DIALING IN ON DISINFECTION: Part 2

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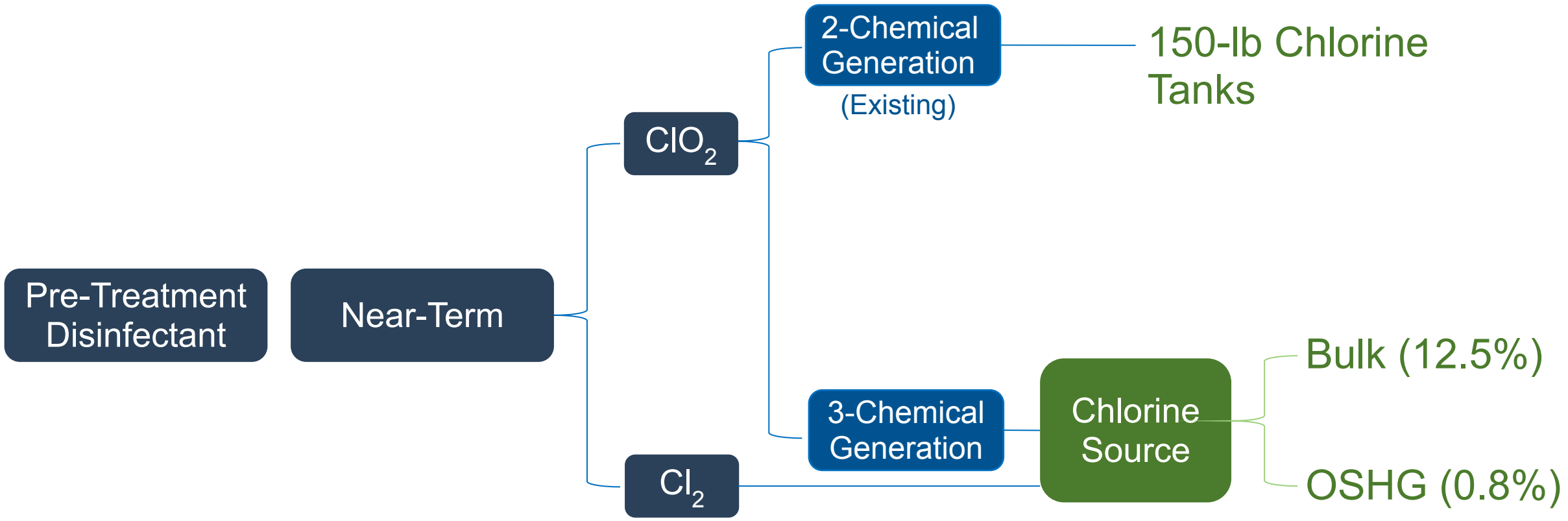
carollo

confluence ENGINEERING GROUP LLC

Skagit PUD PUBLIC UTILITY DISTRICT

// Chlorine Source & Pre-treatment Disinfection Alternatives



DETAILED INFORMATION OF ALTERNATIVES

// Common Criteria

Parameter	Units	Minimum	Average	Maximum
Flow	MGD	4	10	24
Chlorine Dose by Process				
Chlorine Dioxide	mg/L	0.055	0.44	0.715
Pre-Chlorine	mg/L	0.2	0.5	1.0
Disinfection	mg/L	1.0	2.5	3.0
Total Chlorine Dose	mg/L	1.3	3.4	4.7
Chlorine Dioxide Use	mg/L	0.1	0.8	1.3
Ozone Dose				
Pre-Oxidation and Algal Toxins	mg/L	0.5	1.0	2.5
Contact Time	minutes		4	
Disinfection and T&O	mg/L	0.5	2.0	4.0
Contact Time	minutes		10	

// Economic Criteria – AACE Class 5 Estimate **Capital Costs**

- Major facilities and process equipment
- Parametric assumptions for construction costs for: buildings, contactors, excavation, site work, and piping.
- Multiplier for Electrical and I&C
- Indirect costs quantified as multipliers:
  - Contractor Overhead and Profit
  - Sales Tax
  - General Conditions
  - Scope Contingency
  - Engineering and Administration

// Economic Criteria – AACE Class 5 Estimate **O&M and Lifecycle Costs**

- Major chemicals based on average doses
- Major power uses
- Maintenance (2% of equipment)

- 20-year lifecycle
- Interest Rate: 7%
- Inflation Rate: 5%
- Present Worth Factor = 15.72

// Non-Economic Criteria

Criteria	Description	Weight
Safety	• Risk to WTP staff • Risk to WTP neighbors and community	1.2
Resilience / Reliability / Redundancy (RRR)	• Reliability and resilience to chemical supply disruptions • System and major equipment resilience to natural disasters • Redundancy to meet CT requirements	1.1
O&M Complexity	• Ease of operation and maintenance • Minimizes efforts required to comply with safety regulations	0.8
Environmental & Social	• Minimizes potential harm and impacts to environment • Maximizes efficient use of resources (chemical use, energy use, transportation and hauling)	0.8
Implementation Flexibility	• Easier integration with existing WTP infrastructure and future operations • Easier capacity expansion • Minimize stranded investment for future WTP	1.1
Water Quality	• Multibarrier to water quality risks	1.0

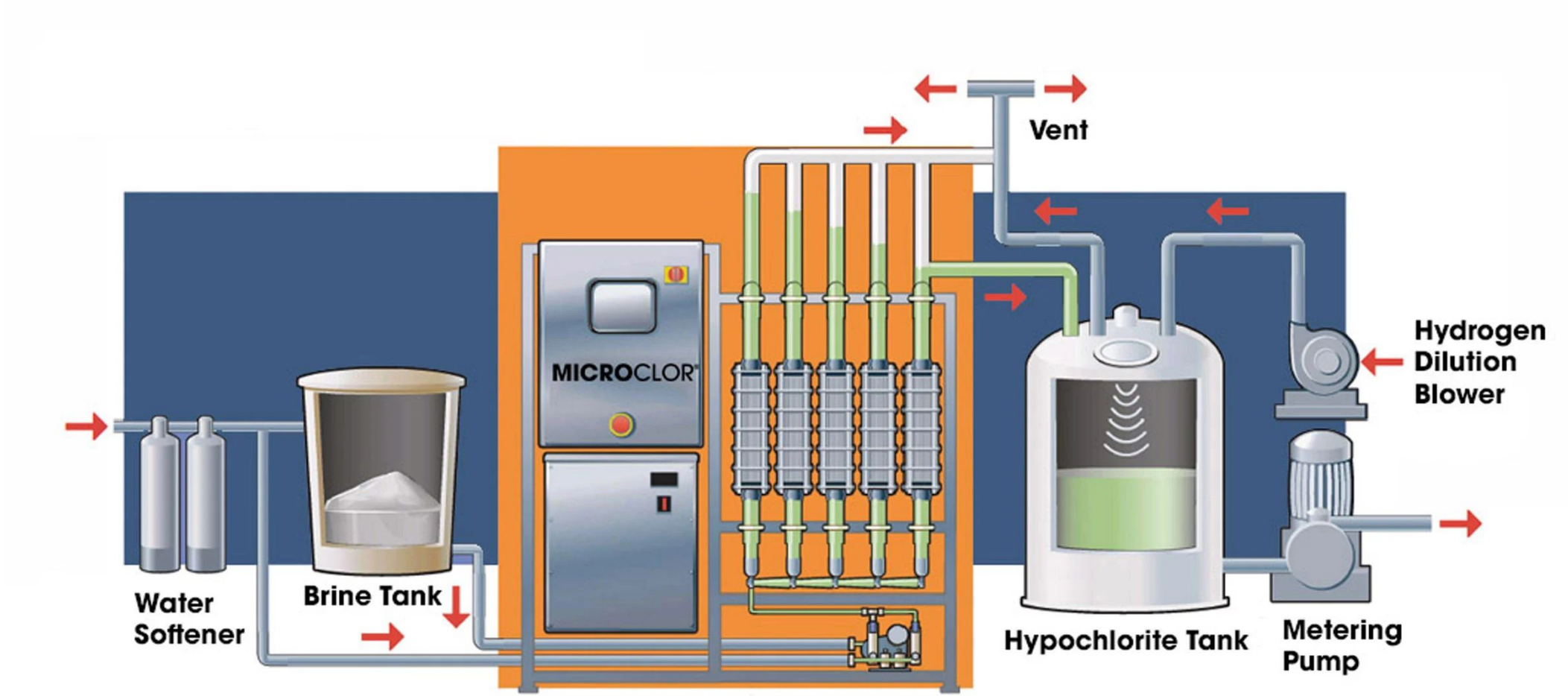
Chlorine Source Alternatives

// Bulk Hypochlorite (12.5%) Design Criteria

Category	Units	Quantity
Number of Tanks	No.	2
Storage Size	gallons	6,000
Total Storage (1)	days	43
Truck Deliveries per Month (1)	No.	0.7
Chlorine Dioxide Metering Pumps (2)	No.	2 (1+1)
Pre-Chlorine Metering Pumps (2)	No.	2 (1+1)
Finished Water Metering Pumps (2)	No.	2 (1+1)

1) At average flow and average dose
2) All metering pumps are peristaltic and assumed to be in a duty + standby configuration.

