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Submerged Membranes: Then, Now & What's Next

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BUILDING A BETTER WORLD

Acknowledgements

Advantages and Limitations of Submerged Membranes

Advantages

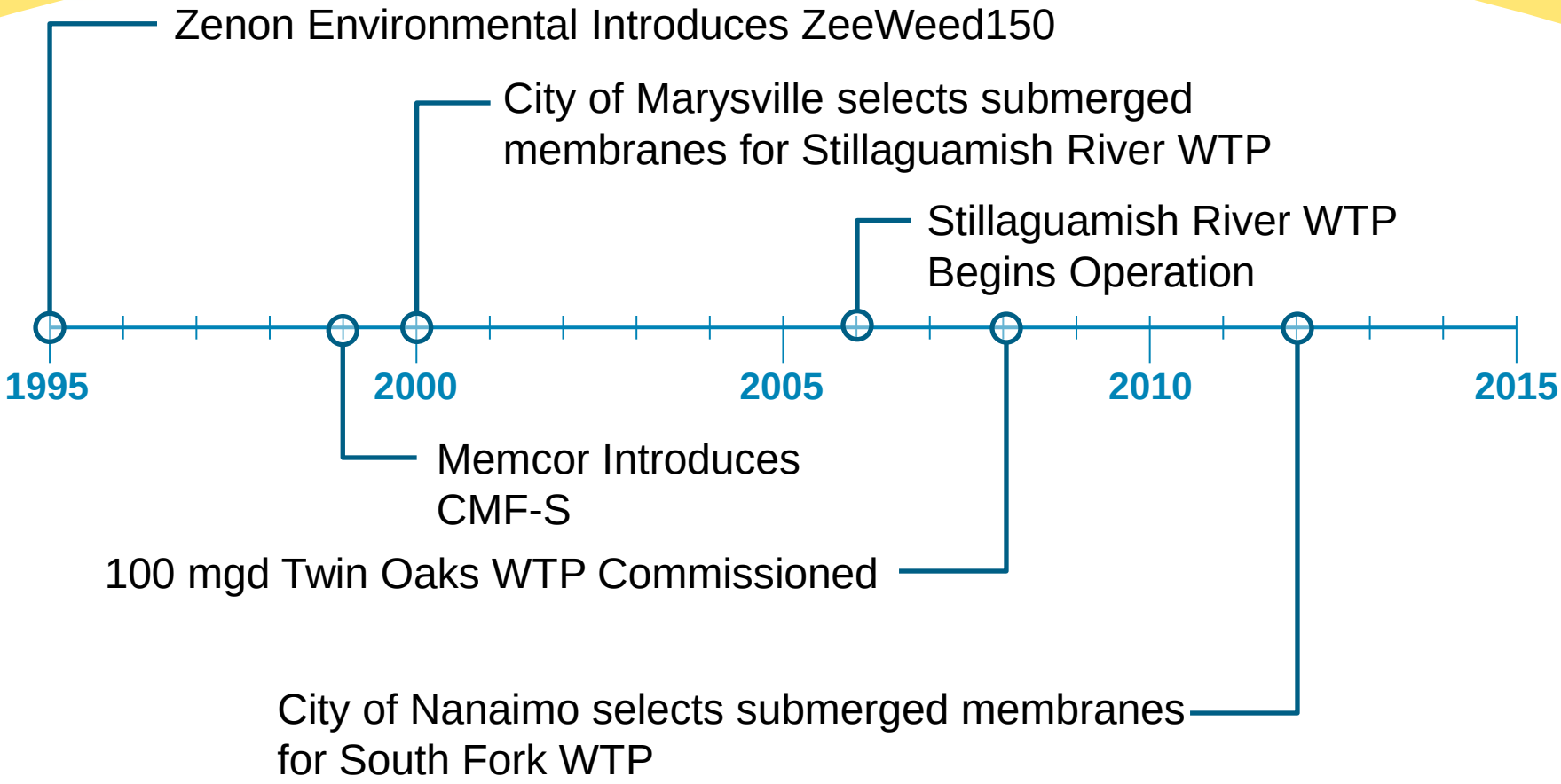
- Absolute barrier to pathogens
- Ease of operation
- Ability to use membrane tank for coagulation and flocculation of solids
- Small footprint
- Modular design

