-8 months

Case 3- Change Drivers

Change Drivers:

Aggressive Water Reclaim Goals

Changing Factory Loads

New Processes

New GHG Abatement

Wastewater Compliance Limits

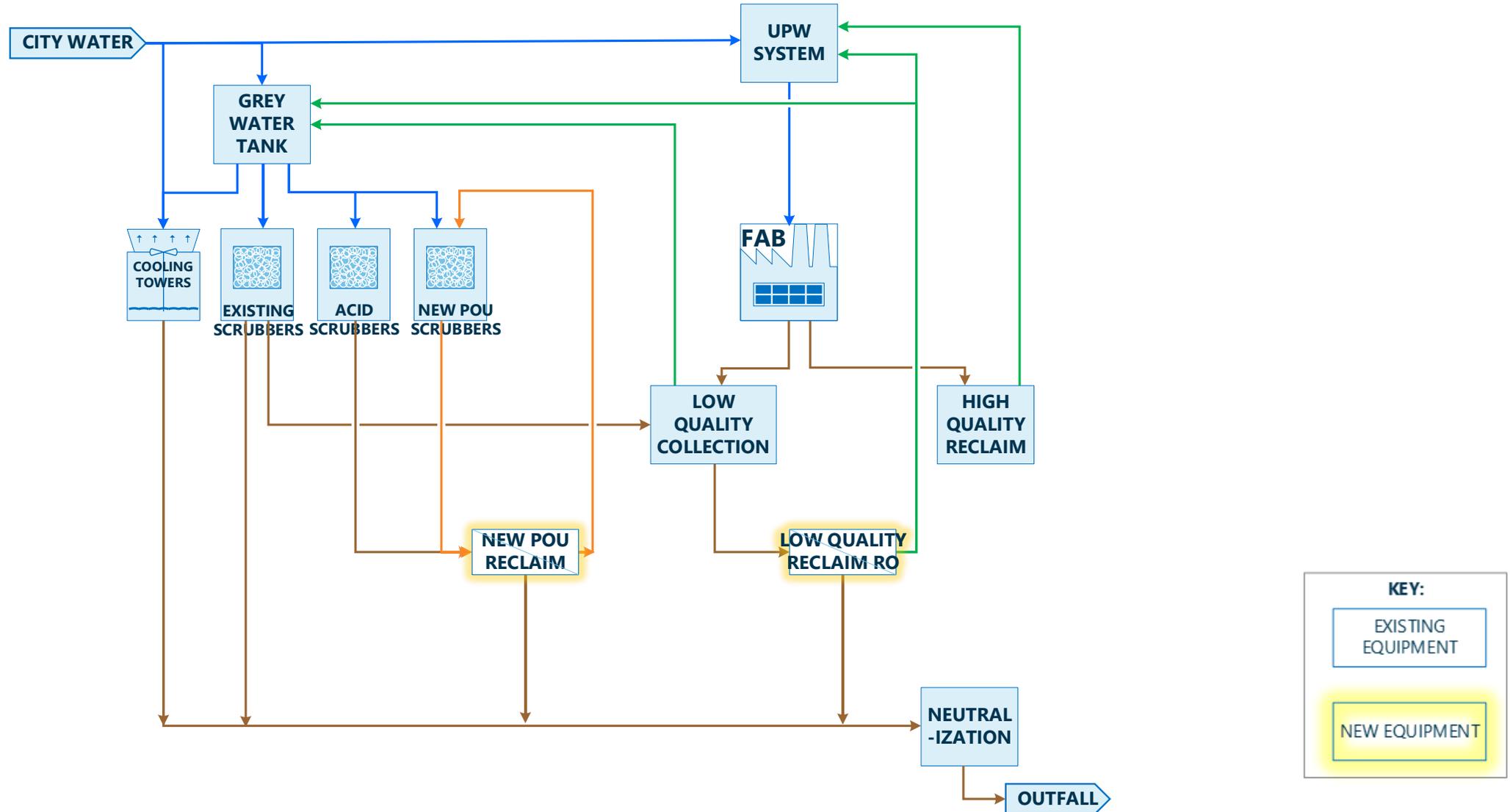
Resource Constraints

Case 3 – The Problem

- Increase site reclaim by 15%.
- Incorporate tool ramp and GHG abatement.
- Fit it in the available footprint on the NXP site.



