Affordable Desalination Collaboration – Phase II Progress

Steve Dundorf

RECLAMATION

Managing Water in the West

Affordable Desalination Collaboration – Phase II Progress

Steve Dundorf **(Denver Technical Service Center)**

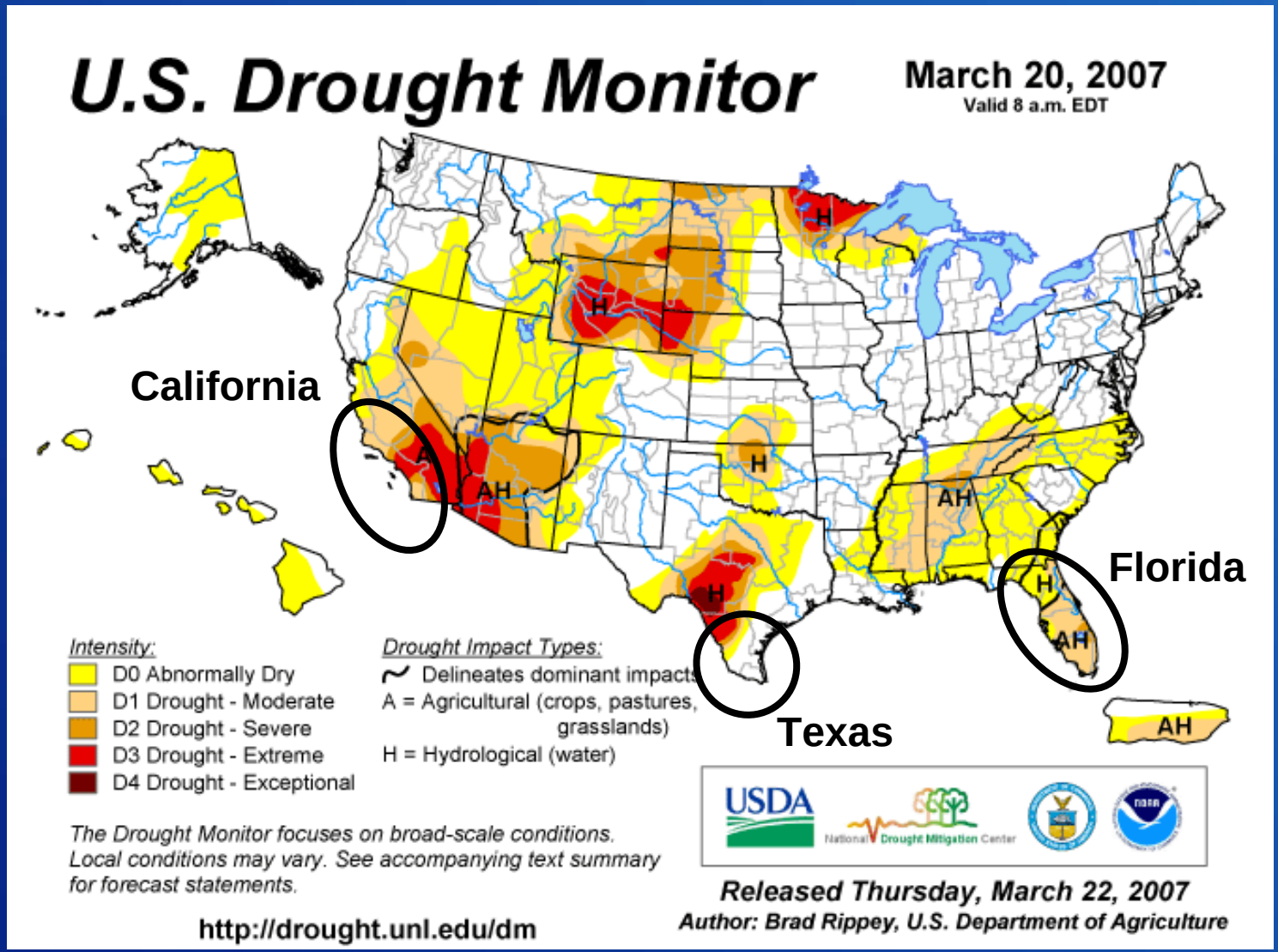
Tom Seacord, John MacHarg

U.S. Department of the Interior
Bureau of Reclamation

Outline

- Background
- Treatment System Description
- Data
- Next Steps

Desalination in the U.S.



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Goals of the ADC

- Demonstrate affordable desalination using off-the-shelf technology
  - 5.6-7.6 kWh/kgal
  - 1.5-2.0 kWh/m3
  - 1850-2467 kWh/acre-ft
- Create a body of data that can guide & benefit future SWRO designs
- Promote seawater desalination as an affordable, viable source of fresh water

Partners Combining Resources

West Basin
municipal water district

Zenon

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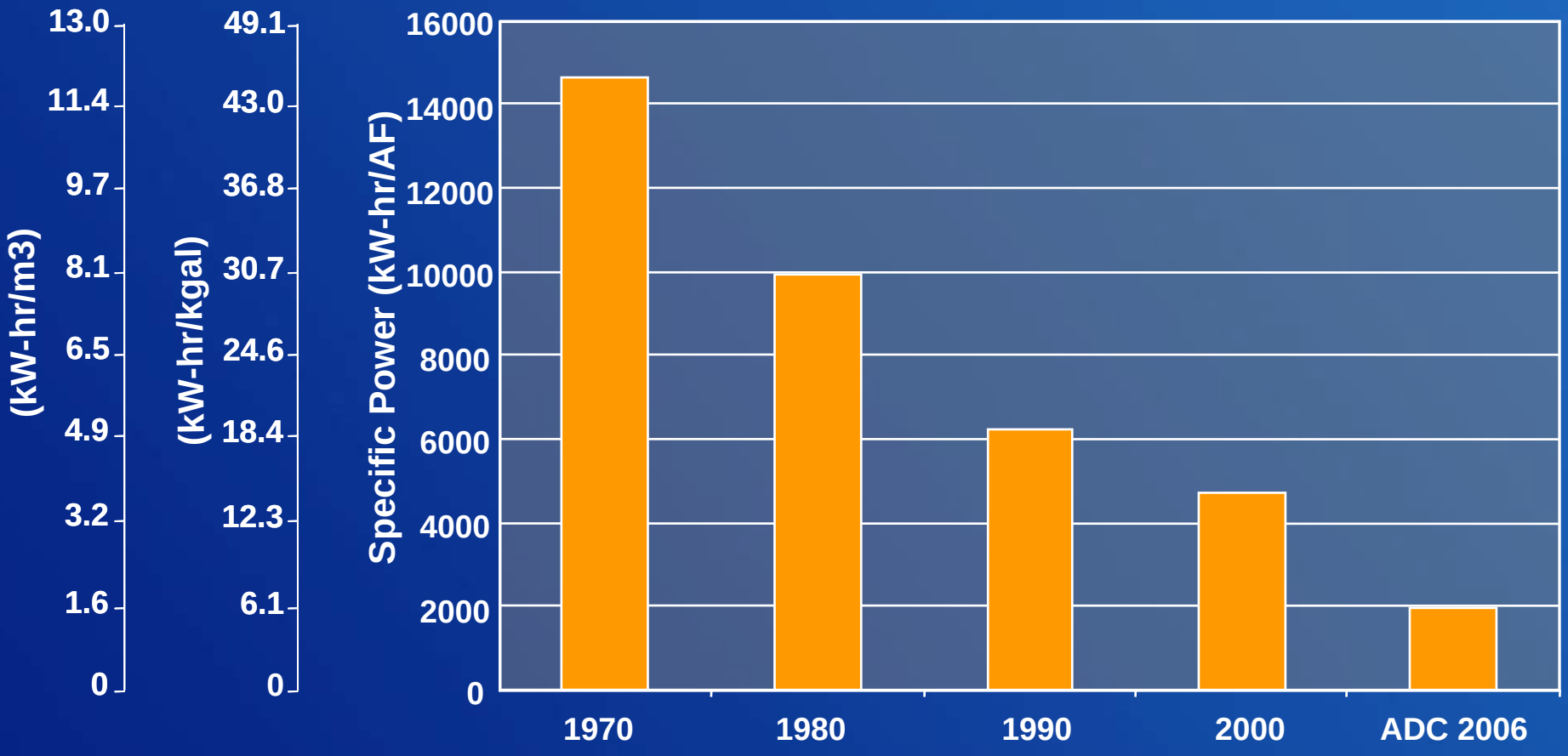
Background

