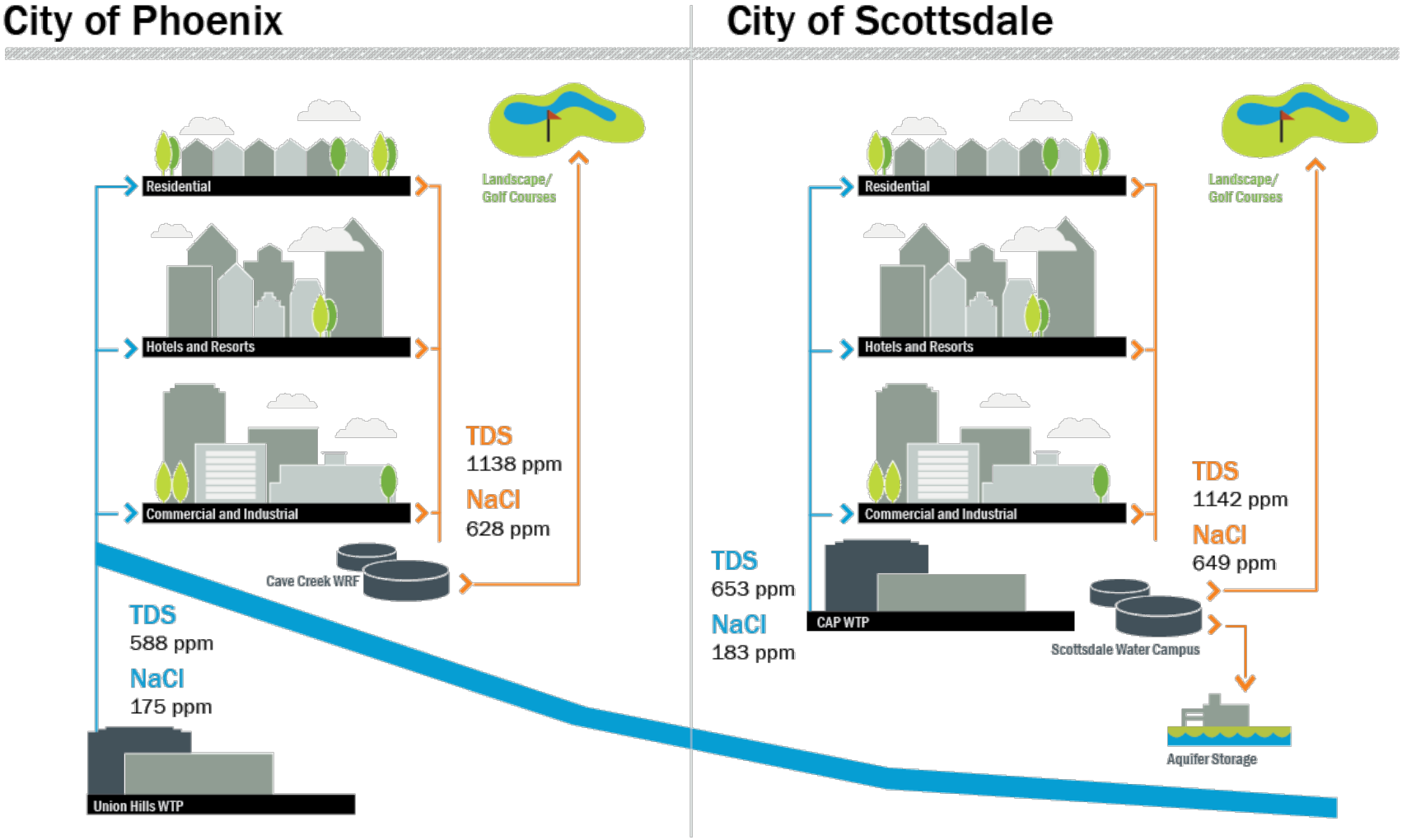
Sodium Chloride Removal

July 2015

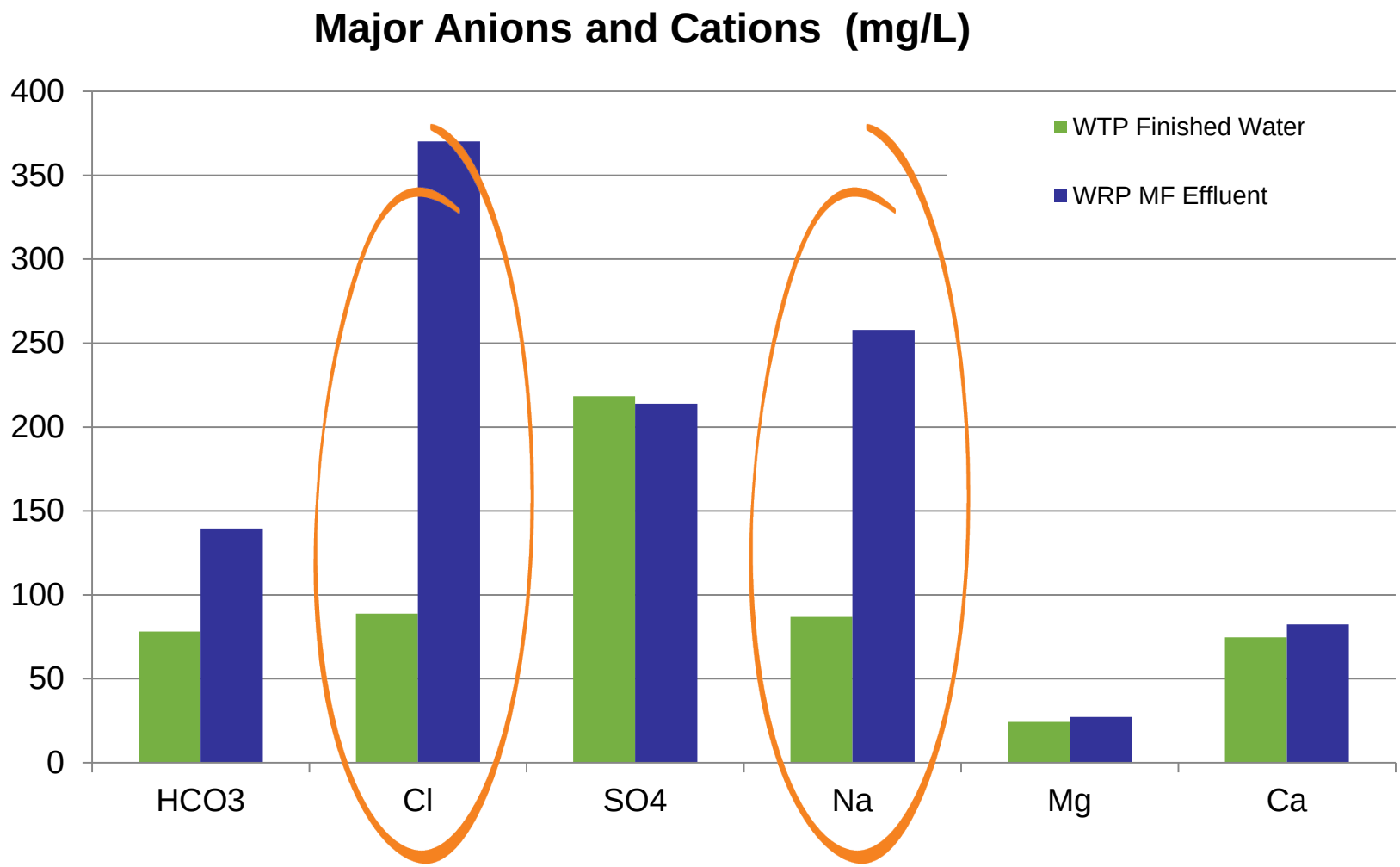
Where we are TODAY

Many utilities' ability to reclaim water for irrigation is being adversely impacted by elevated sodium and chloride levels.