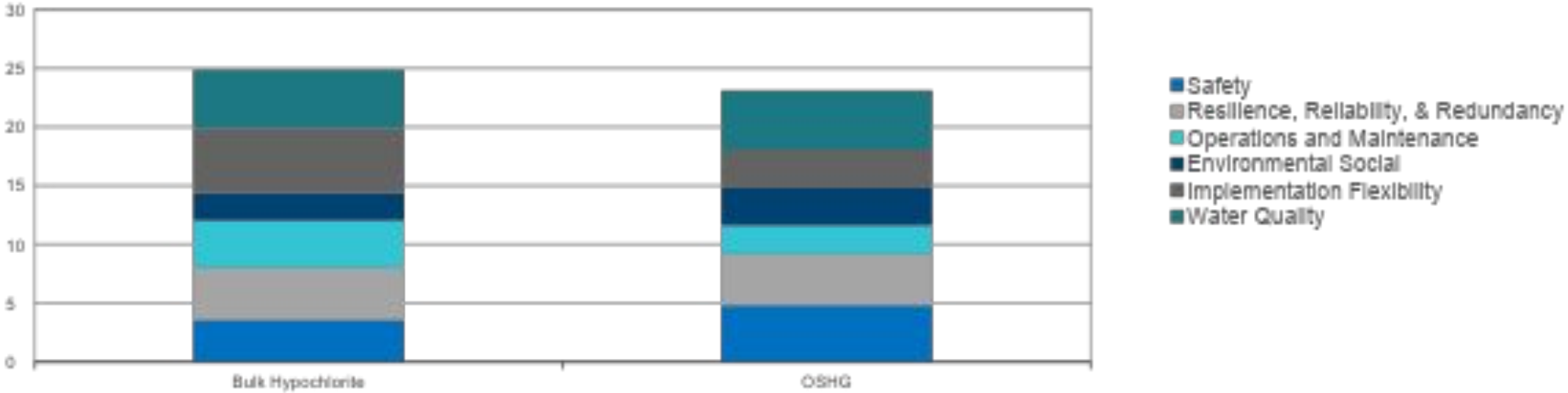
// On-Site Sodium Hypochlorite Generation (OSHG)



// OSHG (0.8%) Design Criteria

Category	Units	Quantity
Number of Generators	No.	2 (1+1)
Generator Capacity	ppd	1,000
Hypochlorite Storage Tank	No.	2
Hypochlorite Storage Size	gallons	6,000
Total Hypochlorite Storage	days	3
Brine Storage Tank	No.	1
Brine Storage Size	tons	30
Total Brine Storage	days	70
Truck Deliveries per Month	No.	0.45
Chlorine Dioxide Metering Pumps	No.	2 (1+1)
Pre-Chlorine Metering Pumps	No.	2 (1+1)
Finished Water Metering Pumps	No.	3 (2+1)

// Non-Economic Considerations

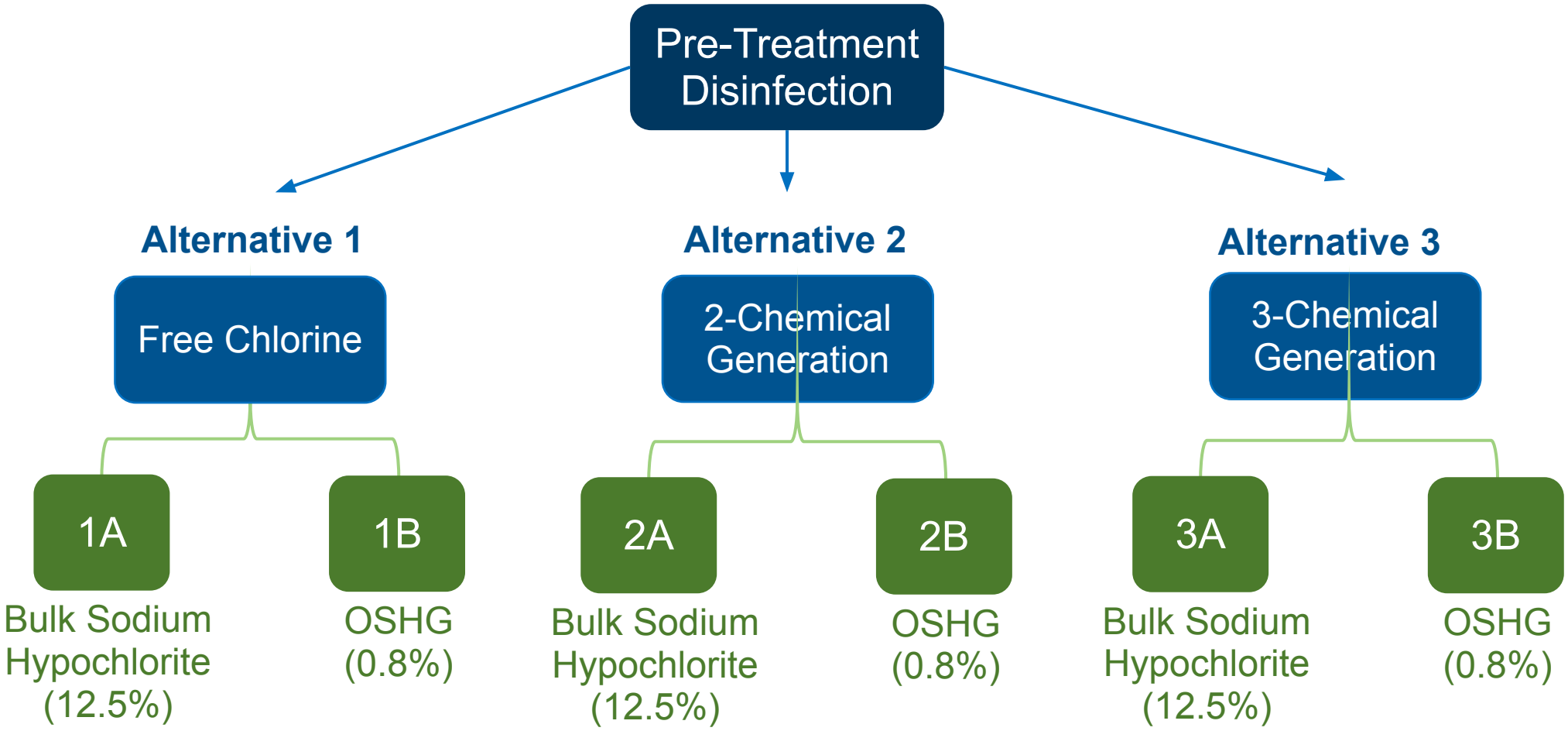


- Bulk hypochlorite
  - Higher scores in O&M and Implementation Flexibility
  - Higher overall score