Case 3 – Preliminary Solution

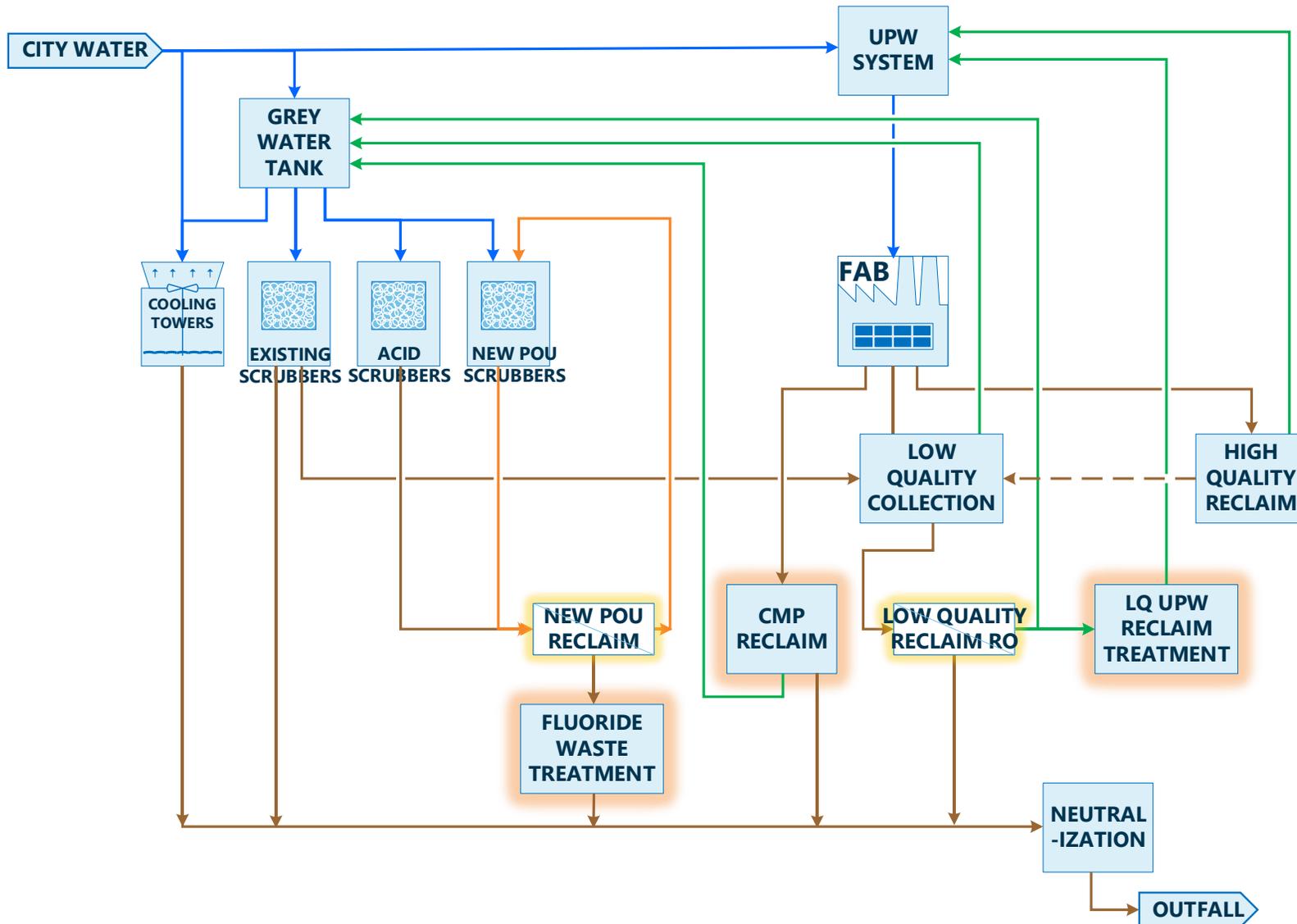


Case 3 – Surprise Risks



Parameter	Expected	Unexpected, Actual Result	Risk	Implications
Outfall Fluoride	< Permit Limit	> Permit Limit	Outfall compliance	Add fluoride treatment
Fluoride in Reclaim Influent	< 20 ppm	> 20 ppm	Corrosion in cooling towers	Add treatment to reject additional Fluoride
Heat Load	Negligible	Significant heat load from GHG abatement	Excessive heat accumulation	Add chilling capacity
Reclaim to UPW System	Only high quality reclaim to UPW required to meet goal	Future reclaim of lower quality stream to UPW required	Missed reclaim target	Add low quality UPW reclaim capability
Reclaim of Unconventional Streams	None required to meet goal	Future reclaim of a CMP stream required	Missed reclaim target	CMP reclaim added

Case 3 – Optimized Solution



PROCESSES ADDED TO PLAN

GHG Abatement and Wastewater

When planning GHG abatement, its effects on wastewater must be accounted for.

For every kT of CO₂ equivalents removed per year, 0.1 – 3.0 kg/day of fluoride is added to wastewater.

In addition to fluoride, other process gases can add significant TDS to abatement blowdown.

- Examples: HCl, Cl₂, HBr, WF₆, TEOS, SiH₄, SiF₄, NH₃
- TEOS adds silica and TOC!

Gas	CO ₂ e Removed	Fluoride Increase in Wastewater	F- concentration in 1.0 gpm (3.79 lpm)
	kT/year	kg/day	mg/L
CF ₄	1	0.32	59
C ₂ F ₆	1	0.19	34
C ₄ F ₈	1	0.20	37
C ₃ F ₈	1	0.25	46
CHF ₃	1	0.15	28
CH ₂ F ₂	1	2.96	544
NF ₃	1	0.13	23
SF ₆	1	0.09	17

Assumes 100% removal efficiency of GHG breakdown products by the wet scrubber

Maintain existing site water and chemical models

As ESG and cost reduction initiatives develop, these will be a strong resource for future plans and decisions, enabling a data-driven approach

Consider the same approach for other NXP sites

Sites without a model will be wise to develop one before demands for rapid decisions come

Validate benefits and assumptions

As projects are implemented, data will be used to validate the benefits and prior assumptions

Takeaways

1

As complexity grows, experience and great engineering intuition is not sufficient: data must validate assumptions early.

2

Change is continuous and comes from many sources. Analysis needs to be fast and comprehensive to understand impacts. Having a water model proactively in place increases the speed of critical decision making.

3

A system- and site-level view, combined with validated data, reveals critical risks before aggressive commitments and costly investments. Decisions made early without enough data can lead to expensive surprises.

4

Risks identified during the data analysis may carry long-term consequences and can be proactively monitored to maintain control over critical issues, including regulatory compliance and system reliability.

5

Future-facing facility planning must prioritize early detection of unknowns and scenario-based validation.

Thank You

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