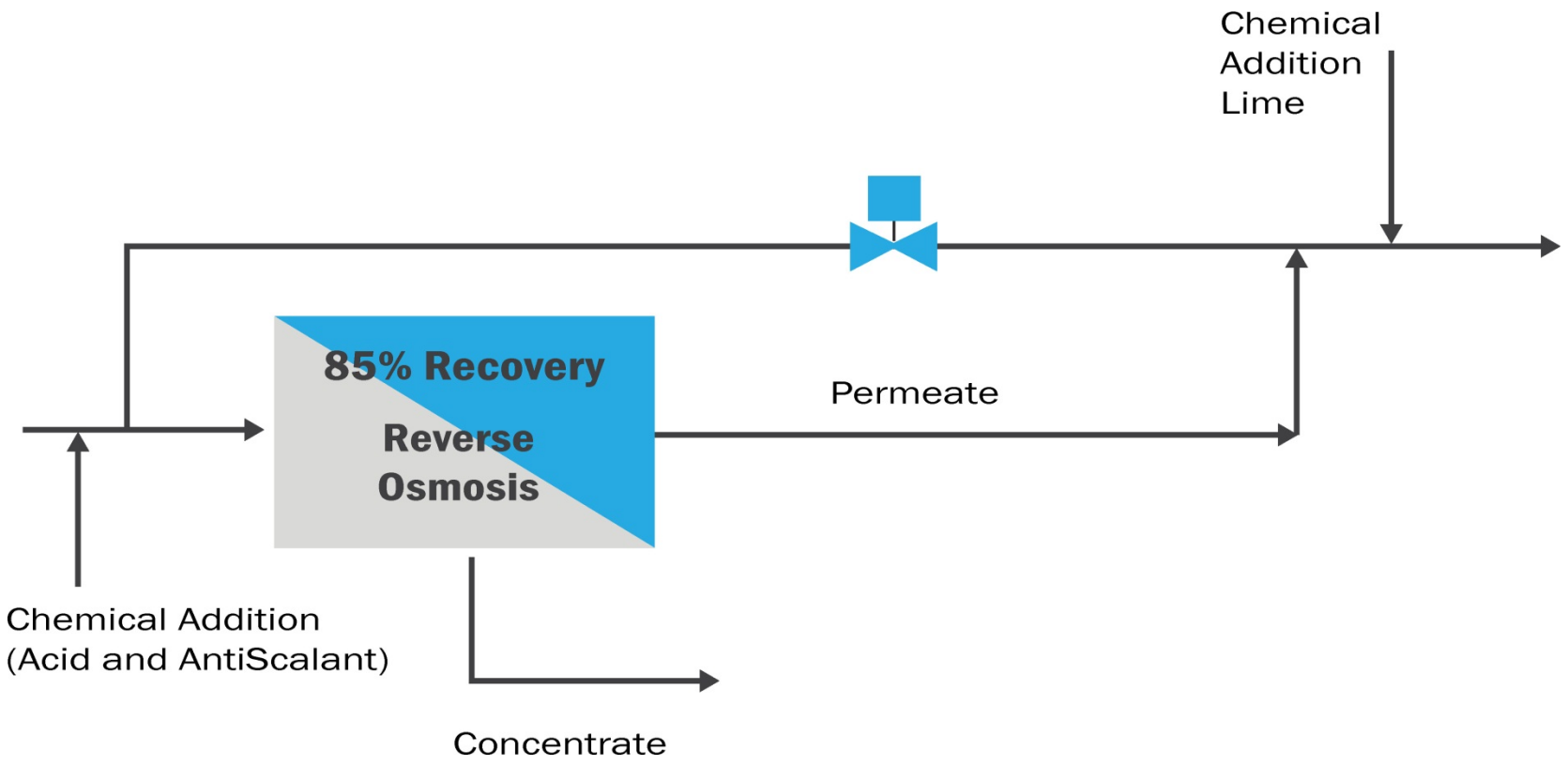
Local Urban Water/Salt Balance



Comparison of Potable and Reclaimed Water



Traditional Treatment Approach



Traditional Treatment Approach

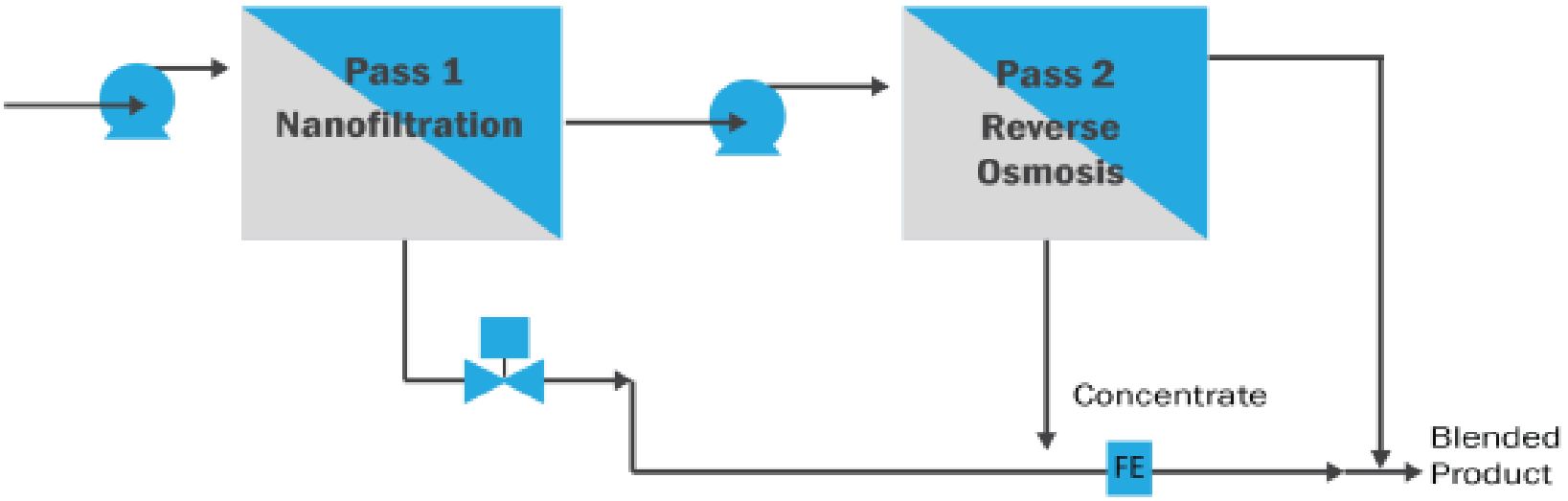
Benefit	Challenge
Reliable, well understood process	Recovery limited by precipitates of carbonates, sulfates, phosphates and silica
Good removal of ions	Must add chemical or blend to re-stabilize product water
Good removal of organics, including emerging contaminants	High TDS concentrate stream that is difficult to treat