Desalination Energy Requirements



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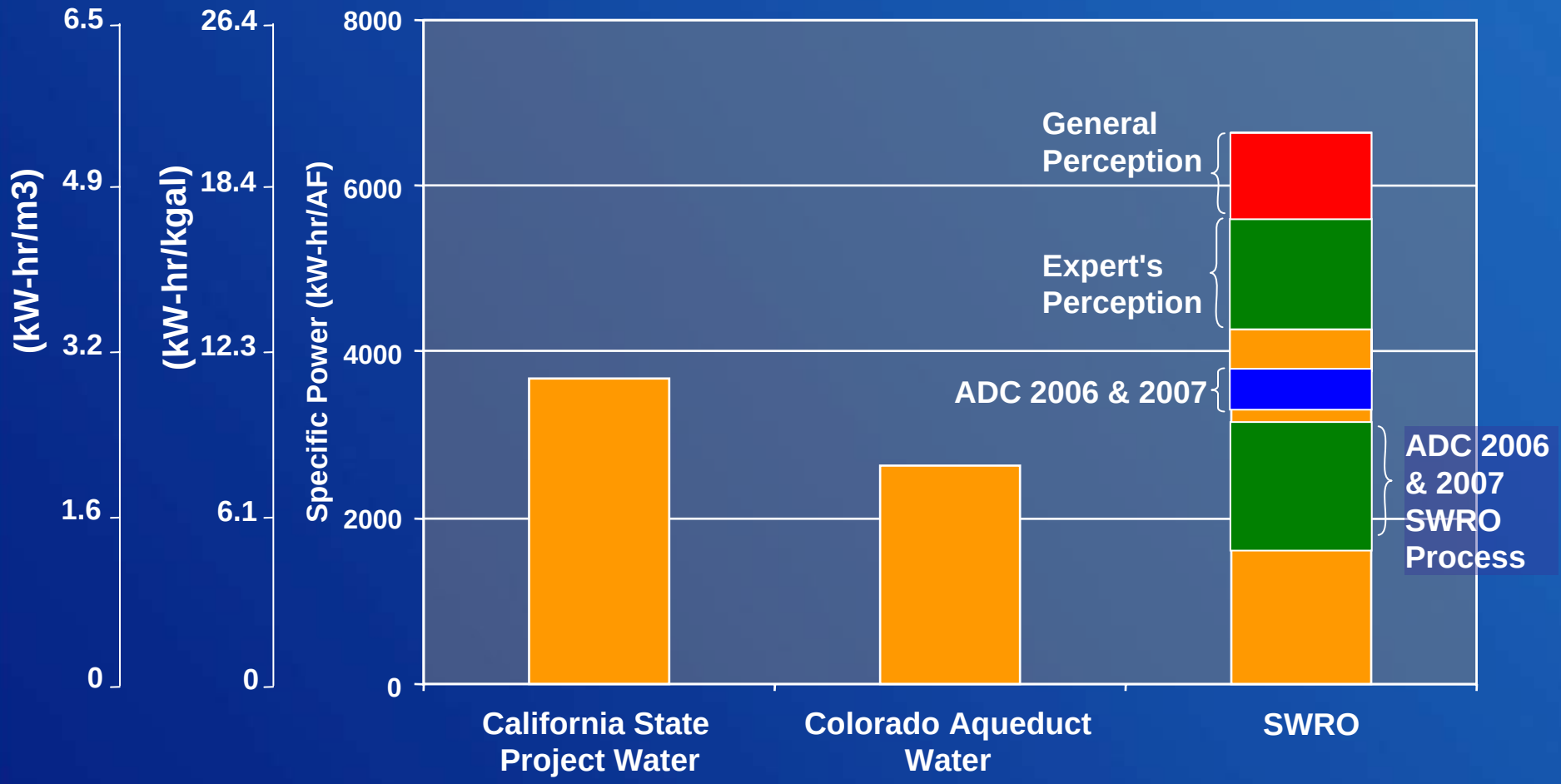
Background



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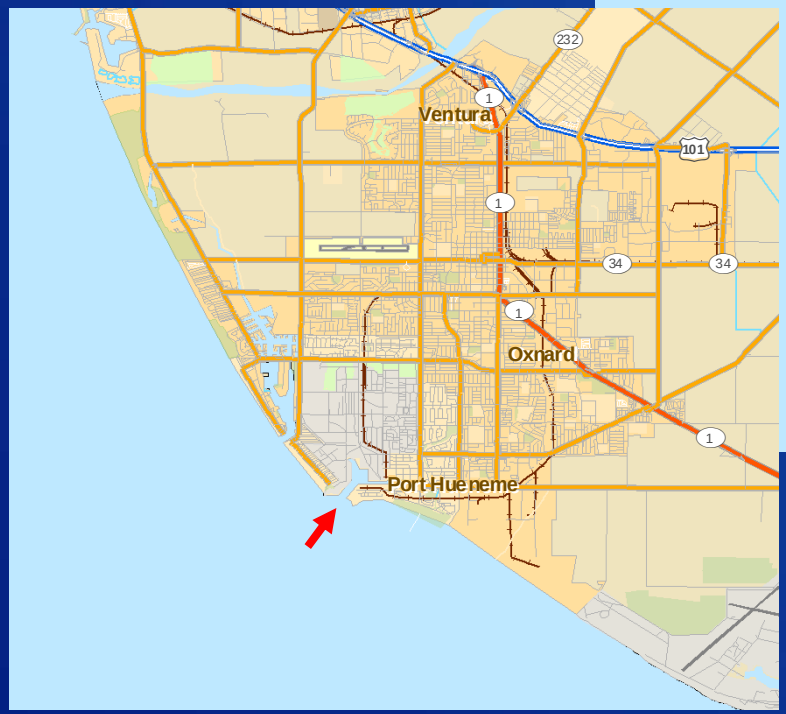
Location

Port Hueneme, CA



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Location

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Location

U.S. Navy – Seawater Desalination Test Facility

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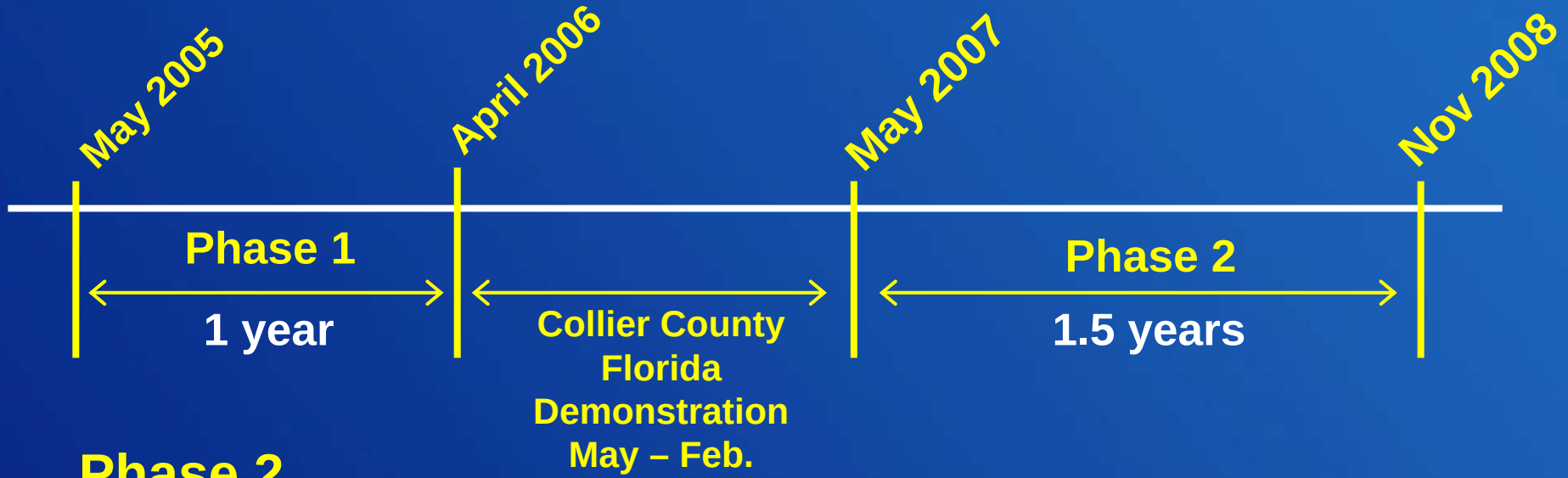
Testing