- OSHG
  - Higher scores in Safety and Environmental/Social Impact

Near-Term Pre-Treatment Disinfection Alternatives & Chlorine Source Alternatives

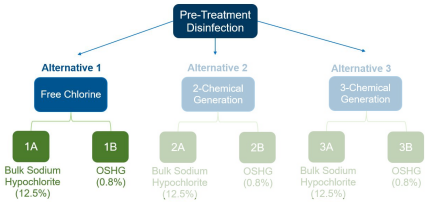
// Alternative Overview



// Alternative Overview

Alternative	1A	1B	2A	2B	3A	3B
Pre-Treatment Disinfection	Free Chlorine	Free Chlorine	Chlorine Dioxide (2-Chemical)	Chlorine Dioxide (2-Chemical)	Chlorine Dioxide (3-Chemical)	Chlorine Dioxide (3-Chemical)
Chlorine Source	Bulk Hypochlorite	OSHG	Bulk Hypochlorite	OSHG	Bulk Hypochlorite	OSHG
Existing Chemicals	-	-	Sodium chlorite	Sodium chlorite	Sodium chlorite	Sodium chlorite
Additional Chemicals	12.5% sodium hypochlorite	Salt	12.5% sodium hypochlorite 150-lb chlorine cylinders	Salt 150-lb chlorine cylinders	12.5% sodium hypochlorite Hydrochloric acid (HCl)	Salt Hydrochloric acid (HCl)
Notes	All chemicals stored in new chlorine building	All chemicals stored in new chlorine building	Sodium chlorite and 150-lb cylinders stored in existing building; bulk hypochlorite stored in new building	Sodium chlorite and 150-lb cylinders stored in existing building; OSHG and storage in new building	Sodium chlorite stored in existing building; bulk hypochlorite and HCl stored in new building	Sodium chlorite stored in existing building; OSHG and HCl stored in new building

// Free Chlorine



- Alternative 1A
  - 12.5% bulk sodium hypochlorite as free chlorine source

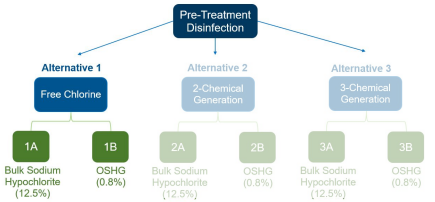
Category	Units	Quantity
Number of Tanks	No.	2
Storage Size	gal	6,000
Total Storage	days	43
Pre-Chlorine Metering Pumps	No.	2 (1+1)
Finished Water Metering Pumps	No.	2 (1+1)

- Alternative 1B
  - 0.8% sodium hypochlorite generated on-site as free chlorine source

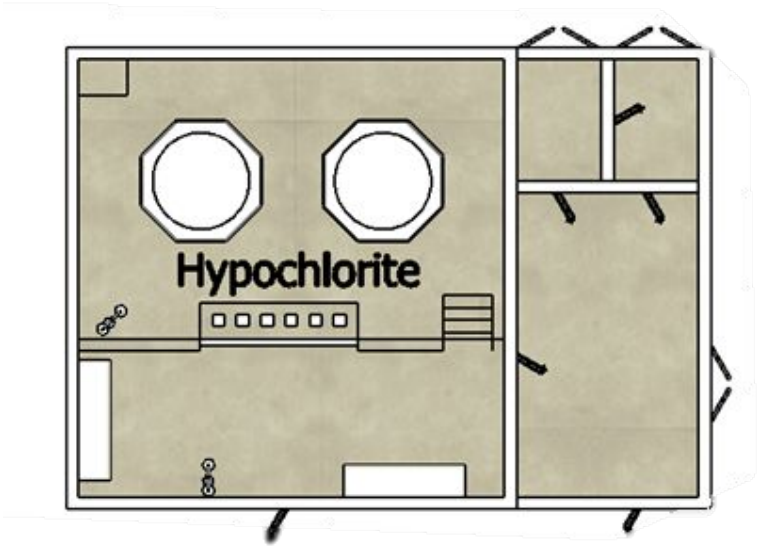
Category	Units	Quantity
Number of Generators	No.	2 (1+1)
Generator Capacity	ppd	1,000
Hypochlorite Storage Tank	No.	2
Hypochlorite Storage Size	gal	6,000
Total Hypochlorite Storage	days	3

Category	Units	Quantity
Brine Storage Tank	No.	1
Brine Storage Size	tons	30
Total Brine Storage	days	70

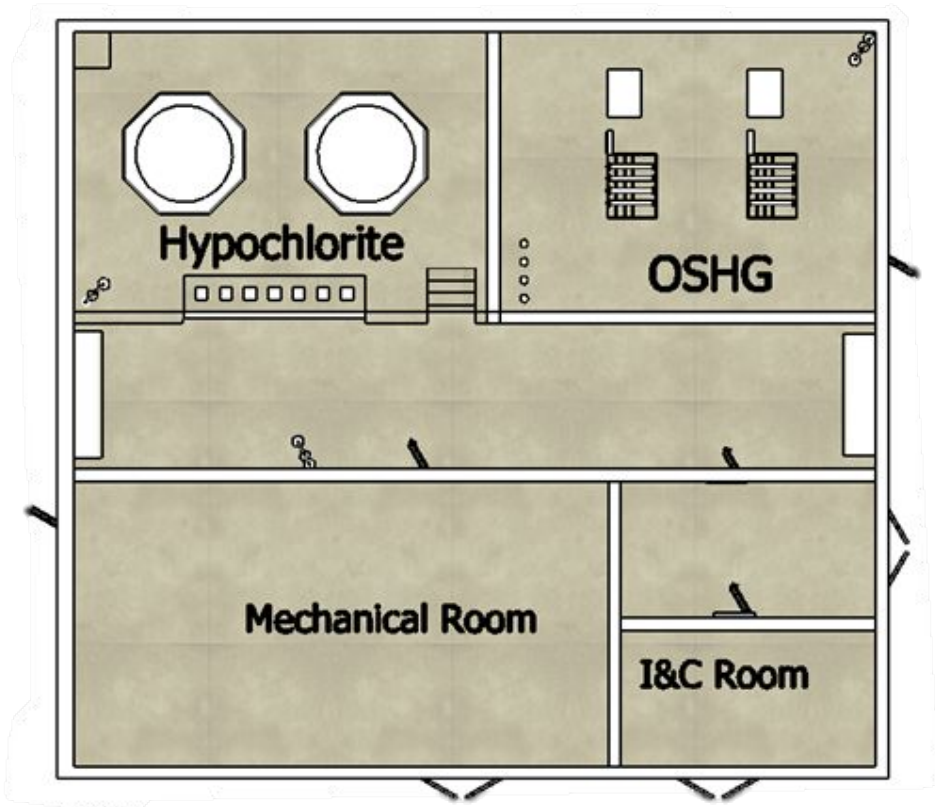
// Free Chlorine

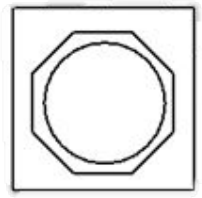


- Alternative 1A – 1,715 sq. ft.

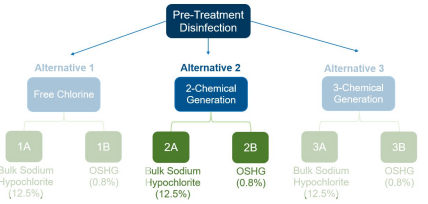


- Alternative 1B – 3,795 sq. ft.





// Chlorine Dioxide (2-Chemical System)

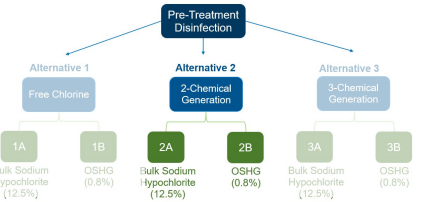


- Alternative 2:
  - Replace one-ton cylinders with nine 150-lb cylinders in the existing storage room
  - Use existing 2-chemical chlorine dioxide generation system:
    - $2\ NaClO_2 + Cl_2 \rightarrow 2\ ClO_2 + 2\ NaCl$