What could be…

Alternative treatment configurations that:

- ☑ Reduce sodium and chloride levels
- ☑ Reduce cost of chemical addition
- ☑ Reduce cost of concentrate management

Hybrid NFRO

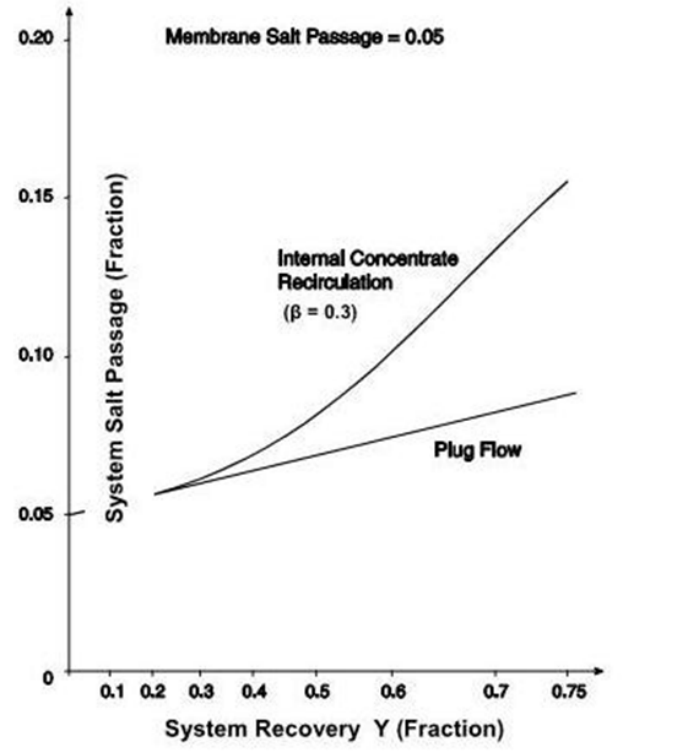

Pass 1
Nanofiltration
Pass 2
Reverse
Osmosis
Concentrate
FE
Blended
Product

Pilot Test of NF

Brown AND Caldwell

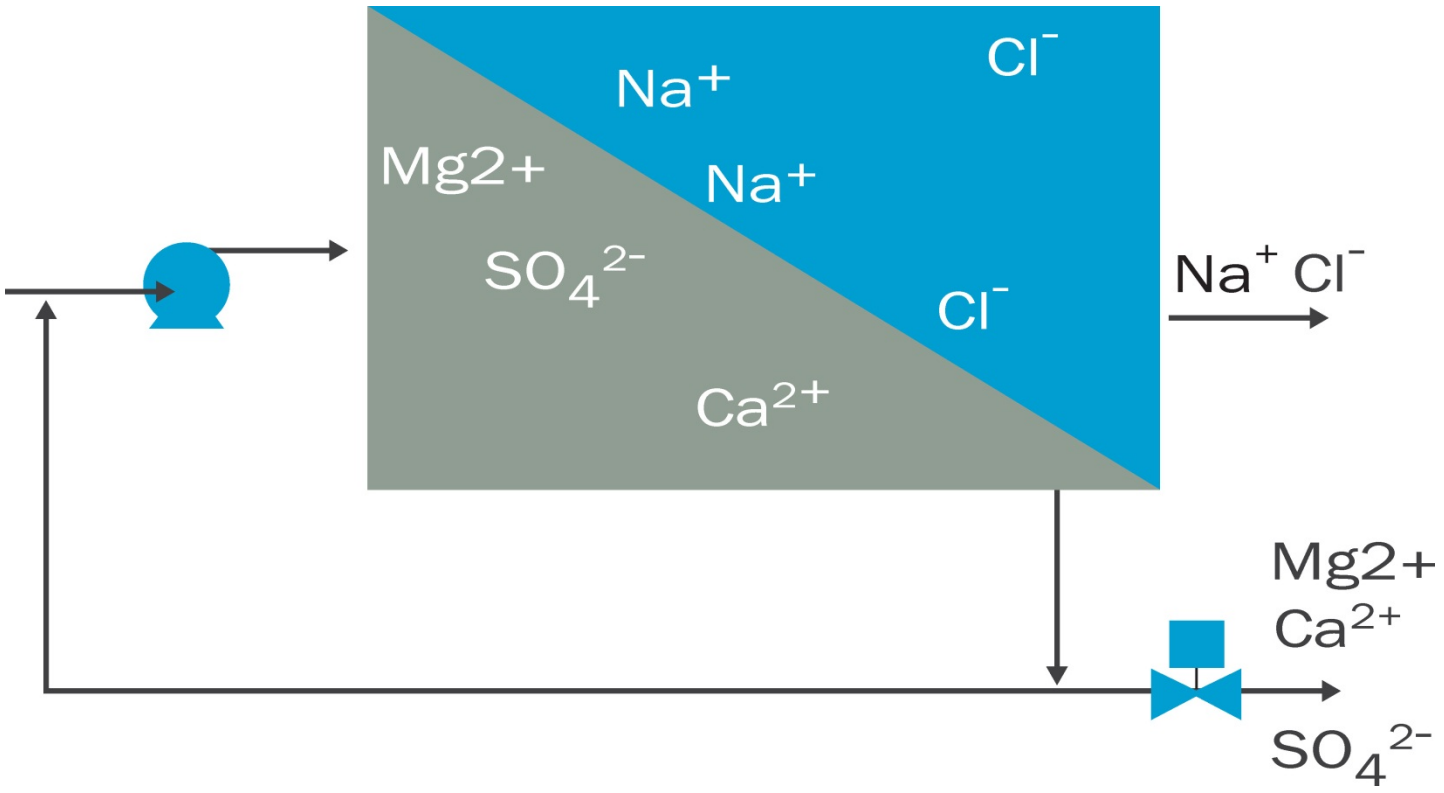
Salt Passage Characteristics

1. Take advantage of different rejection of multivalent vs. monovalent ions in NF membrane
2. Enrich waste with sodium and chloride
3. Retain hardness, sulfates for re-blending