Phase 1

- Construction of pilot system
- Red Tide Event
- Trouble shooting of media filter pre-treatment system
- Testing of 3 different membranes from 1 Manufacturer
- Cost analysis of a 50 MGD system for each

Testing



Phase 2

- Identical testing with 3 other manufacturers
- Change to UF pretreatment
- Staged membranes
- Innovative flow schemes
- Cost analysis of a 50 MGD system

Outline

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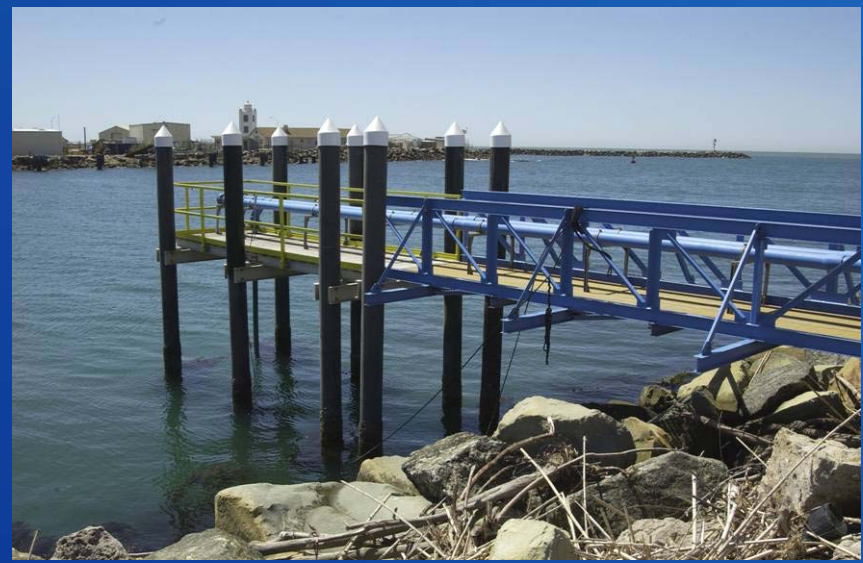

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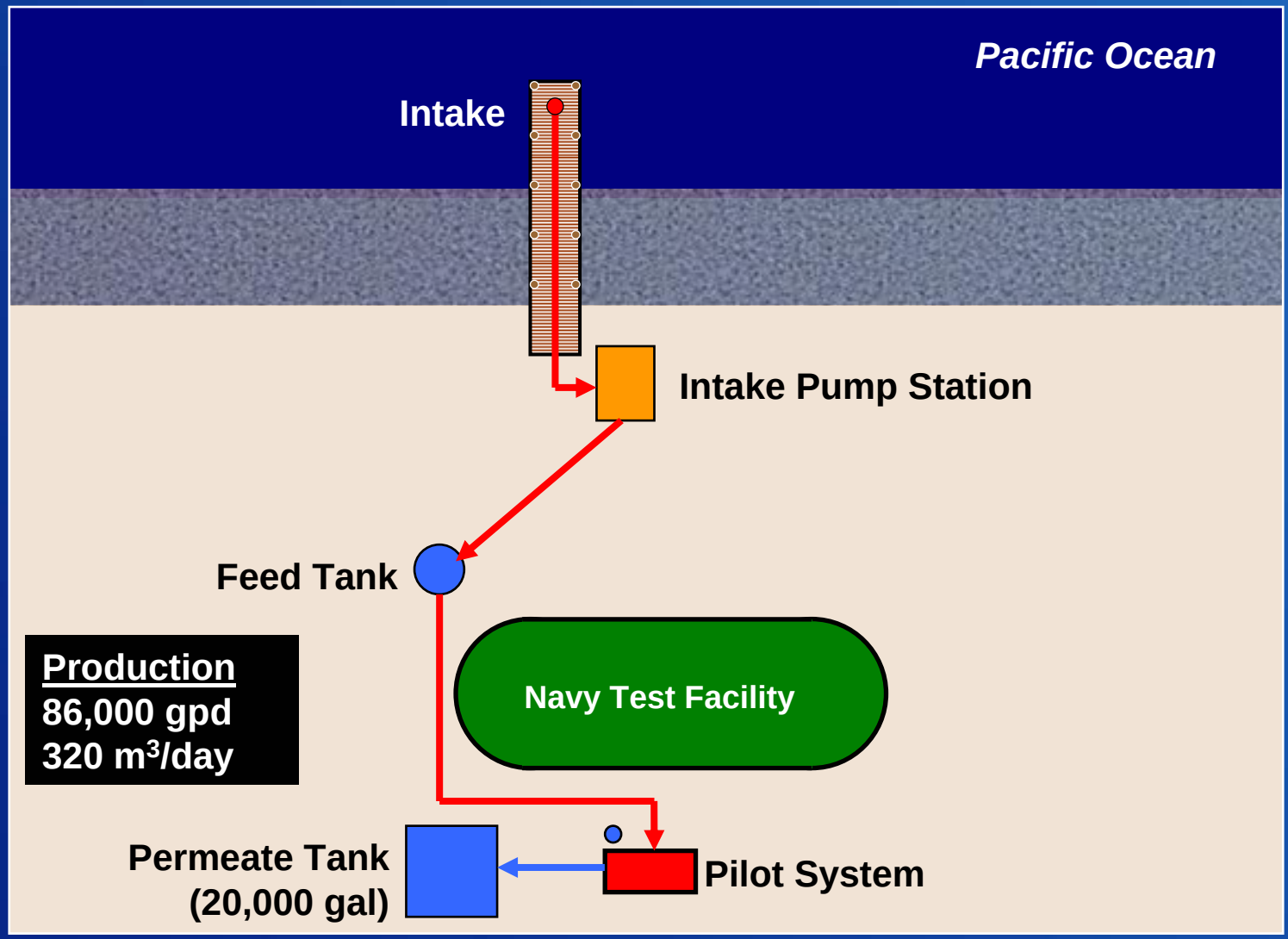
Site Layout



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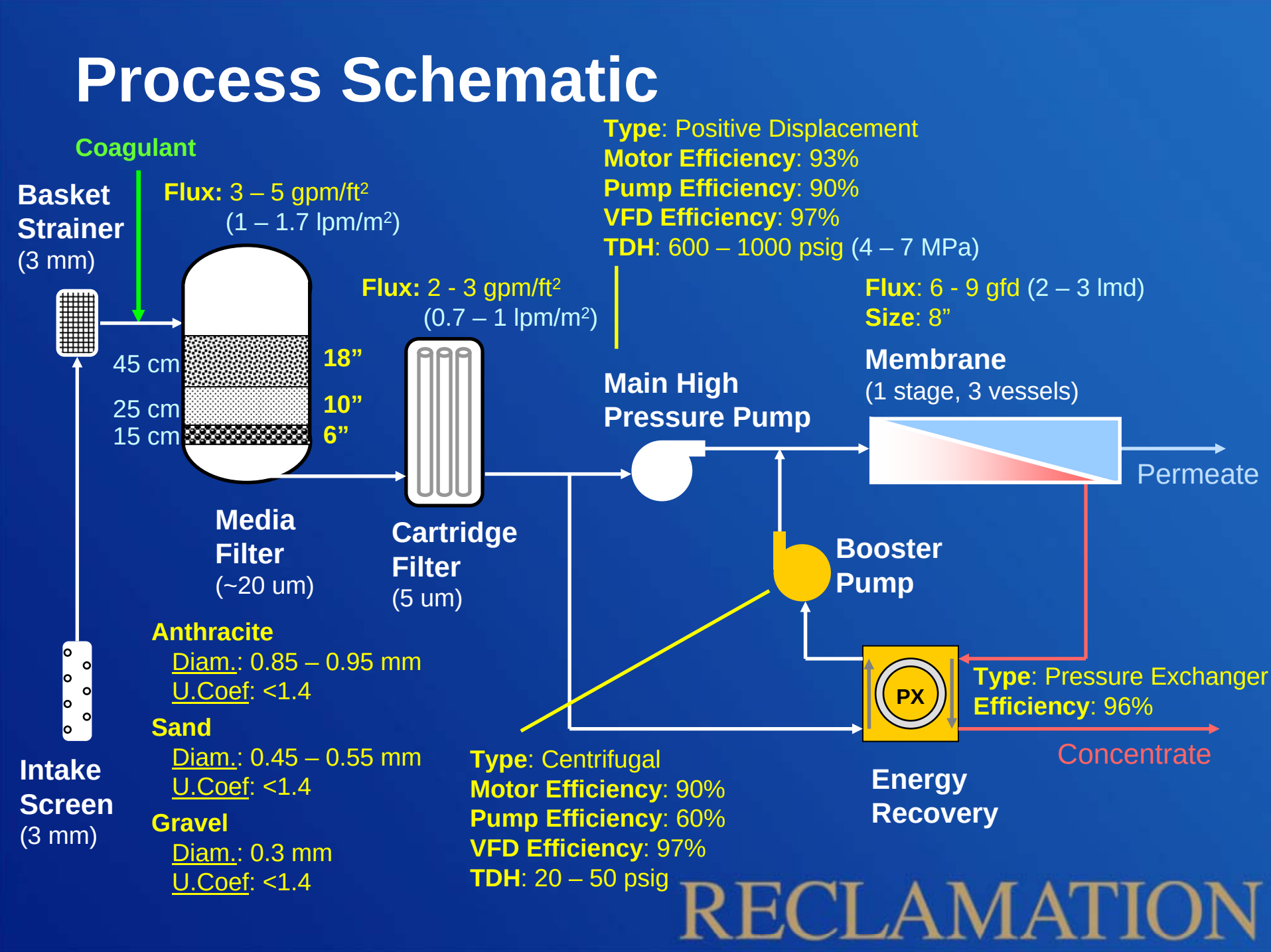
Process Schematic