Limitations

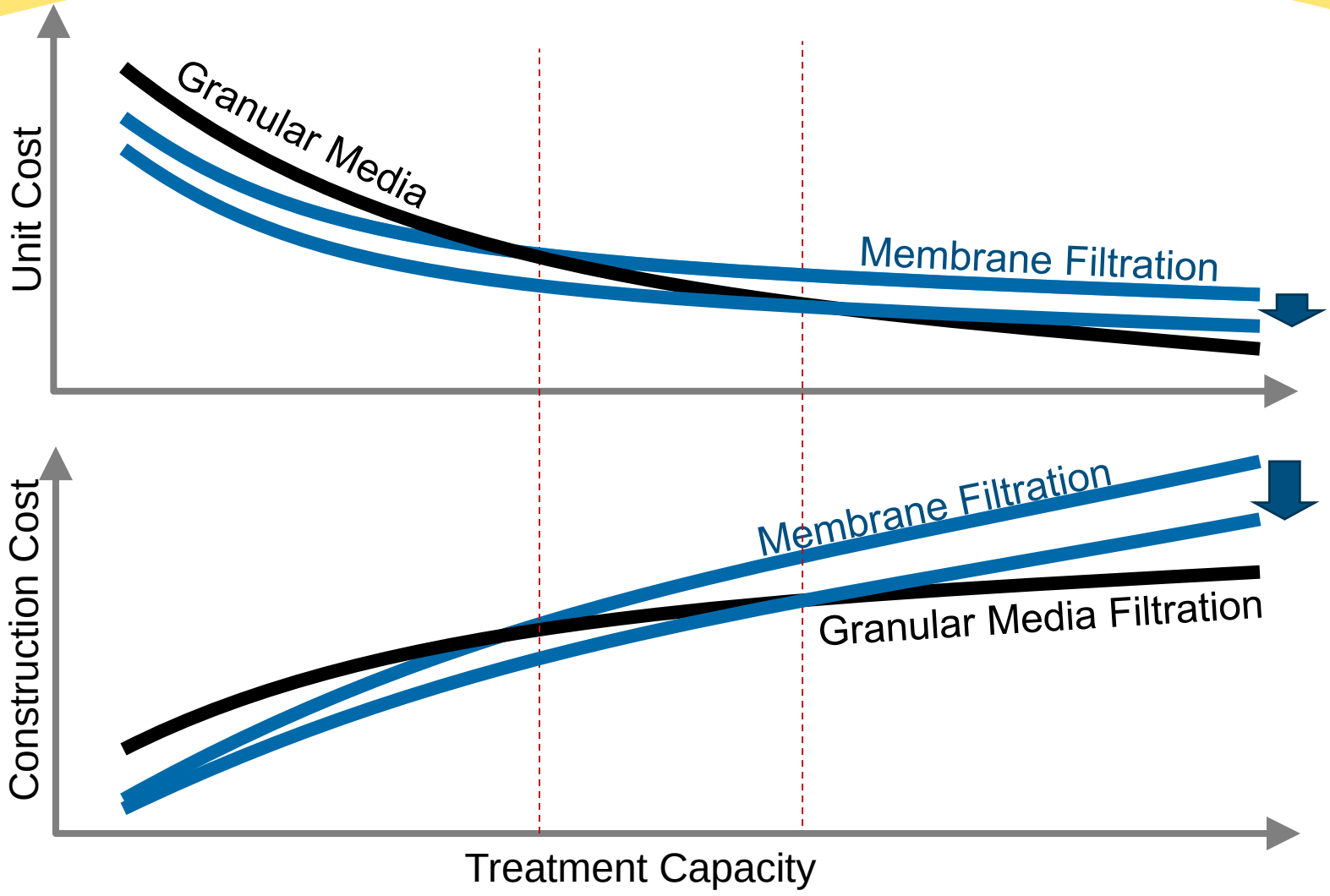
- Susceptible to physical and chemical damage
- Modular design