From DOW Technical Manual Form 609-020501-1004

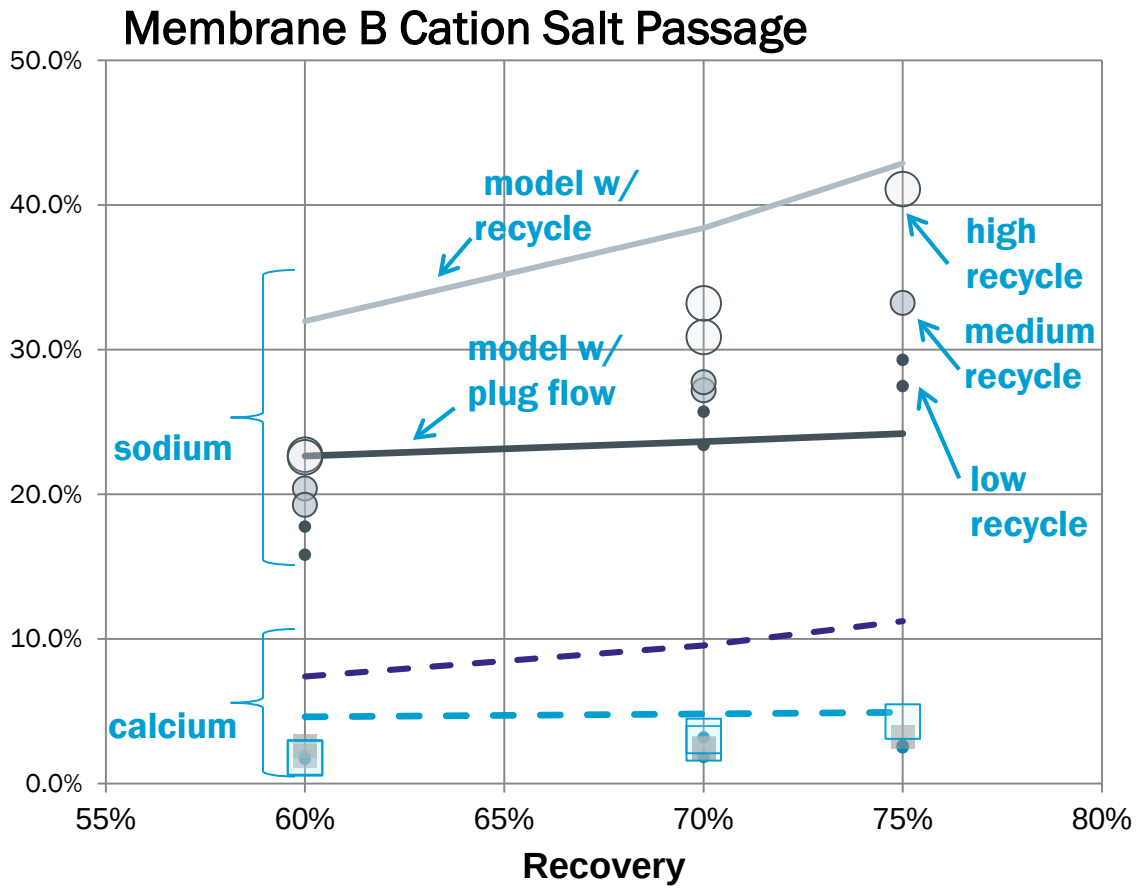
Pilot Study Set Up



3 membranes tested

with multiple recovery and recycle rates

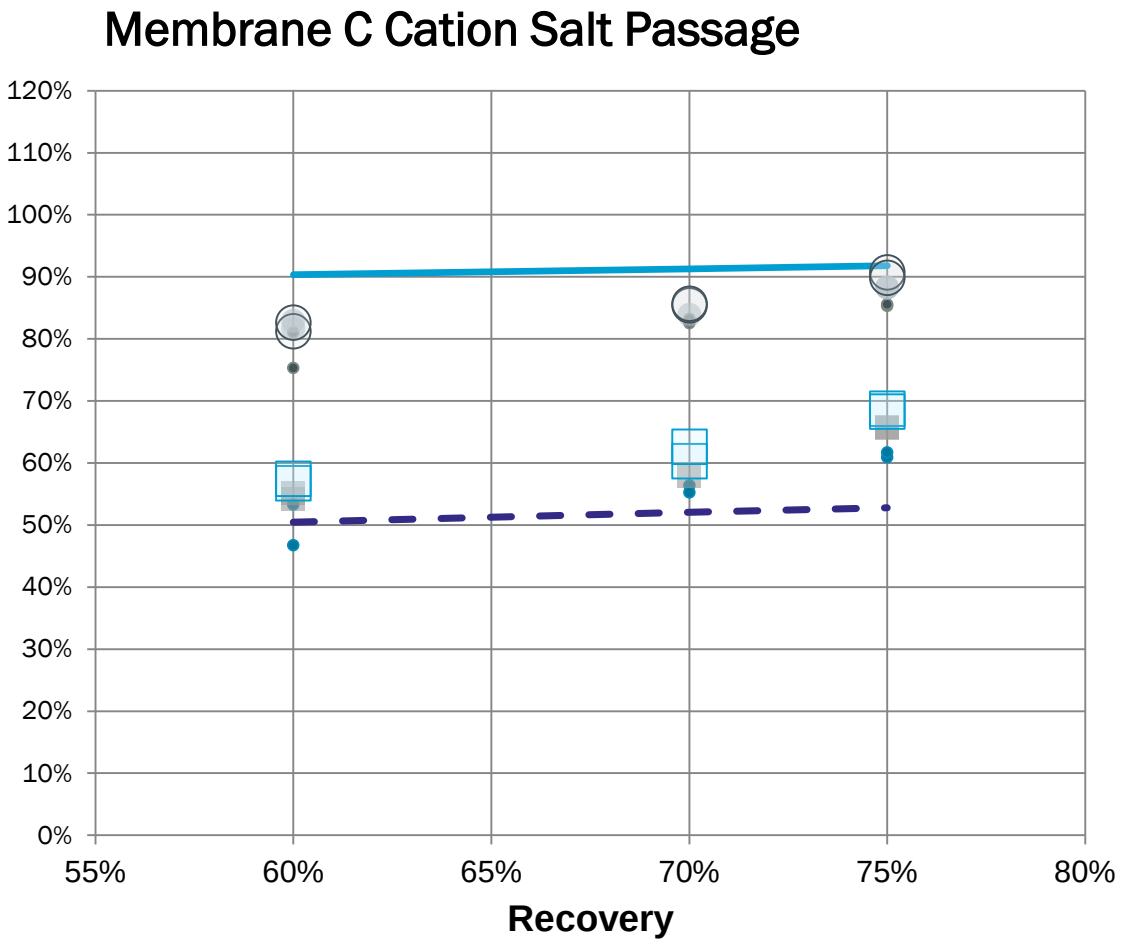
Membrane B Results



Good variability of salt passage with recycle

Trends are similar to model results but lower

Membrane C Results