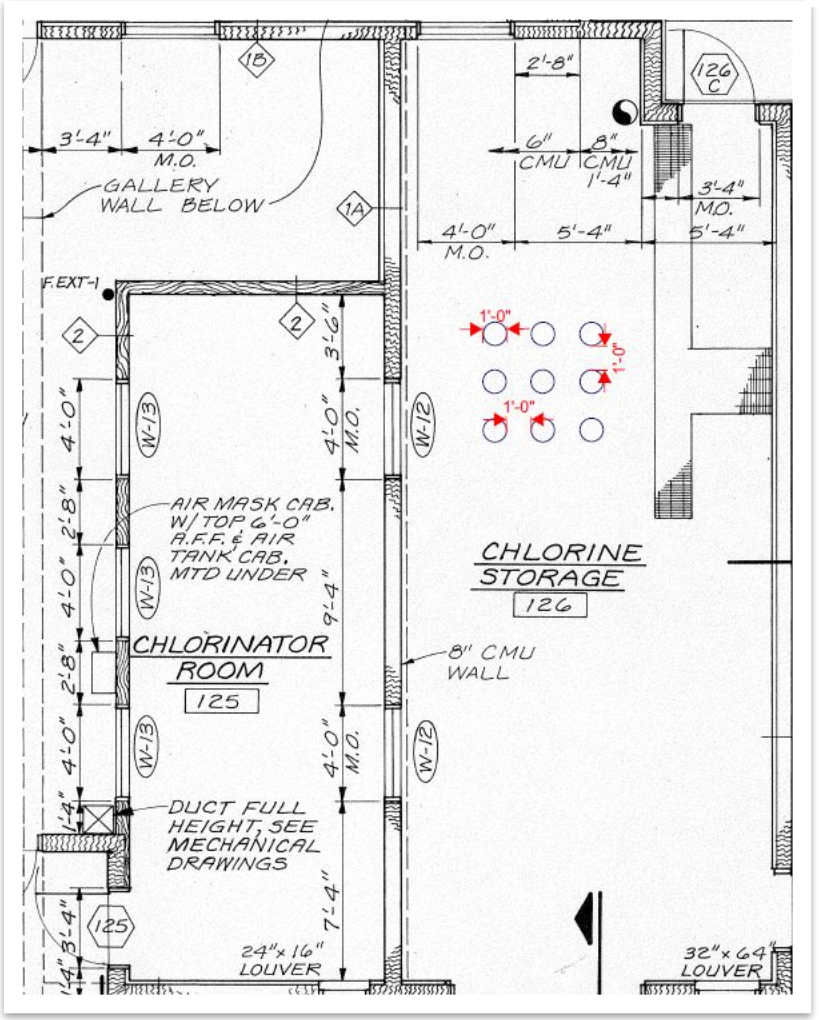
Category	Units	Quantity
Number of Tanks	No.	9
Storage Size	lbs.	150
Total Storage (1)	days	45
Number of ClO_2 Generators	No.	2
ClO_2 Capacity	ppd	220

1) Storage of chlorine gas is based on average and maximum chlorine dioxide usage

// Chlorine Dioxide (2-Chemical System)

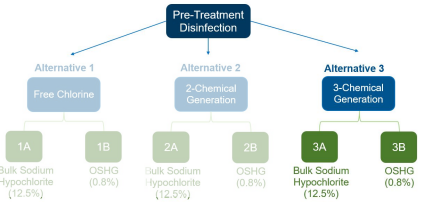


- Alternative 2A – 1,715 sq. ft.
  - Combined with 12.5% bulk sodium hypochlorite disinfection option
- Alternative 2B – 3,795 sq. ft.
  - Combined with 0.8% OSHG disinfection option



*No modifications to previously shown layouts aside from storage of nine 150-lb chlorine gas cylinders

// Chlorine Dioxide (3-Chemical System)

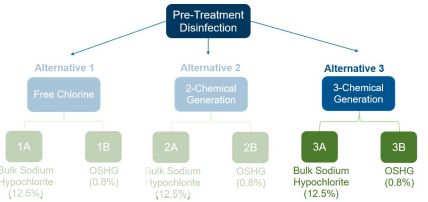


- Alternative 3:
  - Replace existing generators
  - Use a 3-chemical chlorine dioxide generation system:
    - $2\ NaClO_2 + NaOCl + 2HCl \square 2\ ClO_2 + H_2O + 3\ NaCl$

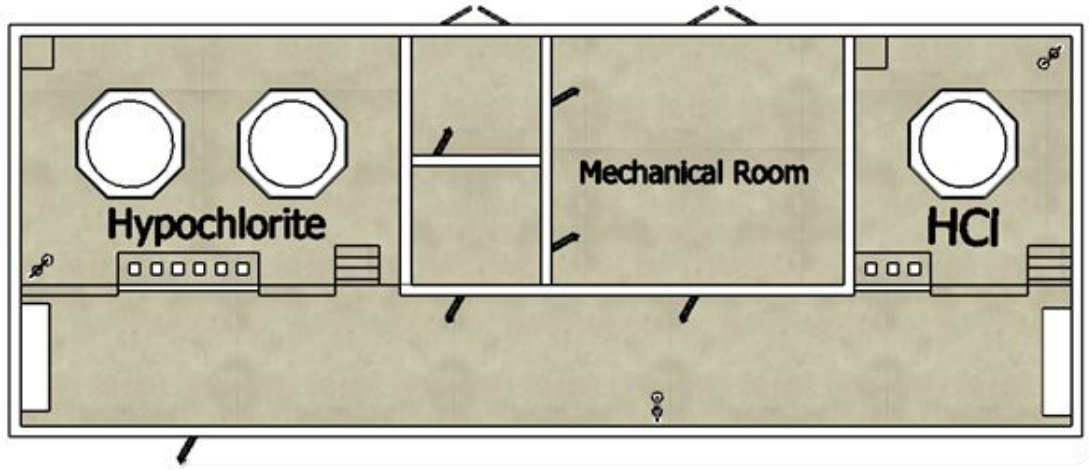
Category	Units	Quantity
HCl Total Storage	gallons	3,500
Total HCl Storage	days	132
Sodium Chlorite Total Storage	gallons	7,000
Number of ClO_2 Generators	No.	2
ClO_2 Capacity	ppd	220

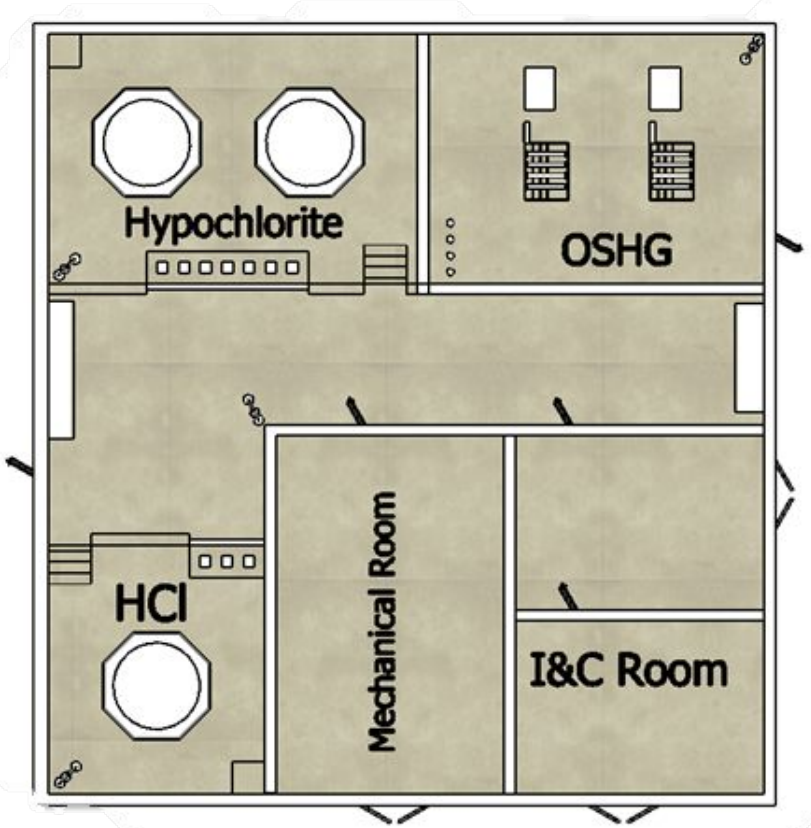
1) Storage of HCl is at the average dose of ClO_2 and average flow

// Chlorine Dioxide (3-Chemical System)