ZeeWeed 1000 Ultrafiltration Membrane

Timeline of Submerged Membranes for Drinking Water Treatment

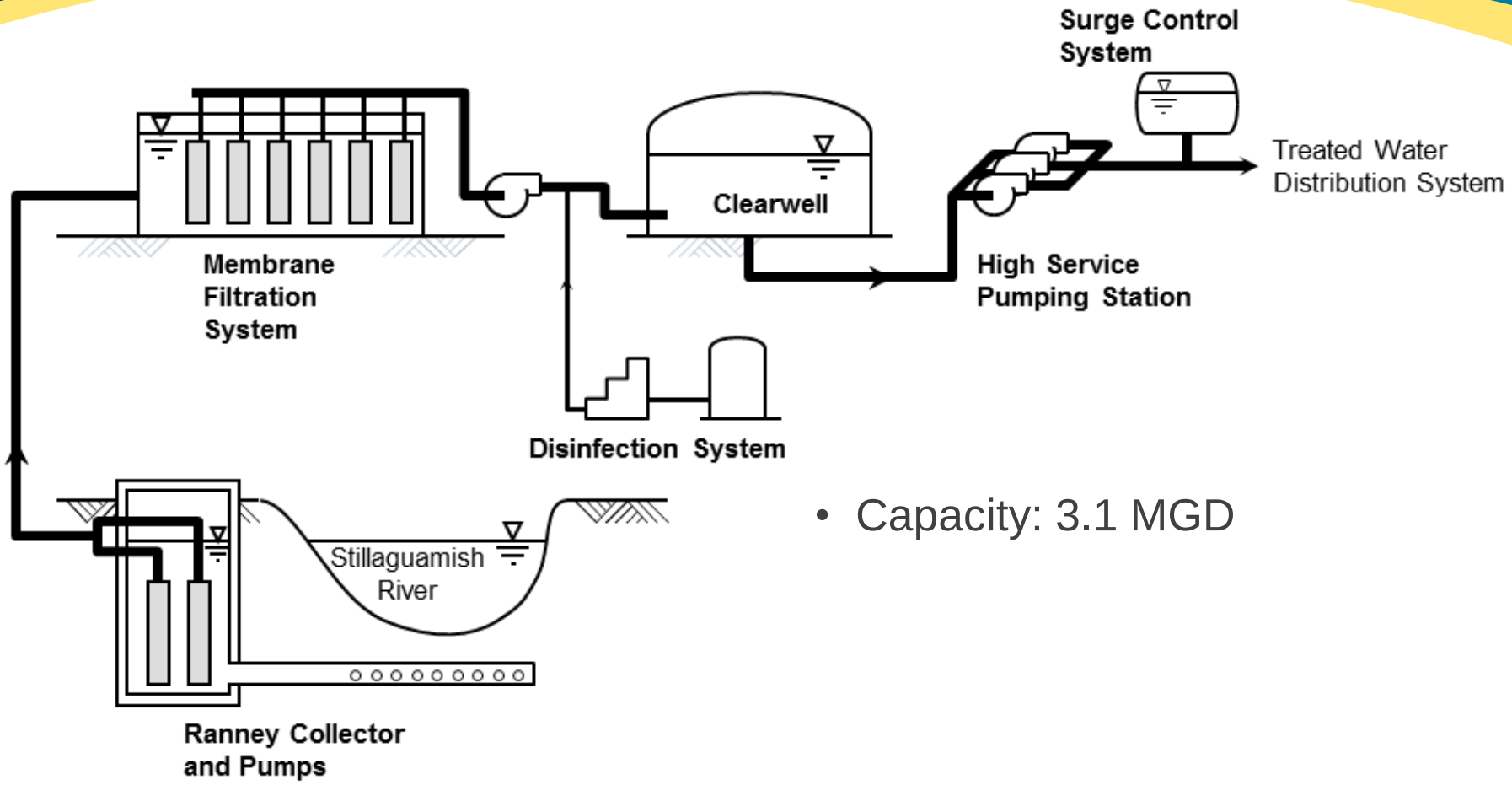


Relative Construction Cost of Membrane and Granular Media Filtration Varies with Capacity