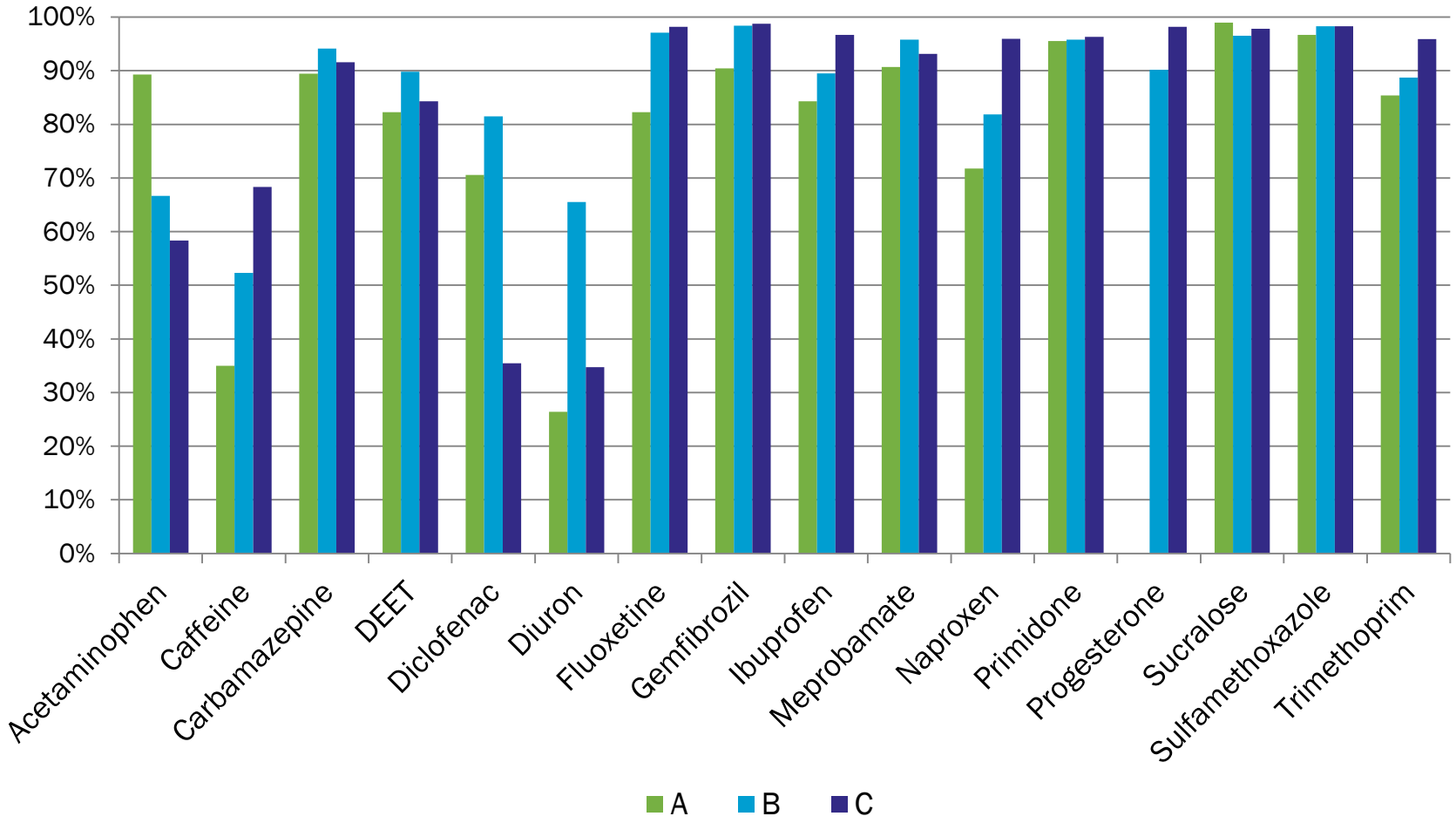
Provides adequate sodium and chloride passage but

Calcium and Magnesium passage higher than expected

Average Concentrations

Constituent	Feed	Permeate		
		A	B	C
TOC	2.3	< 0.5	<0.5	<0.5
TKN	2.3	1.2	1.3	1.5
Ammonia	1.4	0.86	0.62	0.88
Nitrate	4.0	4.2	1.2	4.4
Silica	14.9	12.2	3.4	14.2
Sulfate	214	ND	ND	0.03
Orthophosphate	1.1	<0.2	<0.2	<0.2