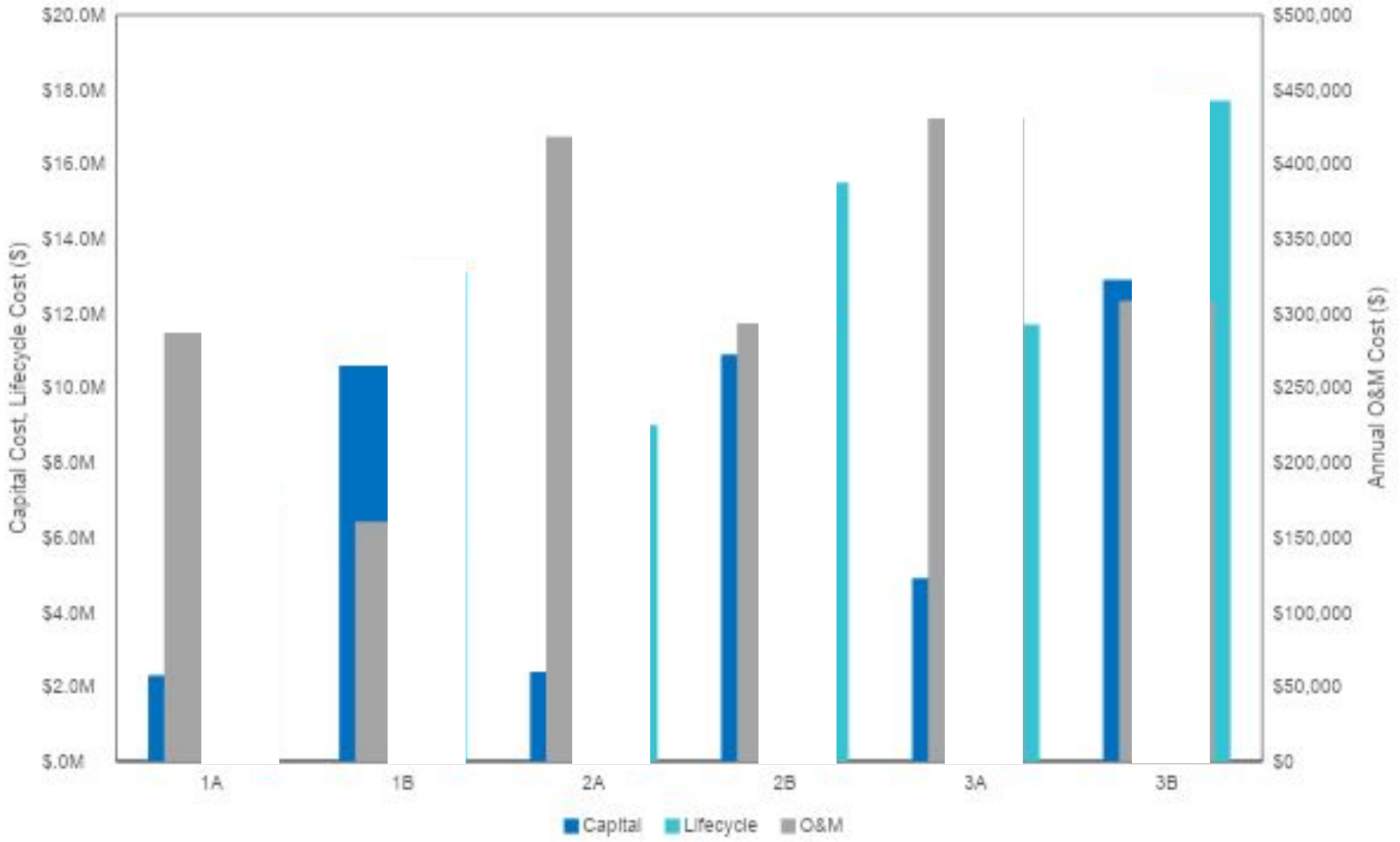


- Alternative 3A – 3,492 sq. ft.
  - Combined with 12.5% bulk sodium hypochlorite disinfection option
- Alternative 3B – 4,422 sq. π.
  - Combined with OSHG (0.8%) disinfection option