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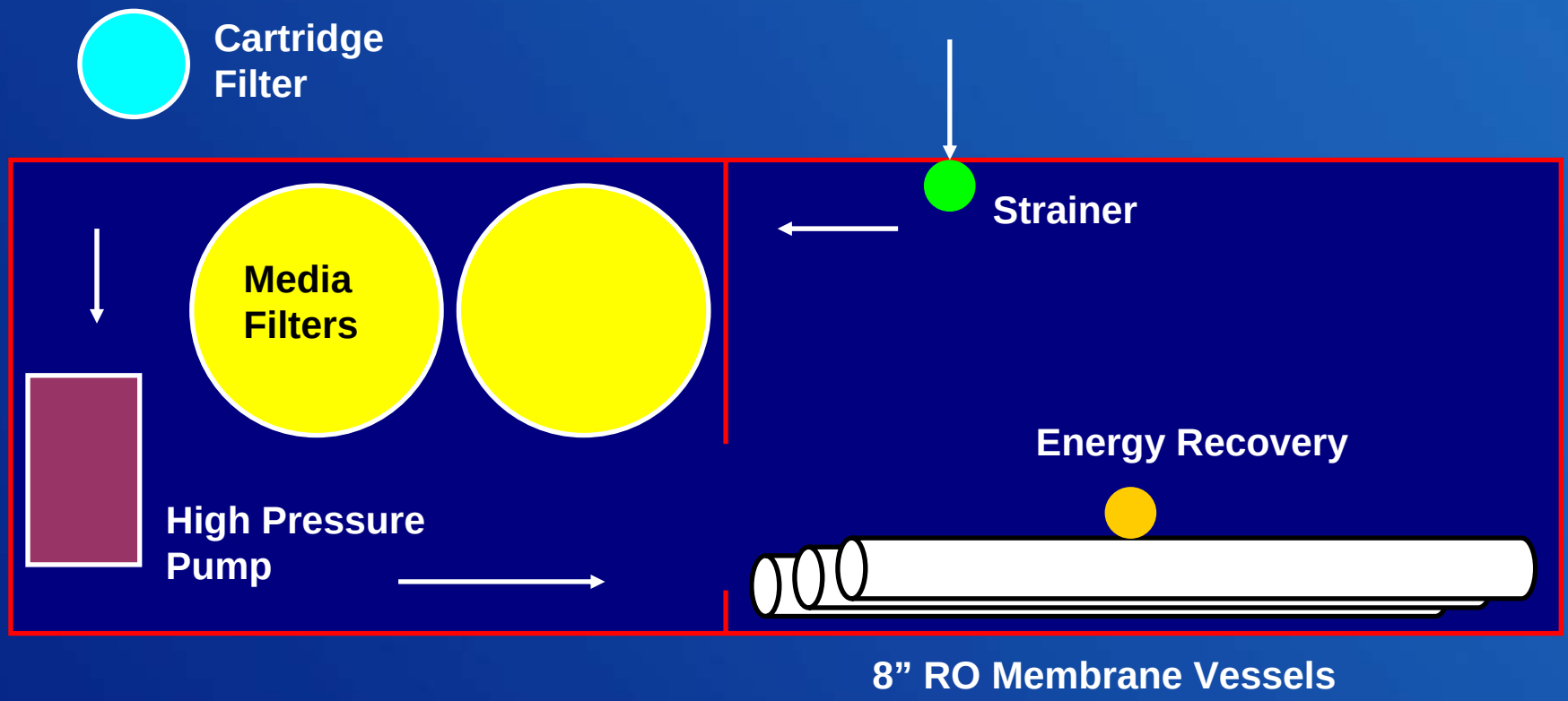
Pilot Layout



Pilot System

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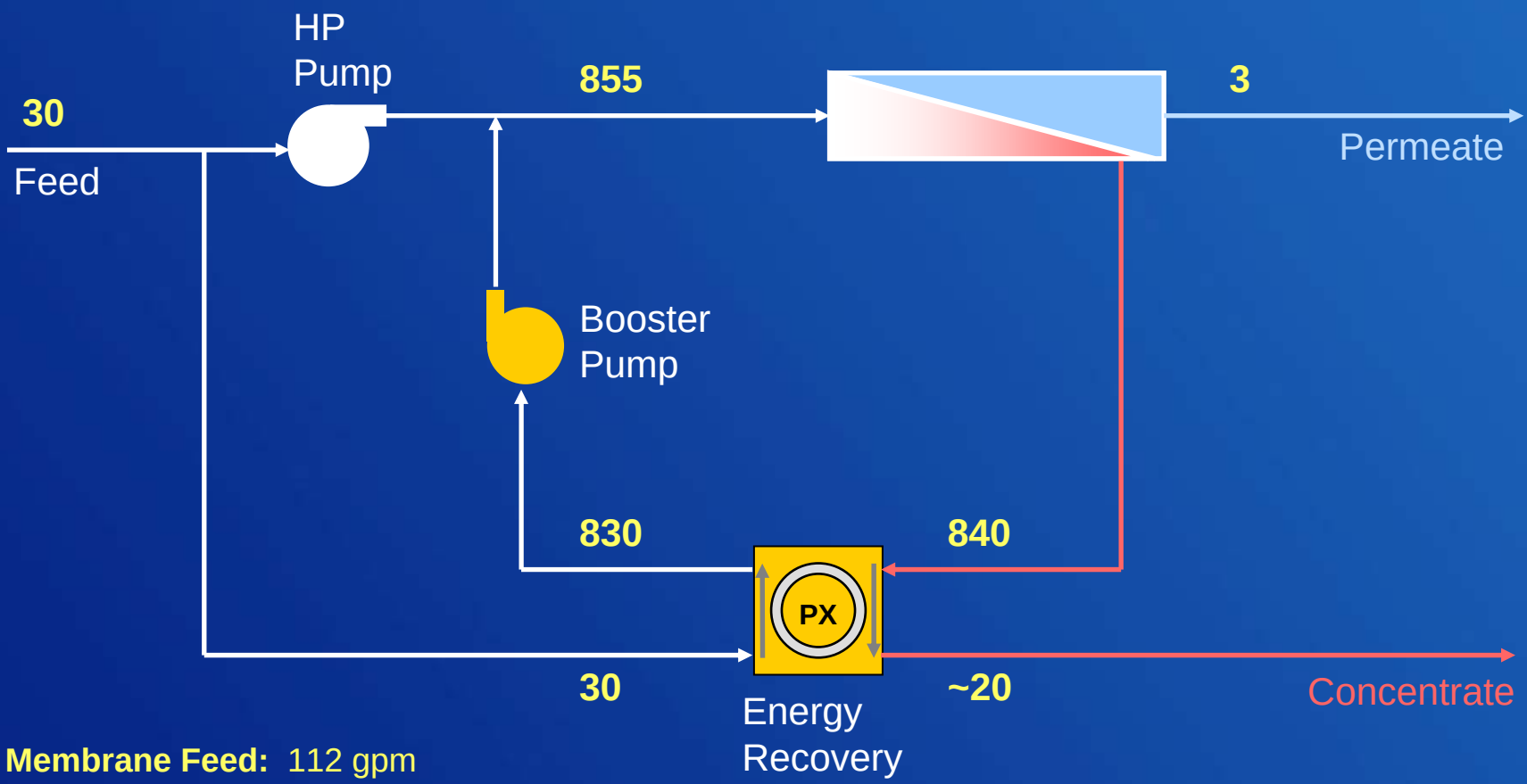
Process Schematic