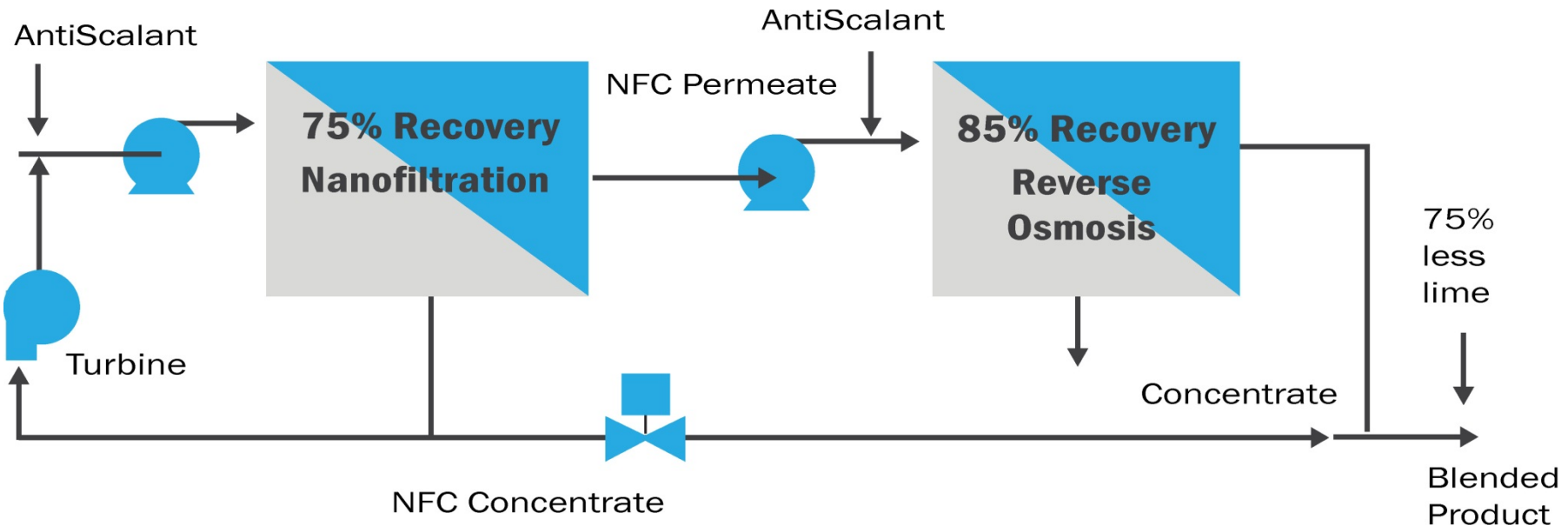
Trace Organics



Analysis

Brown AND Caldwell

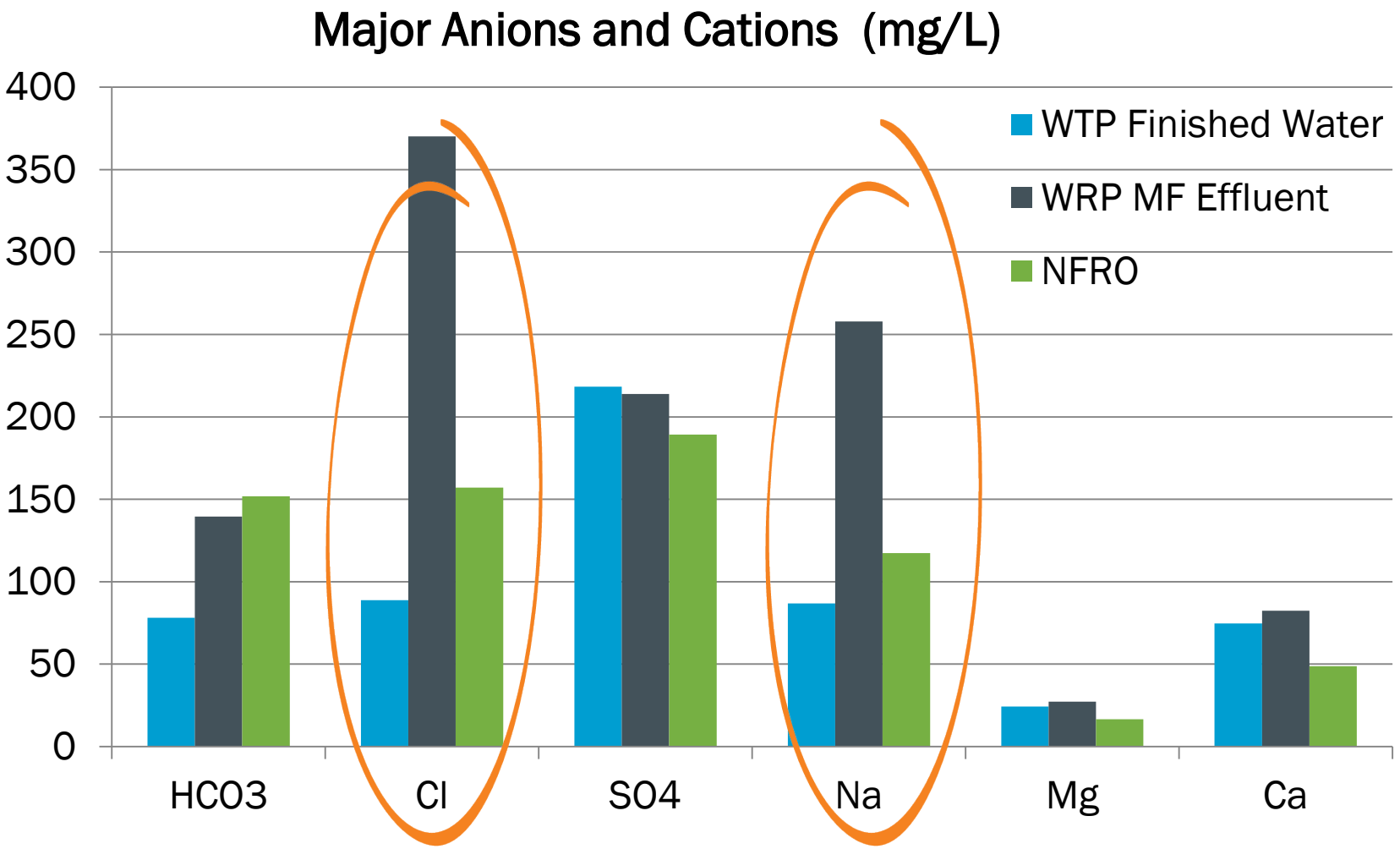
Model NFRO Schematic



Benefits

Brown AND Caldwell

Improve Water Quality

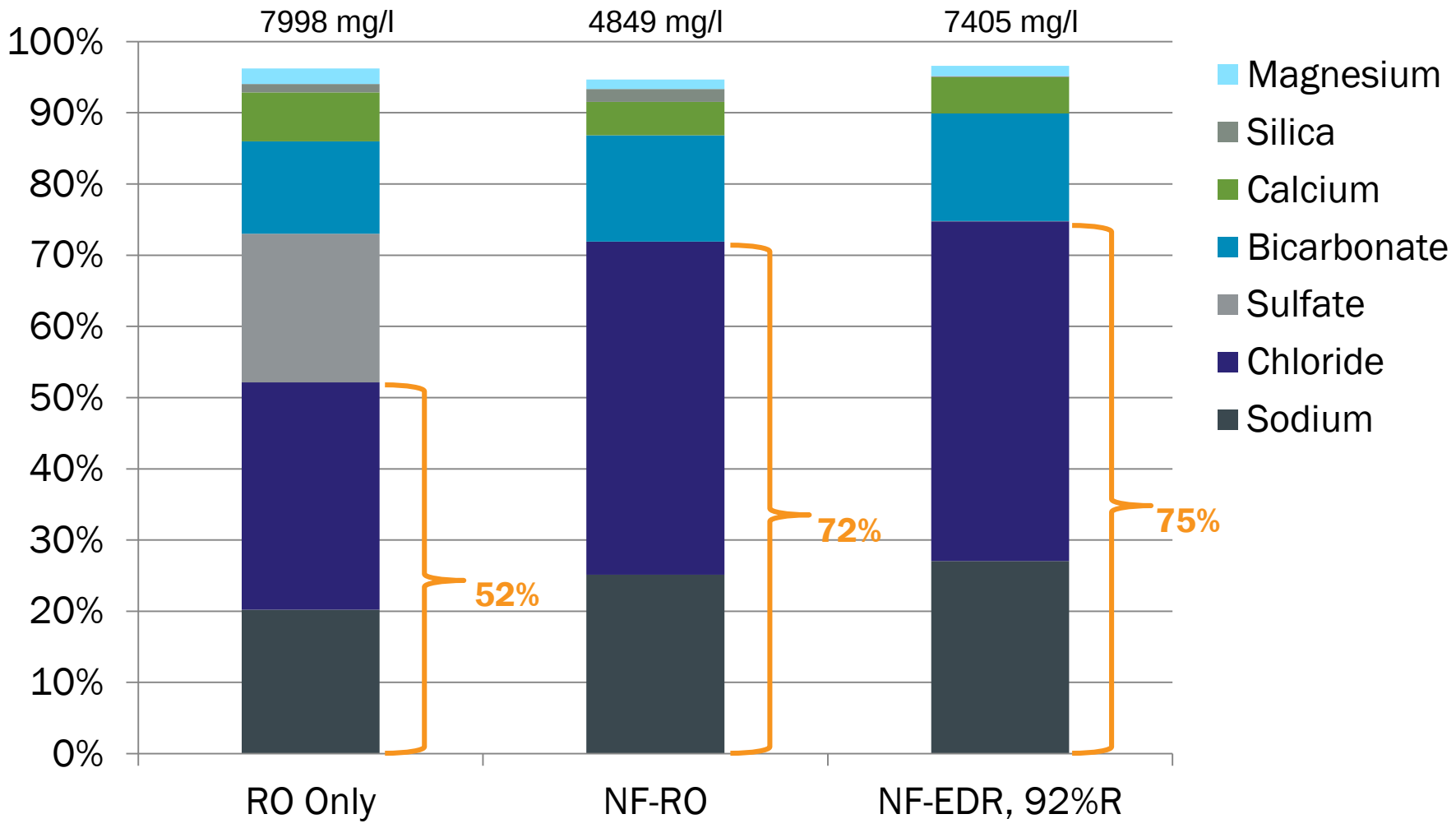


Reduce Chemical Consumption

	RO + Blend	NF-RO
Sulfuric acid, ppd	188	0
Threshold inhibitor, ppd	13.3	11.5
Lime, ppd	220	49
Chemical Cost Per year	$47,545	$45,374