// Cost Comparison



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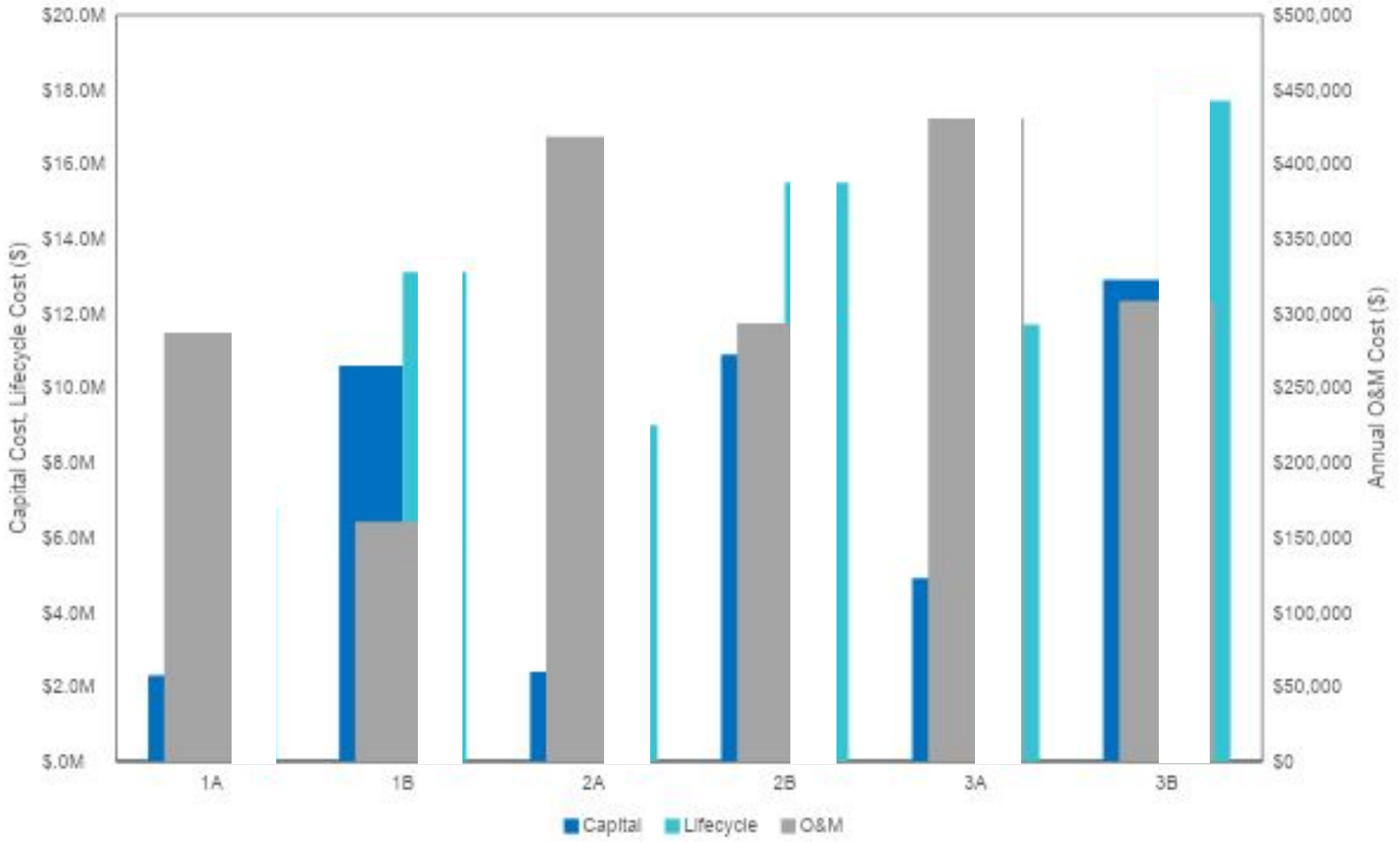
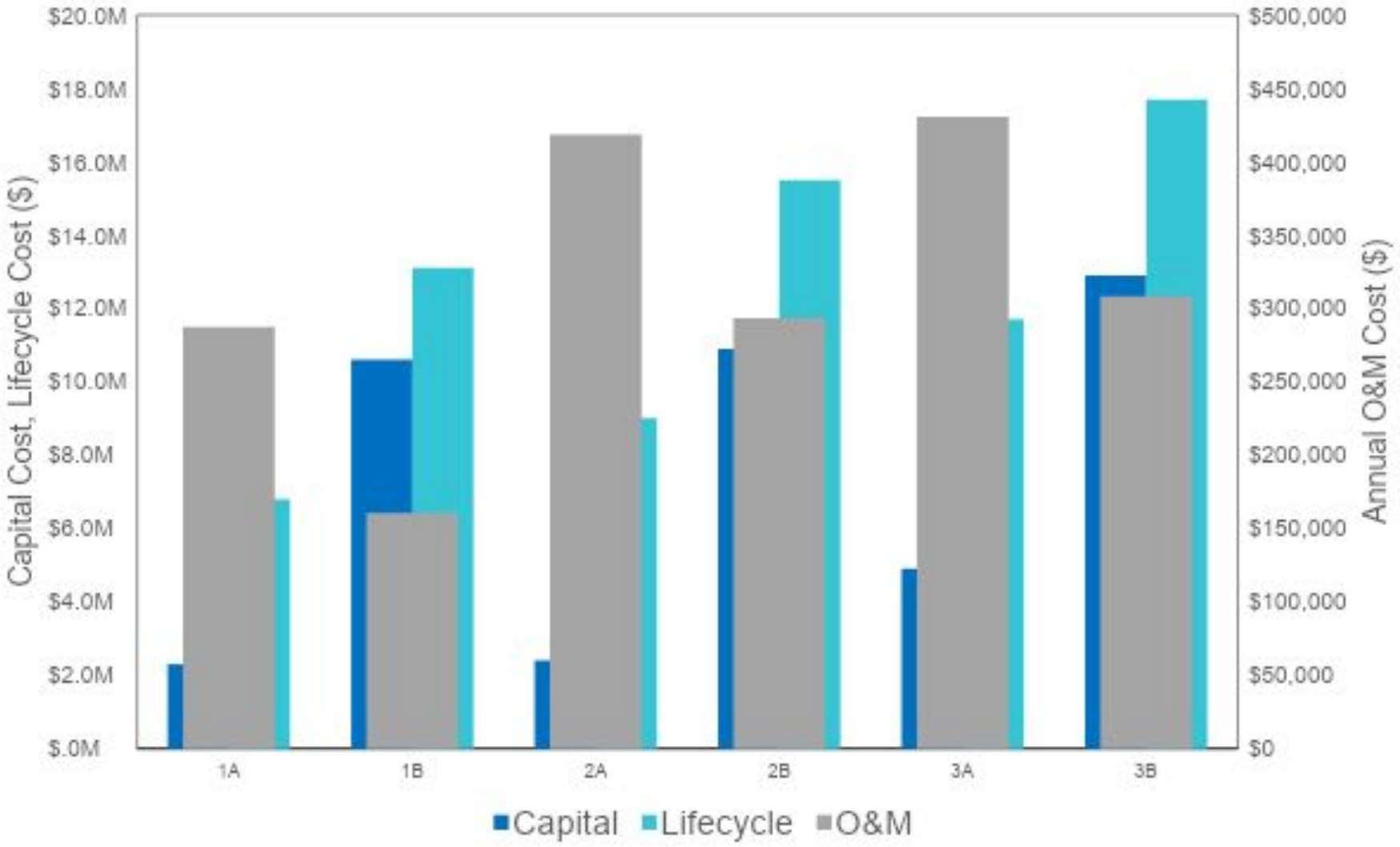
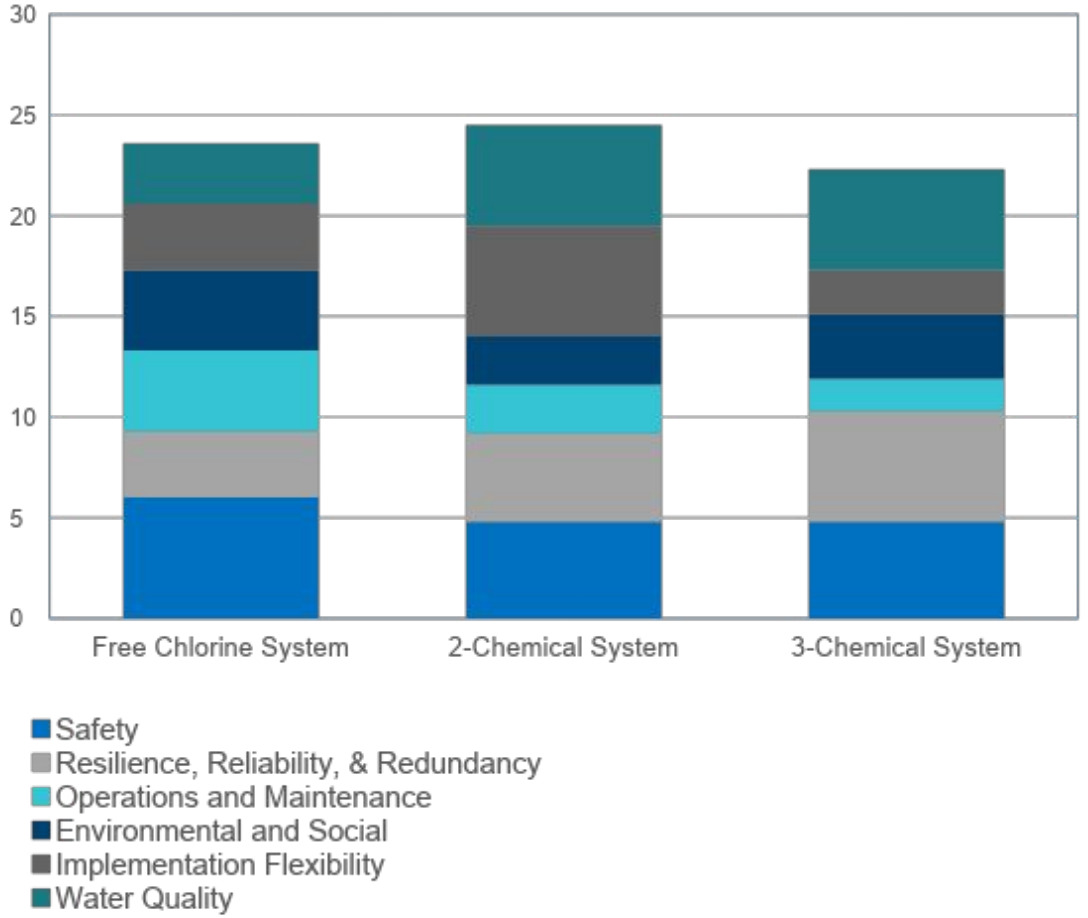