Then

City of Marysville's
Stillaguamish River WTP



- Capacity: 3.1 MGD

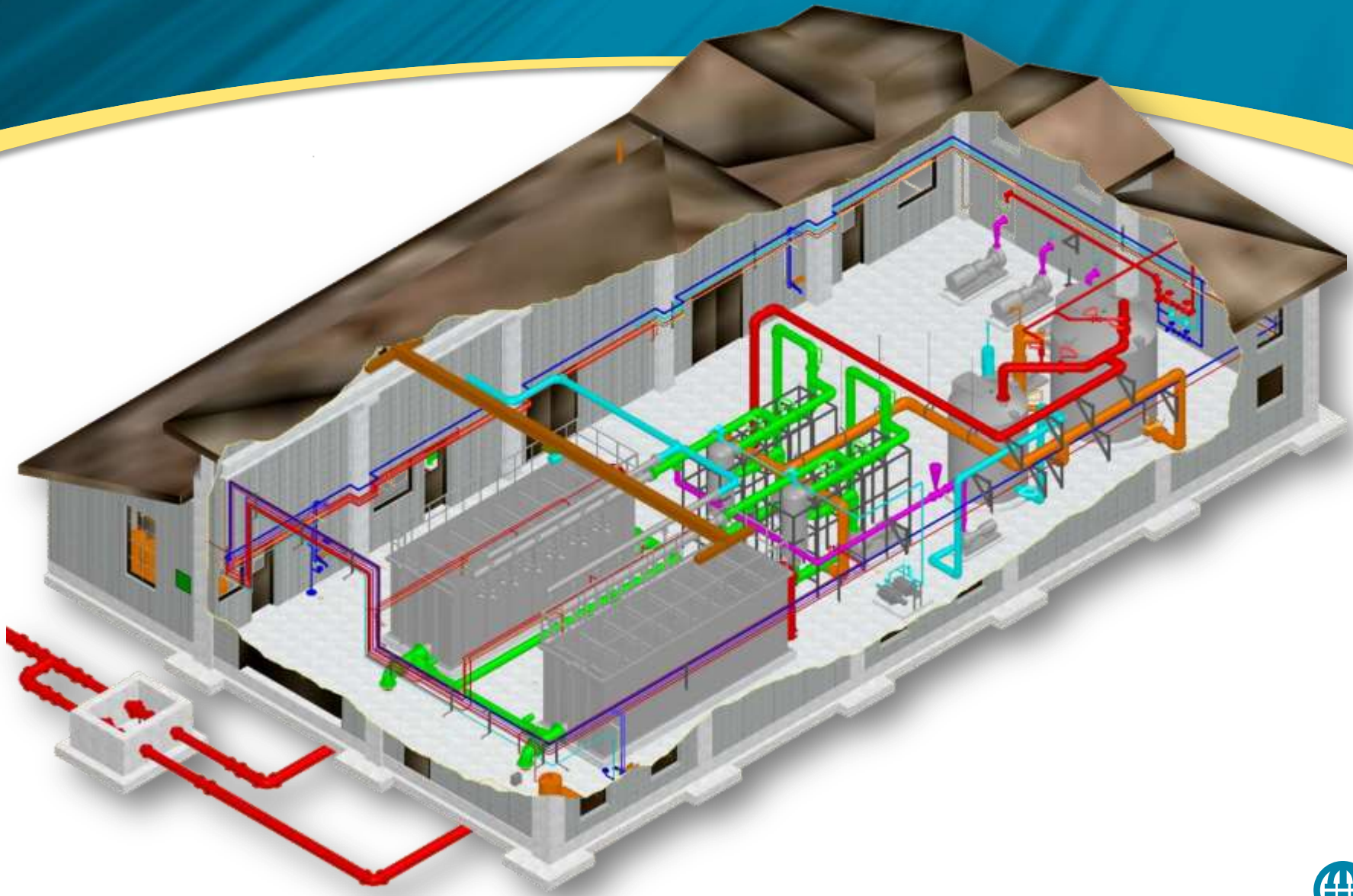
Stillaguamish River WTP Design Criteria

Design Basis`	Criteria	
Trains (No.)	2	
Membrane Model	ZeeWeed 500	
Cassettes per Train (No.)	6	
Modules per Cassette (No.)	26	
Membrane Area per Module (ft^2)	250	
Membrane Area per Train (ft^2)	39,000	
Raw Water Flow (MGD)	3.24	
Treated Water Flow at Maximum Recovery (MGD)	3.14	
Maximum Operating TMP (psig)	-12	
Design Flux ($gal/ft^2/day$)	>37.7	
Wastewater Discharge	Sanitary Sewer	