- ✓ *700 gpm feed each*
- ✓ *88% overall recovery*

Comparison of Concentrate Quality

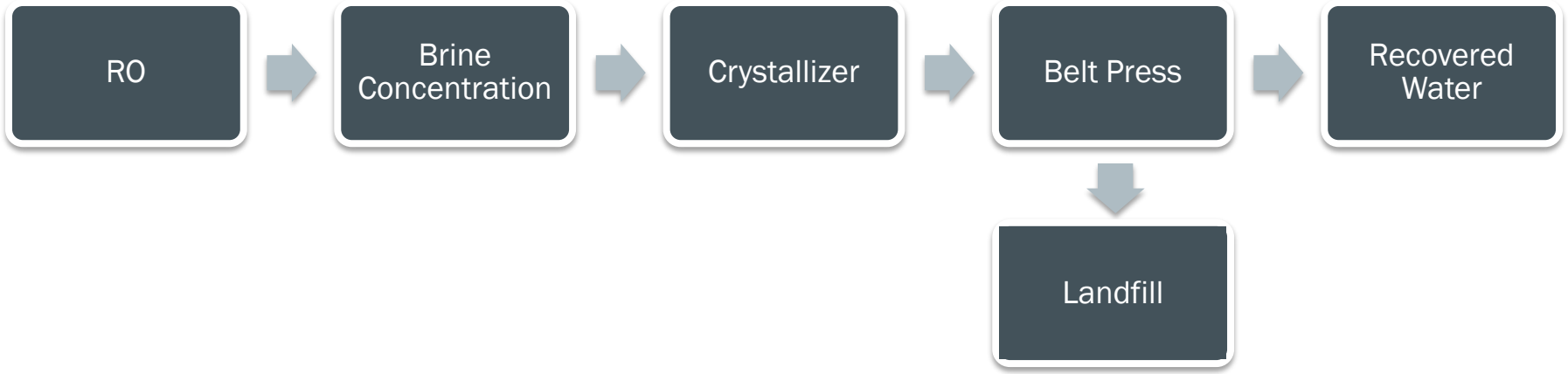


Concentrate Quality

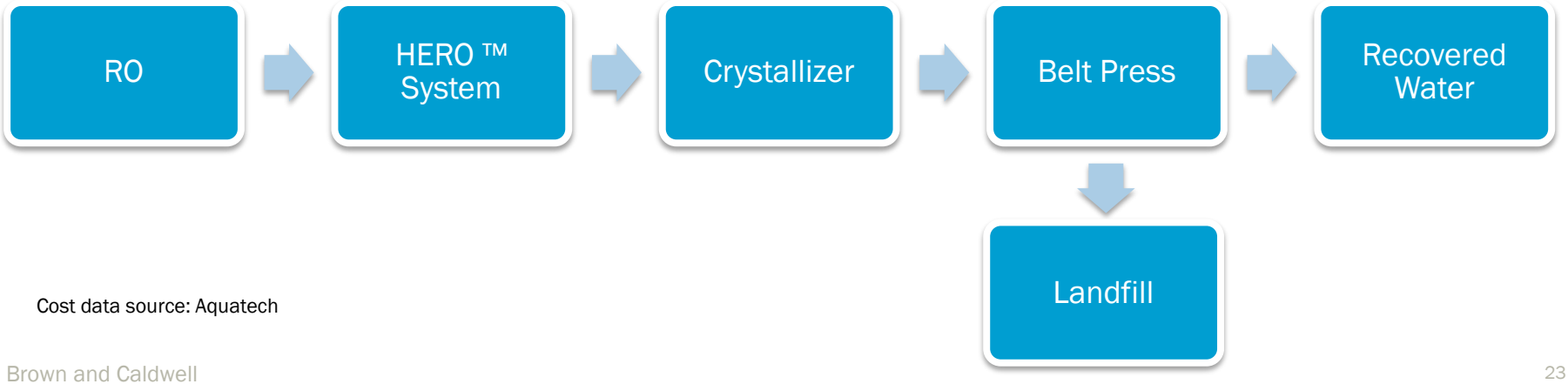
- ✓ 40% less TDS
  - ✓ The balance is conserved in the blended product
- ✓ Very low total organic carbon
  - <2.5 ppm versus 16 ppm
- ✓ Little to no phosphate
  - None detectable in NF permeate or NFRO concentrate
  - 29.6 ppm in ‘traditional’ RO concentrate