// Cost Comparison



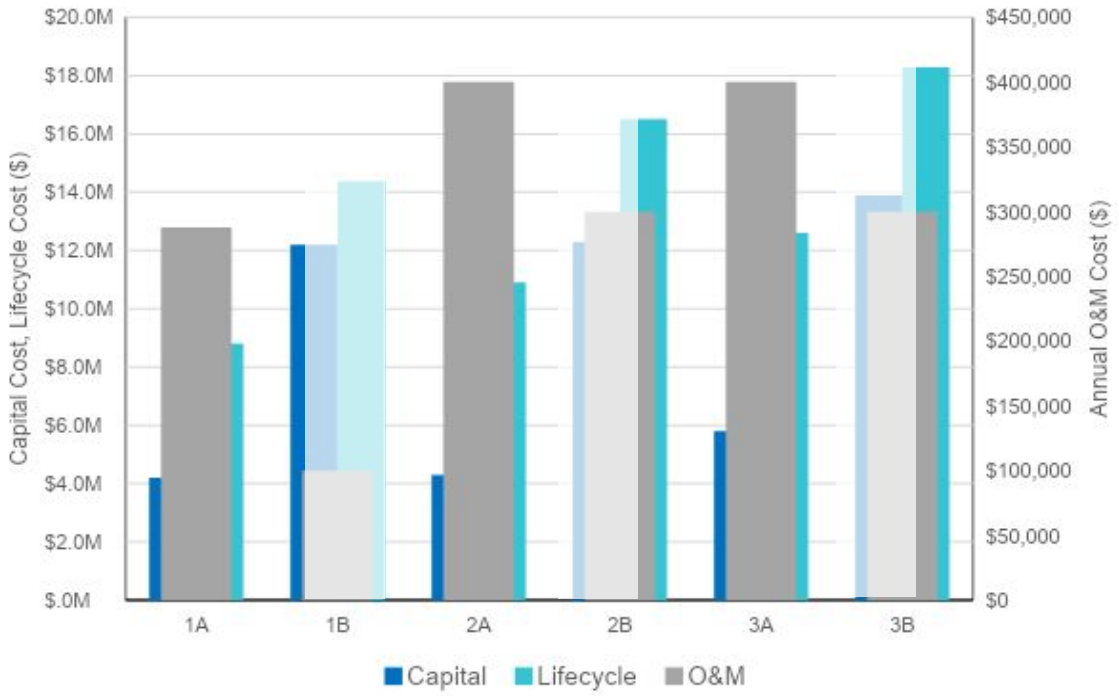
// Non-Economic Evaluation

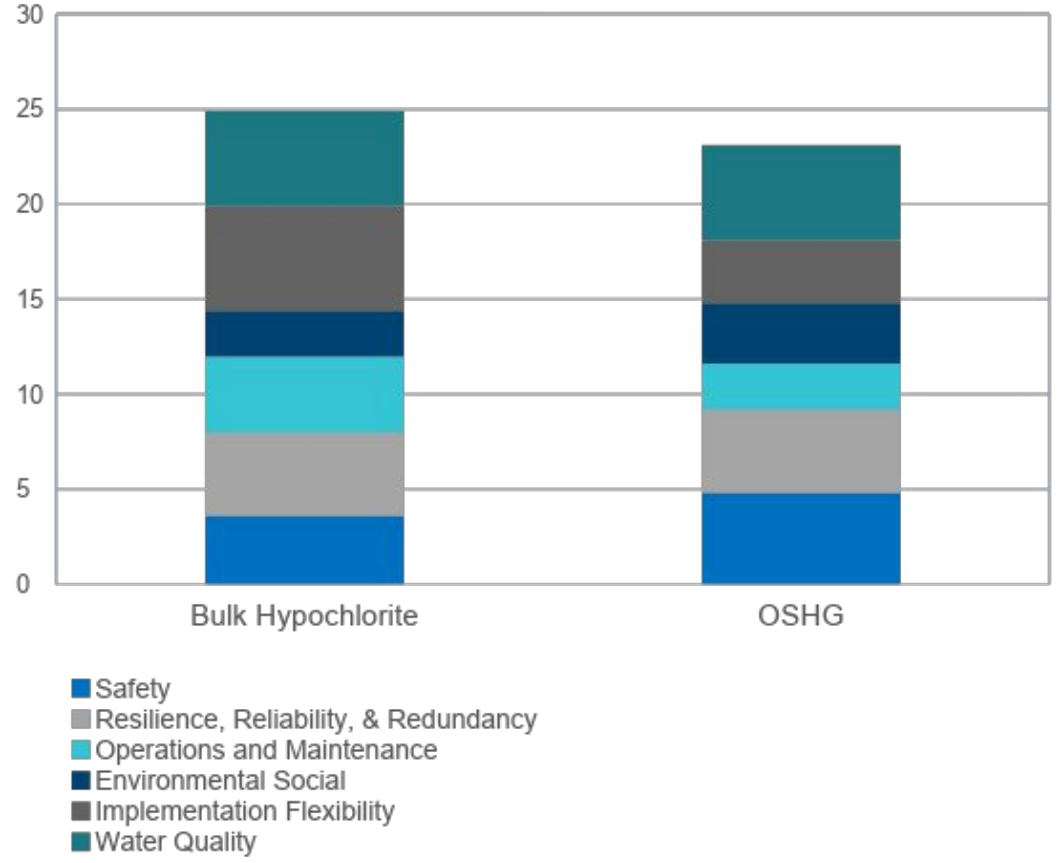
- Free Chlorine
  - Higher scores in Safety, O&M, and Environmental and Social Impact
- 2-Chemical System
  - Higher scores in Implementation Flexibility and Water Quality
  - Highest score overall
- 3-Chemical System
  - Higher scores in RRR and Water Quality



// Near-Term Pre-treatment Disinfection Alternatives

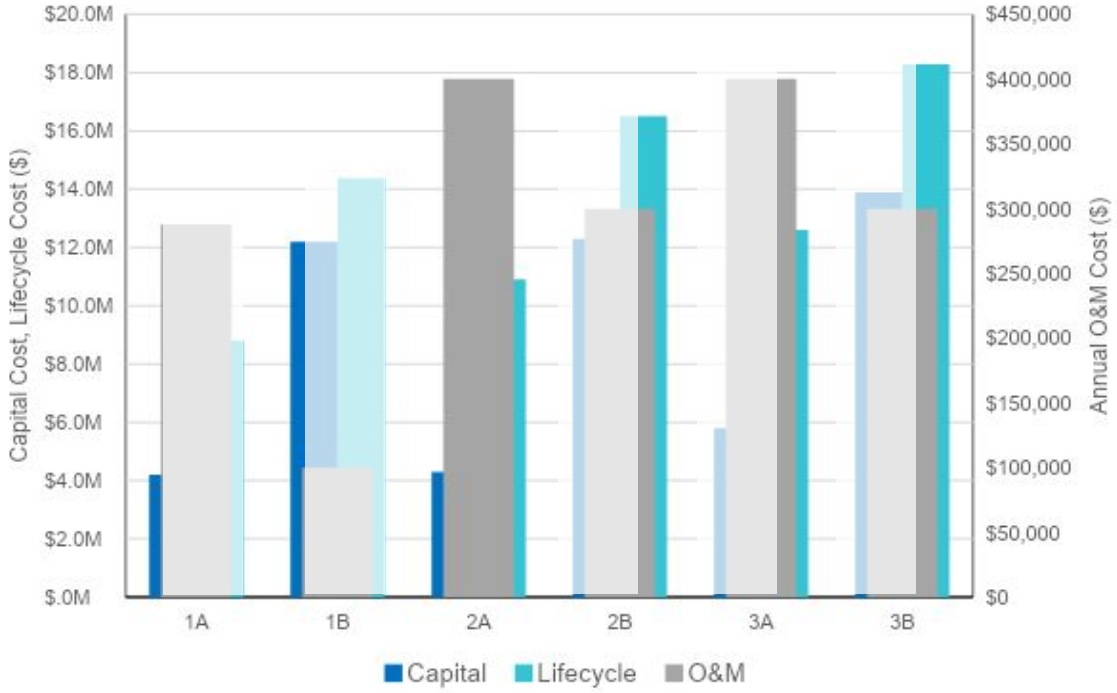
- Applying the non-economic scores of the chlorine supply alternatives to the near-term pre-treatment alternatives.