South Fork WTP Design Criteria

Design Basis`	Primary Membrane	Secondary Membrane
Trains (No.)	8	4
Membrane Model	ZW1000	ZW500
Cassettes per Train (No.)	5	1
Modules per Cassette (No.)	84	56
Membrane Area per Module (ft^2)	450	420
Membrane Area per Train (ft^2)	189,000	
Raw Water Flow (MGD)	30.9	0.4 - 1.5
Treated Water Flow at Maximum Recovery (MGD)	30.9	0.4
Maximum Operating TMP (psig)		
Design Flux (gal/ft^2/day) @ 20°C	26.2	18.3
Wastewater Discharge	Secondary Membrane	Mechanical Dewatering

Process Room at Stillaguamish River WTP



Seven Years of Operation at the Stillaguamish River Water Treatment Plant

- Plant continues to operate as designed
- No process disruptions
- No fiber breaks
- Near complete flux recovery after cleaning.

Ribbon Cutting

Current Operators

Now

Current Submerged Membrane Market for Drinking Water Treatment

evoQUA WATER TECHNOLOGIES

MEMCOR® CS Submerged Membrane System

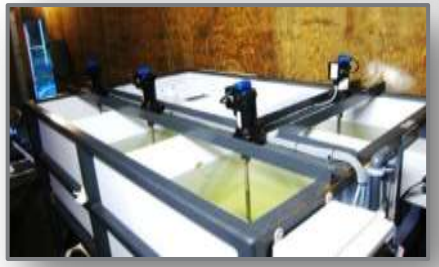
GE Power & Water
Water & Process Technologies

ZeeWeed ® 500 and 1000 Modules

City of Nanaimo

South Fork WTP

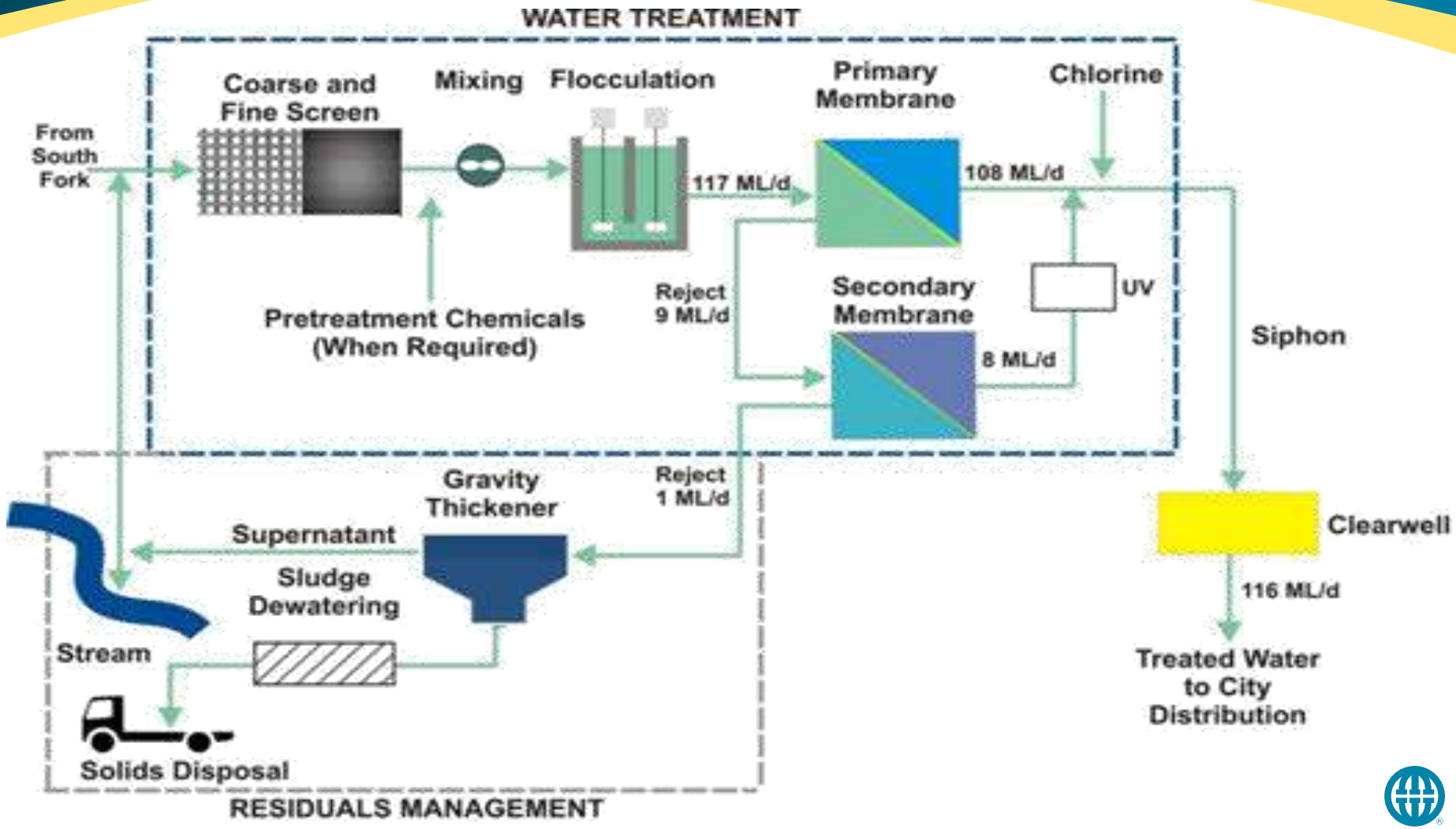
Submerged membranes were the highest-rated and lowest-cost option for the South Fork WTP