Comparison of ZLD Capital Cost

System Cost: $9.2M



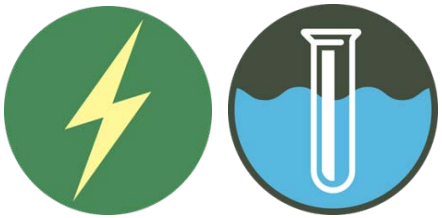
System Cost: $10.1M



Cost data source: Aquatech

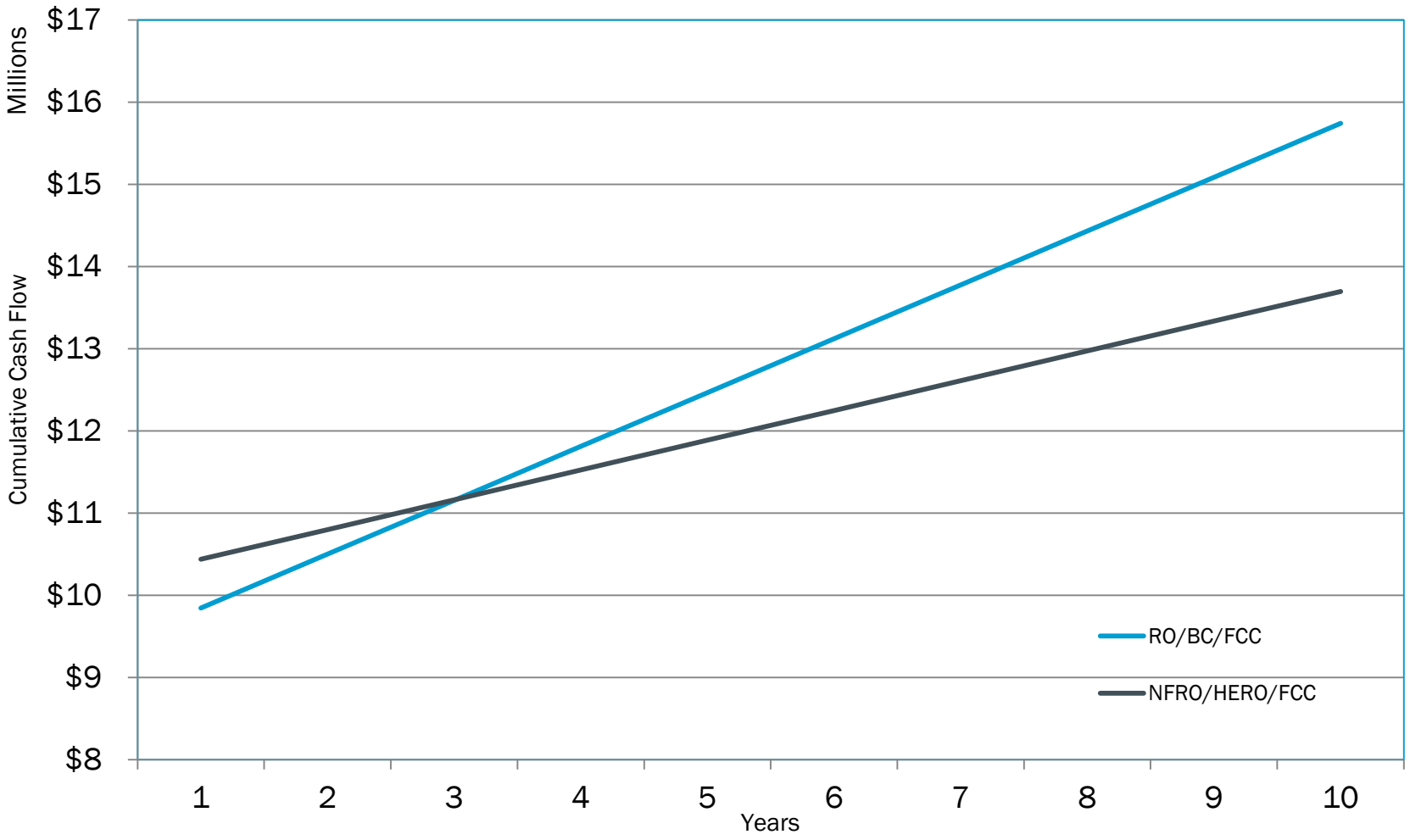
Comparison of ZLD Operating Costs

Item	RO/BC/FCC	NFRO/HERO/FCC	Savings
Power	$431,000	$216,000	$215,000
Chemicals	$202,000	$130,000	$72,000
Other	$22,000	$16,000	$6,000
Total	$655,000	$362,000	$293,000



45% annual operating cost savings

ZLD Simple Payback



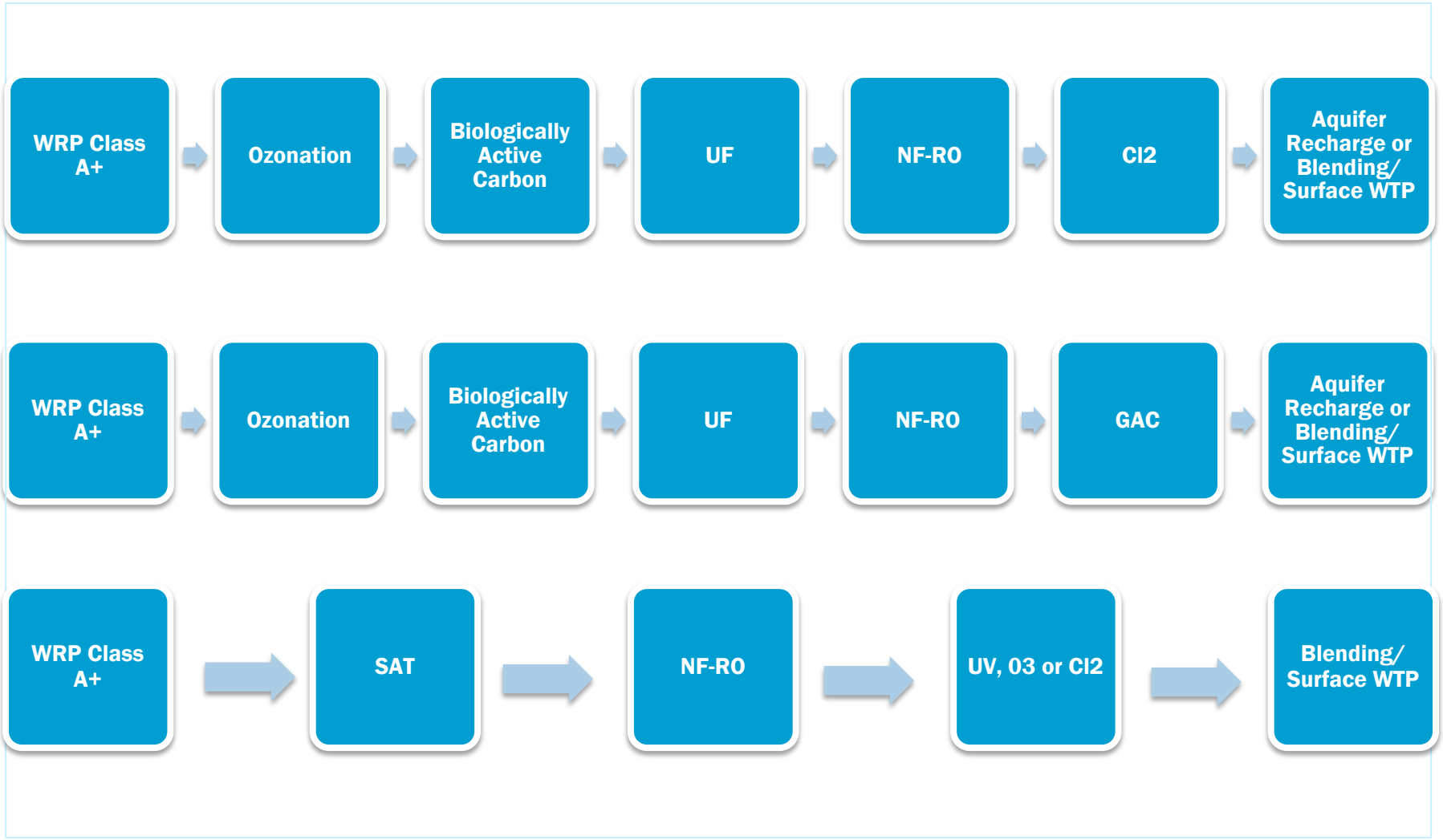
Challenges

Brown AND Caldwell

Hybrid NFRO Challenges

Higher pumping energy	Recover hydraulic energy with ERD
More membrane required (+25%)	Low NF recovery and high quality feed to RO likely to result in less cleaning and replacement
Threshold inhibitor in product	Most products are NSF certified
Little removal of trace organics and TOC	Not regulated for non-potable reuse Use alternate processes for potable reuse

Options for Potable Reuse Scheme



Hybrid NFRO Benefits

Feature	Benefit
Reduces sodium and chloride	Improves Sodium Adsorption Ratio; Reduces Chloride Toxicity
No acid addition, less scale inhibitor Retains multivalent ions	Lower overall chemical cost
Concentrate contains low sulfate, phosphate and TOC	Lower cost concentrate treatment
Plug-and-Play into a direct reuse or potable reuse scheme	Versatility

Questions