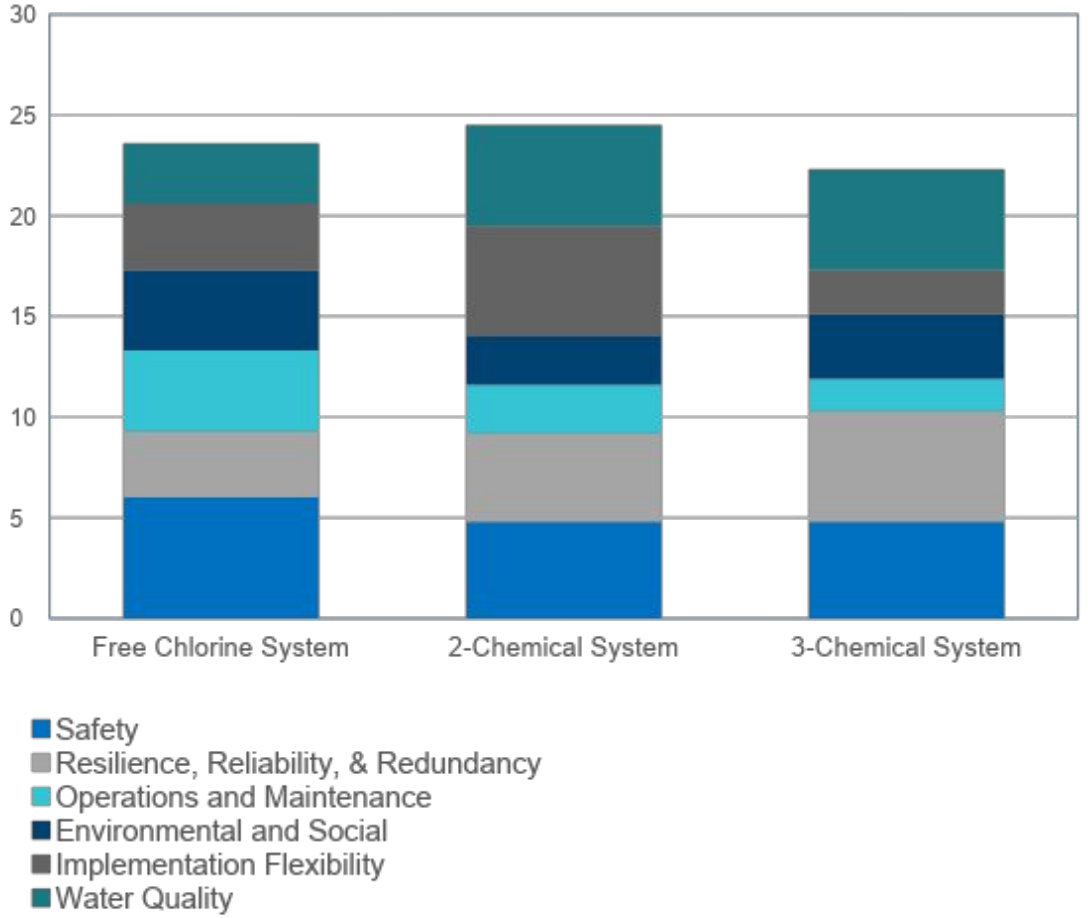




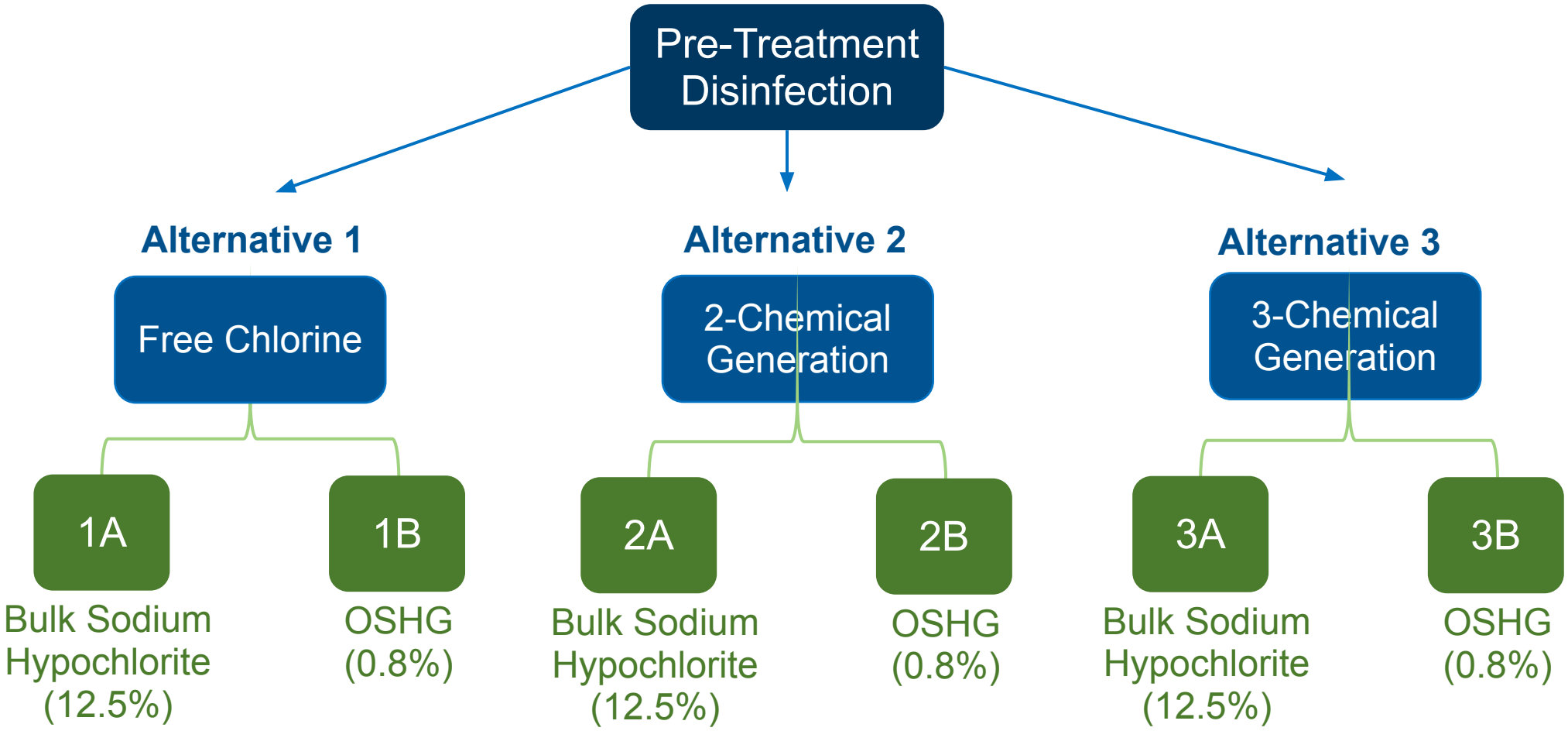
// Near-Term Pre-treatment Disinfection Alternatives

- Applying the non-economic scores of the near-term pre-treatment alternatives.
- Any other factors that should be considered?



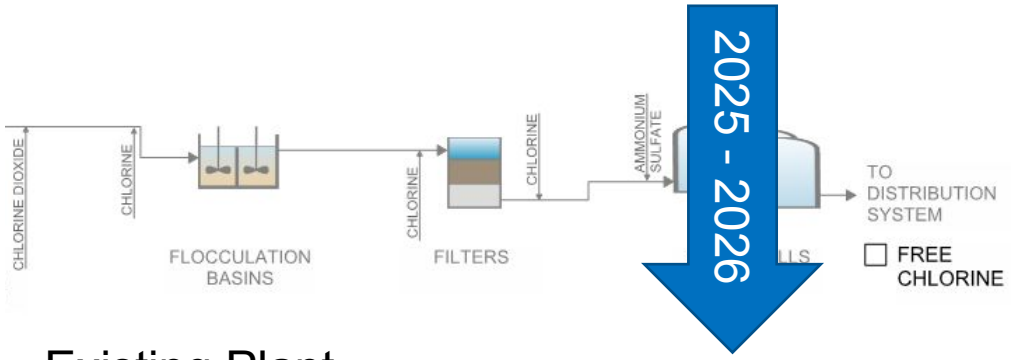


// Alternative Overview



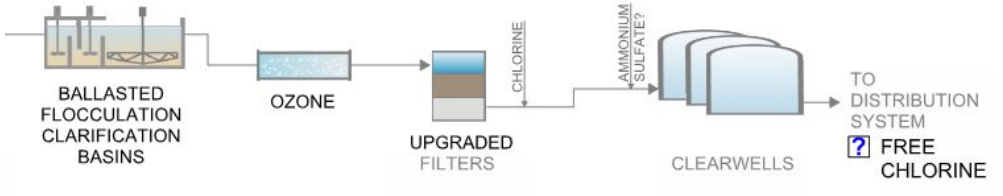
Alternative Selection and Phasing

// Pathways for Implementation



Existing Plant

2-chemical w/ small Cl_2 gas tanks

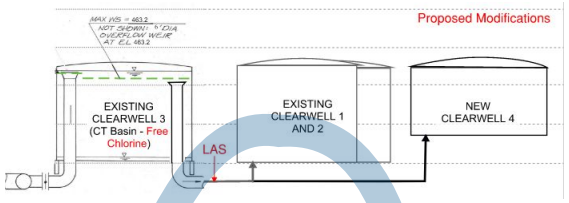


Future Plant

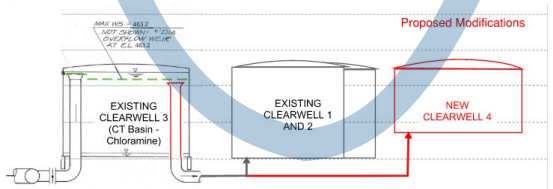
ClO_2 | NH_4Cl | NH_4Cl

ClO_2

Bulk Hypo Facility



Cl_2



Hydraulic Improvements / Clearwell 4

O_3 | Cl_2 | Cl_2 or NH_4Cl

Decision on ozone design type (for power needs)

QUESTIONS