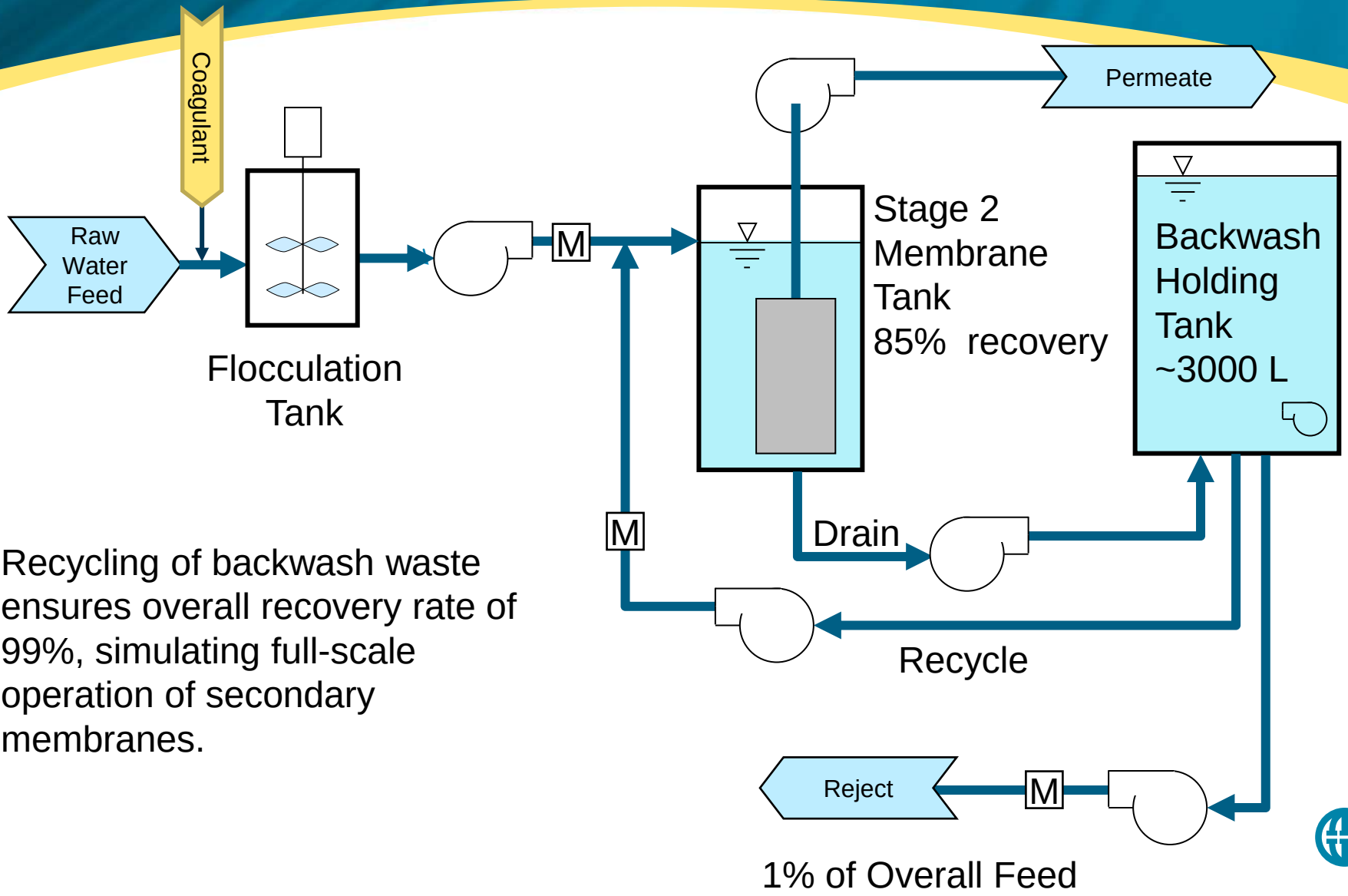
Treatment Option	Captial Cost ($ million)	Life Cycle Cost ($ million)
Direct Filtration	58	94
DAF/Filtration	61	102
Submerged Membranes	58	87