Pressure (psi)



Membrane Feed: 112 gpm
42.5% Recovery
7.5 gfd
1.93 kWh/m³
Boron: 0.9 mg/L

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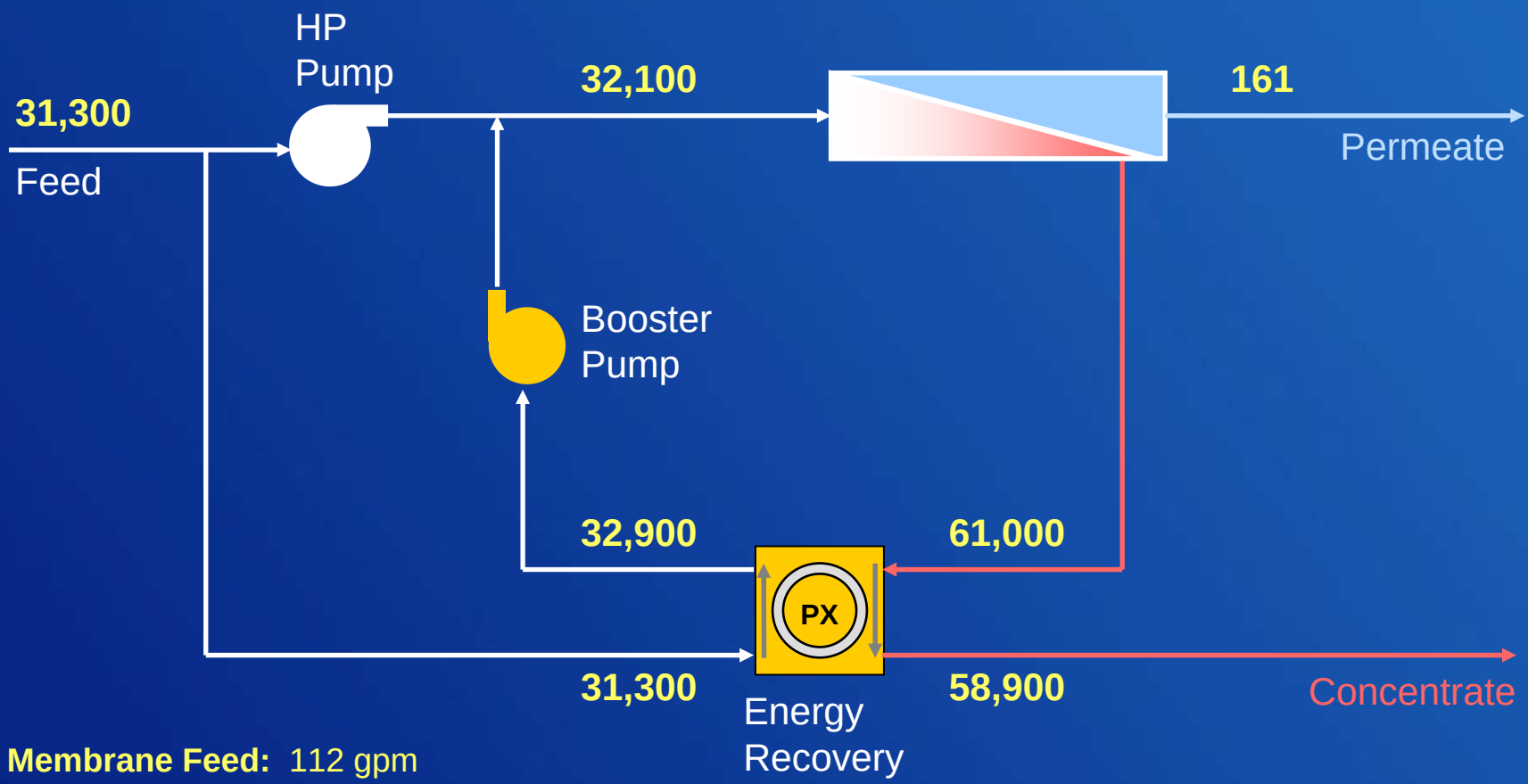
Process Schematic

Total Dissolved Solids (mg/L)



Membrane Feed: 112 gpm
42.5% Recovery
7.5 gfd
1.93 kWh/m³
Boron: 0.9 mg/L

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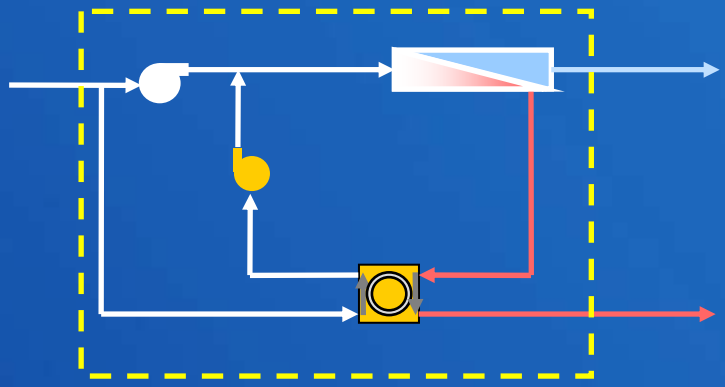
Energy Recording



High Pressure Pump
(Positive Displacement)

Power Monitored Individually

Total Power

Booster Pump
(Centrifugal)

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Outline

- Background
- Treatment System Description
- Data (Preliminary)
- Next Steps

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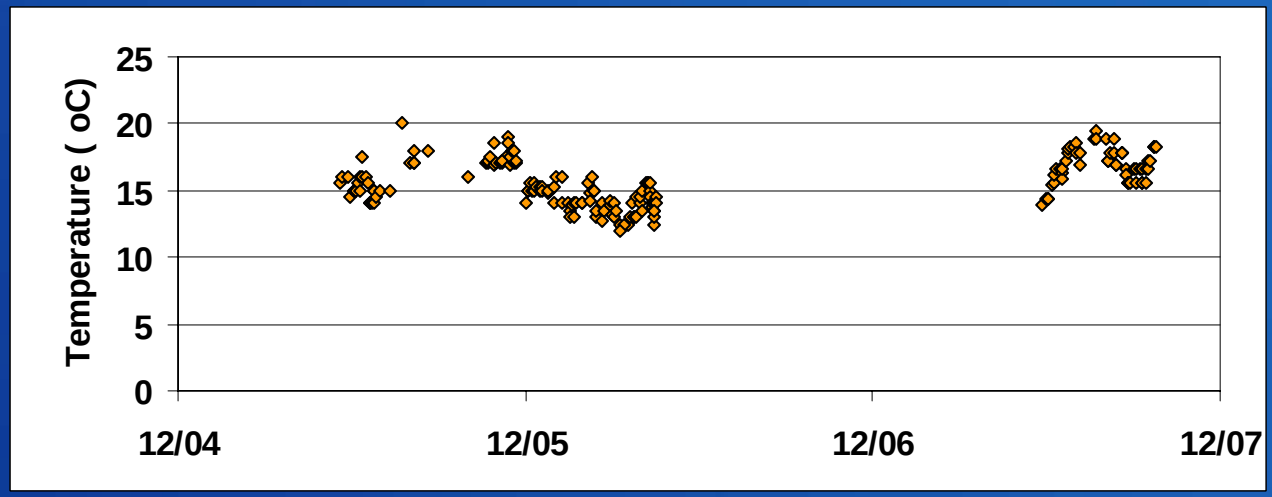
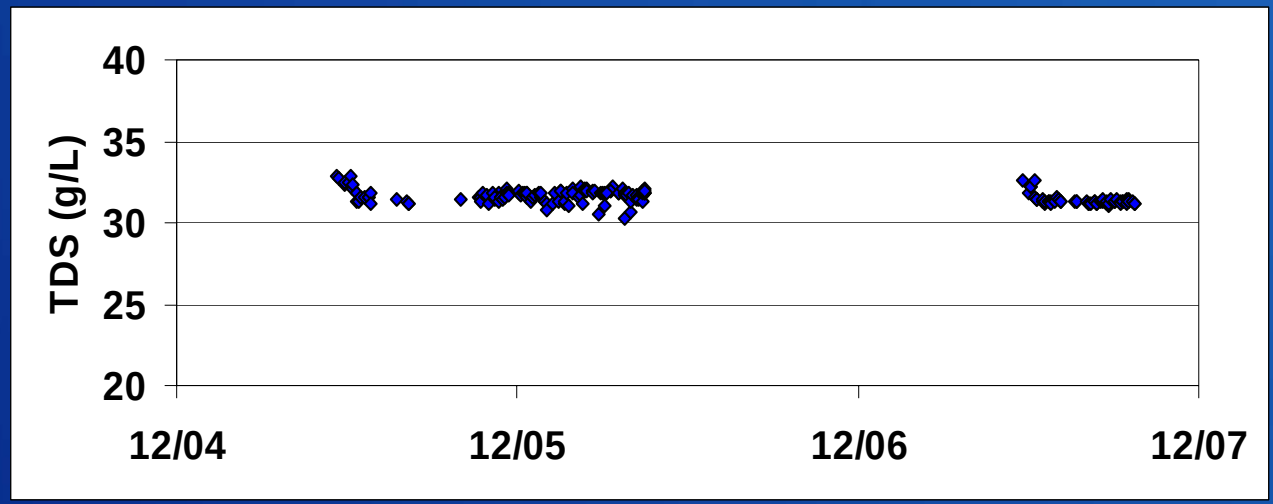
Raw Water Quality

- Temperature:
  12 – 20 ^{o}C



- TDS:
  30,000 – 33,000 mg/L



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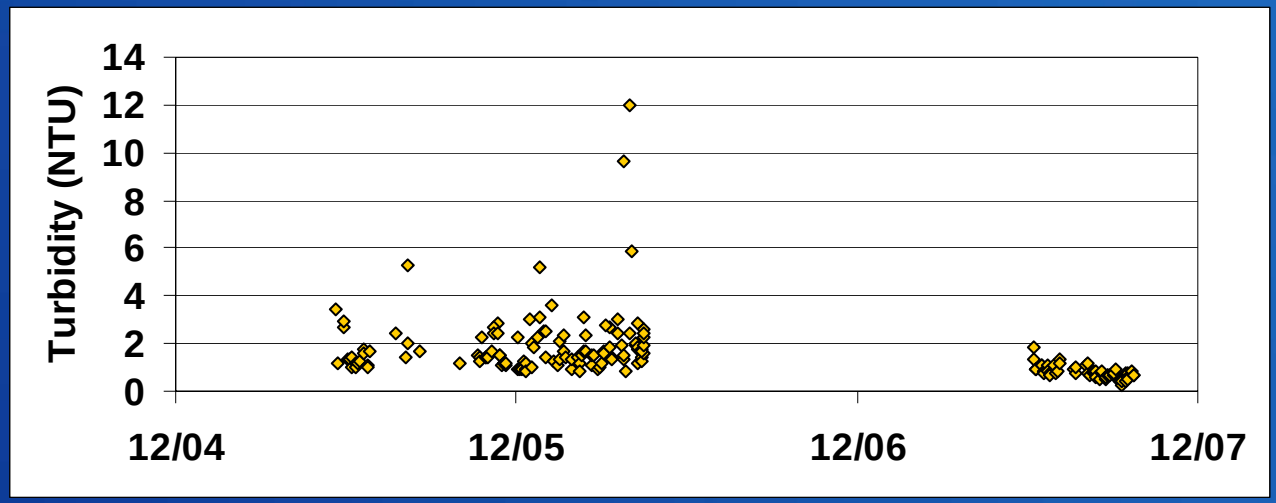
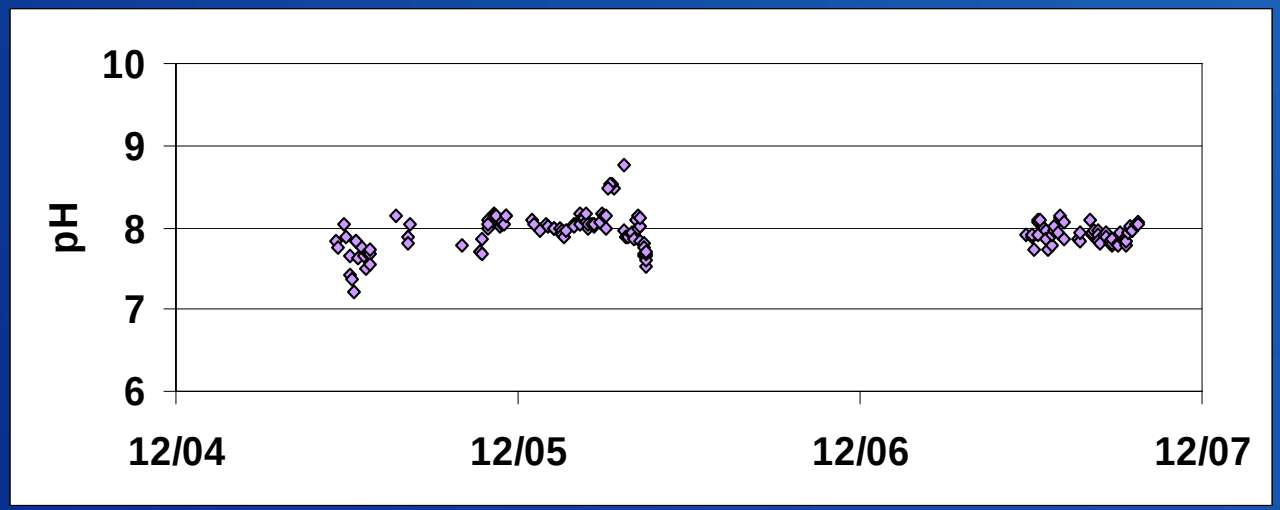
Raw Water Quality

- Turbidity:
  0.3 – 12 NTU



- pH:
  7.2 – 8.8 mg/L



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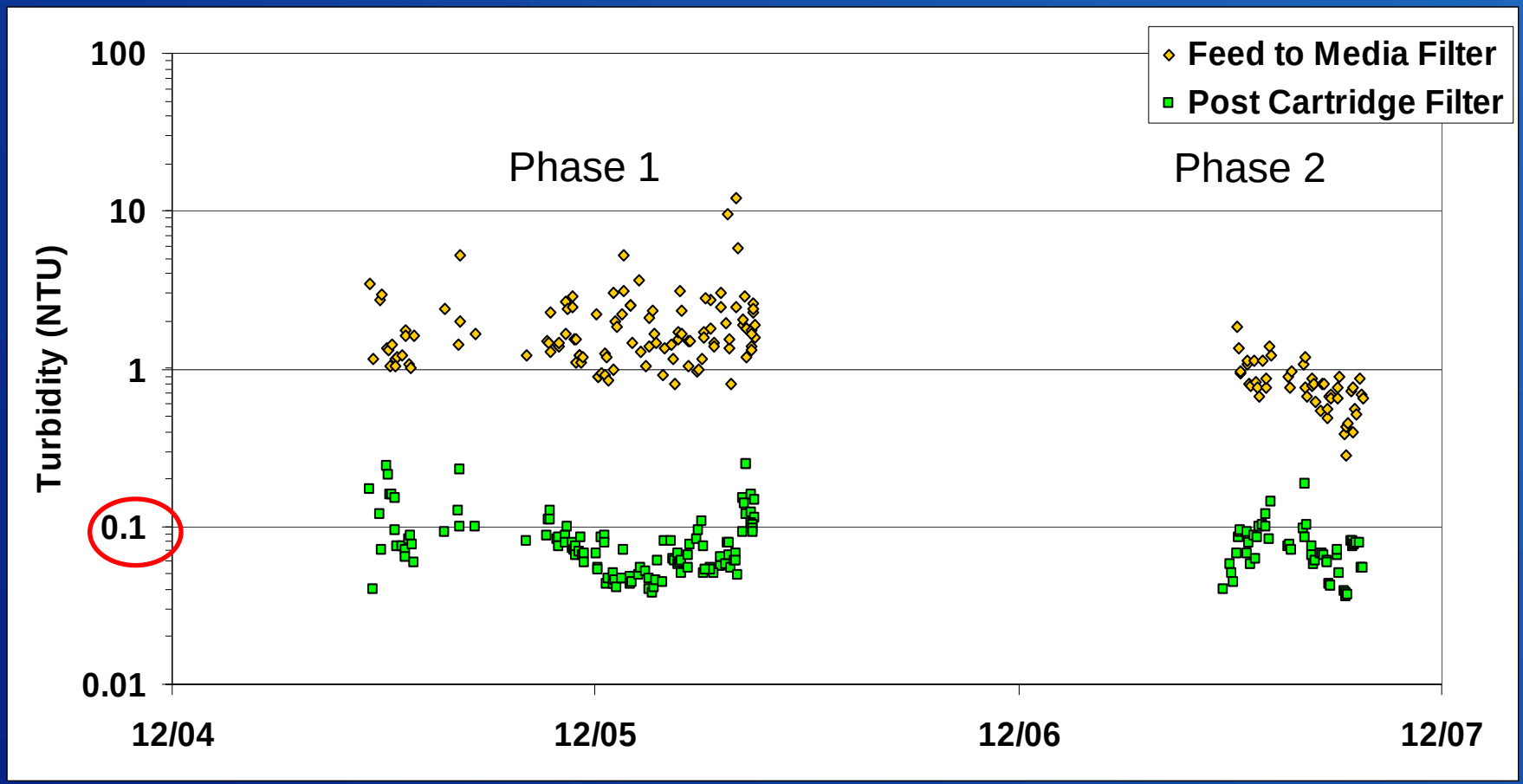
Pretreatment