- All options successfully pilot tested
- Submerged membranes preferred
  - Ease of operation
  - Lower chemical use
  - Minimal residuals

South Fork WTP Process



Demonstration Testing
2nd Stage Process Flow Diagram



Recycling of backwash waste ensures overall recovery rate of 99%, simulating full-scale operation of secondary membranes.

Stage 1 Membrane System Design

Parameter	Value	Comments
Stage 1 Permeate Flow	111.3 MLD	
Number of Stage 1 Trains	8	Initially membranes for 7
Stage 1 Recovery	97%	
Stage 1 Design Flux	44 lmh @ 20degC 29 lmh @ 3degC	28 gfd; Two trains out of service 18 gfd; Two trains out of service
Permeate Driving Force	Siphon	
Installed membranes per train	5 cassettes with 84 modules each	ZW1000 V4. Spare spaces for 12 more modules.
Backwash period	49 to 77 minutes	
Maintenance Clean Period	2 to 14 days	Hypochlorite cleans and HCl cleans
Recovery Clean Period	30 to 60 days	Hypochlorite cleans and Citric/HCl cleans

Stage 2 Membrane System Design

Parameter	Value	Comments
Stage 2 Permeate Flow	4.78 MLD	
Number of Stage 2 Trains	4	Initially membranes for 4.
Stage 2 Recovery	85%	
Stage 2 Design Flux	31 lmh @ 20degC 20 lmh @ 3degC	19 gfd; One train out of service 13 gfd; One train out of service
TMP Range	17 to 76 kPa	
Permeate Driving Force	Siphon	Primary reject pumped
Installed membranes per train	1 cassettes with 54 modules each	Spare spaces for 8 additional modules if needed
Backwash period	52 to 118 minutes	
Maintenance Clean Period	2 to 7 days	Hypochlorite cleans
Recovery Clean Period	30 to 60 days	Hypochlorite cleans and Citric/HCl cleans

SFWTP Cutaway View

SFWTP Construction Photos

What's Next?

Future Membrane Technology and Applications

- Continued refinement of existing submerged membrane designs
- Replacement of original membrane cartridges
- New membrane materials
  - Ceramic
  - Carbon nanotubes
- Biological treatment of drinking water

Biological Treatment of Drinking Water with Submerged Membranes

- Granular media provides a substrate for growth of microbes
  - Potential issues with binding and sloughing
  - Substrate-enhanced biofiltration shows promise for removal of a range of pharmaceuticals and pesticides
- Submerged membranes commonly used for MBRs, but maintenance of a mixed liquor is not appropriate for drinking water treatment.
- New technologies fix microbes onto a biocatalyst, configured specifically for the contaminants of concern.

Questions?

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