- Turbidity
  (Goal: < 0.1) Not exceeded 88%



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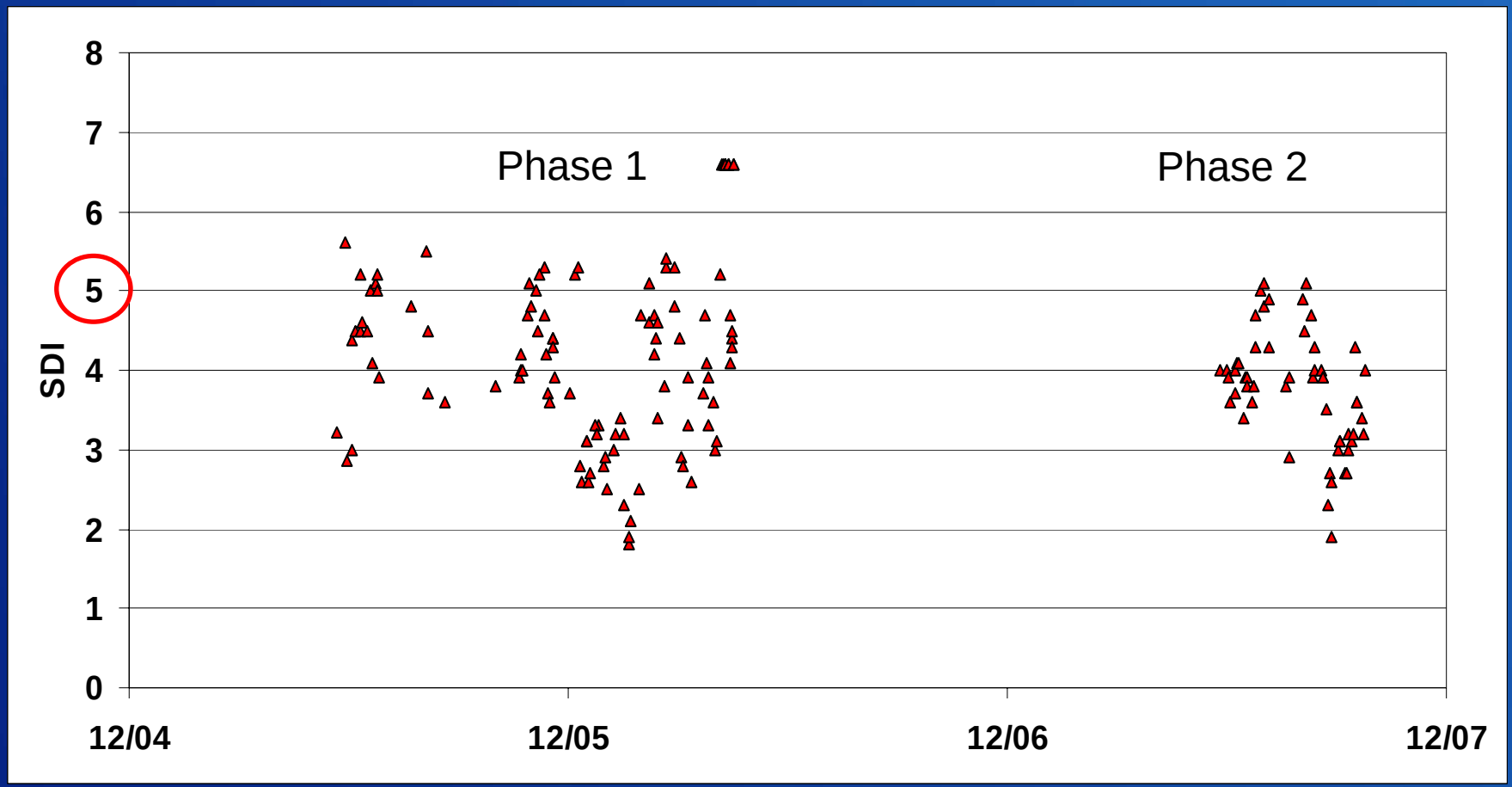
Pretreatment

- SDI

  (Goal: < 5) Not exceeded 86%



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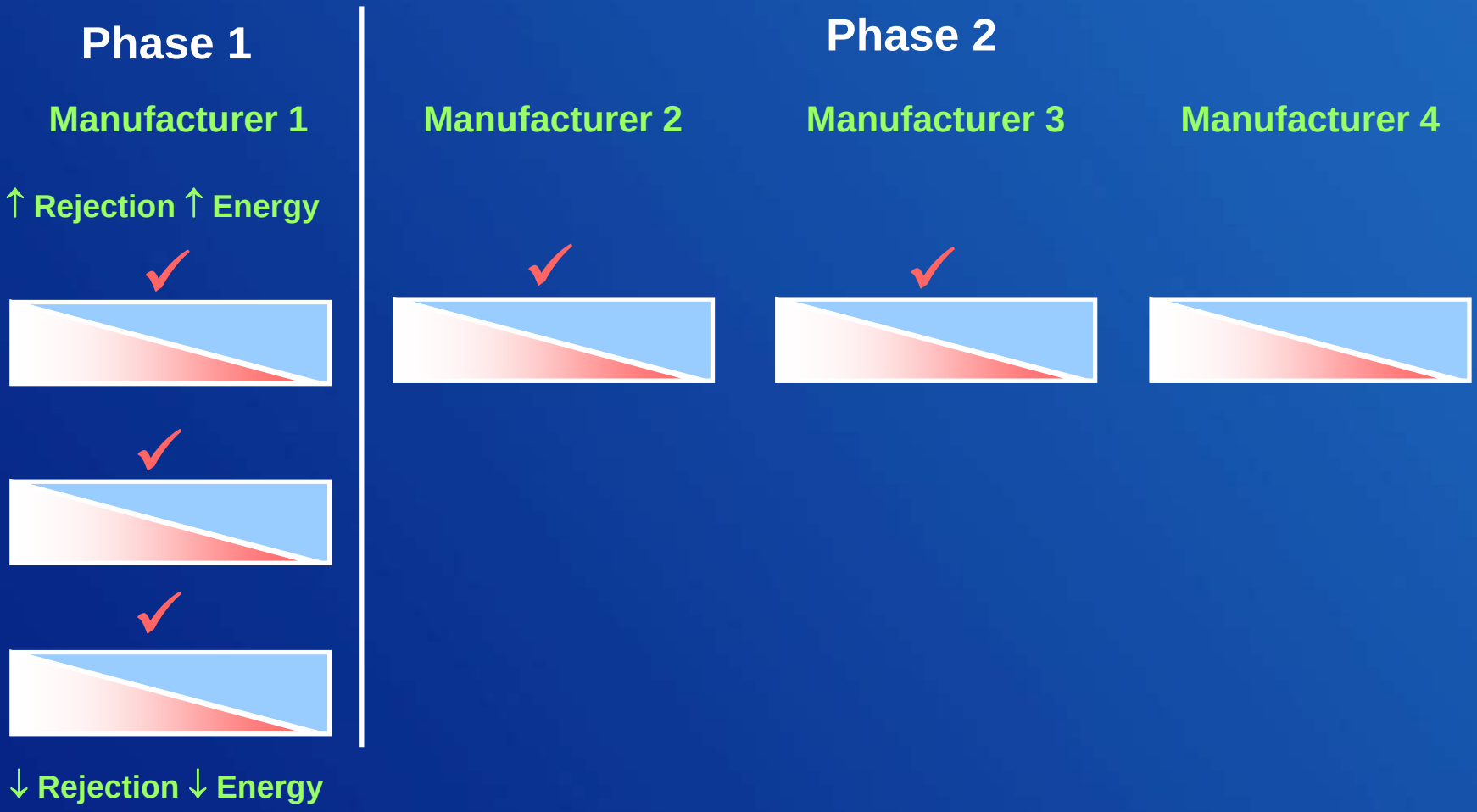
RO Performance Tests

Multiple Membrane Manufacturer Testing



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RO Performance Tests

Phase II Flux & Recovery Matrix

Flux (gfd) \ Recovery	42.5%	46%	50%
6.0			
7.5			
9.0			
10.0			

→ **Longer Term Testing @ Optimum Cost Point (2 weeks)**

Phase 1: Recovery was 35%, 42.5%, 50%

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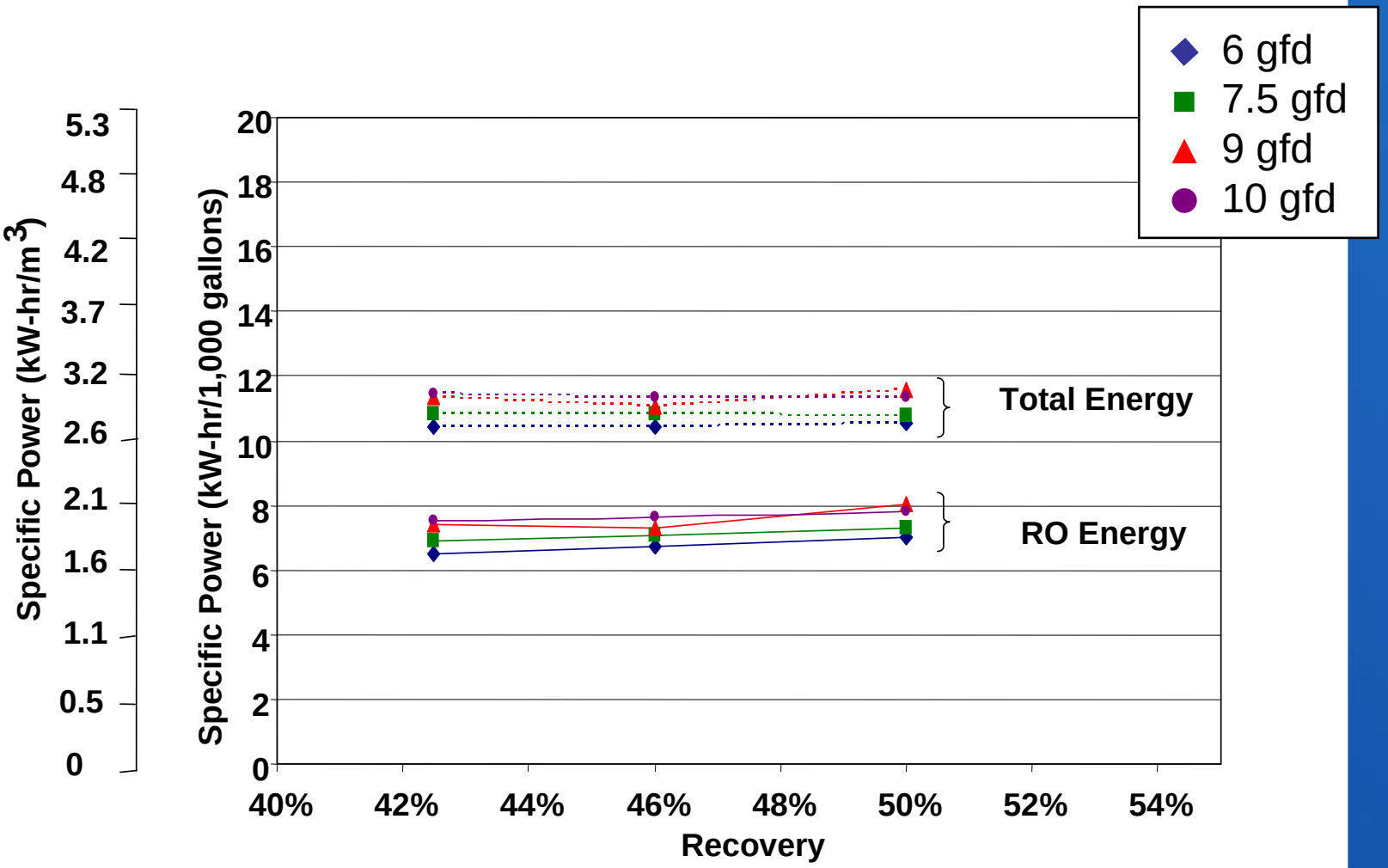
Specific Power Consumption

Manufacturer 2



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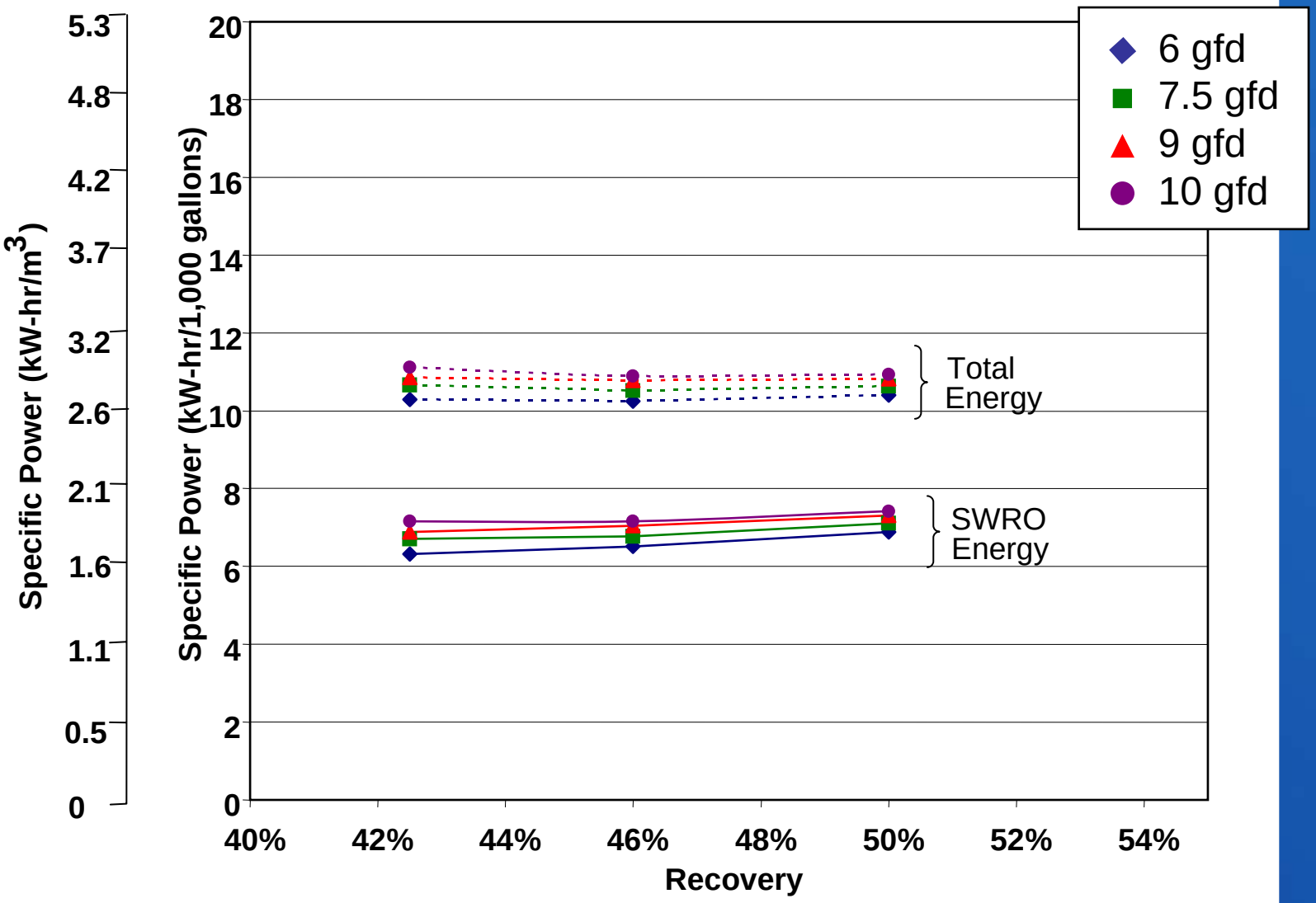
Specific Power Consumption

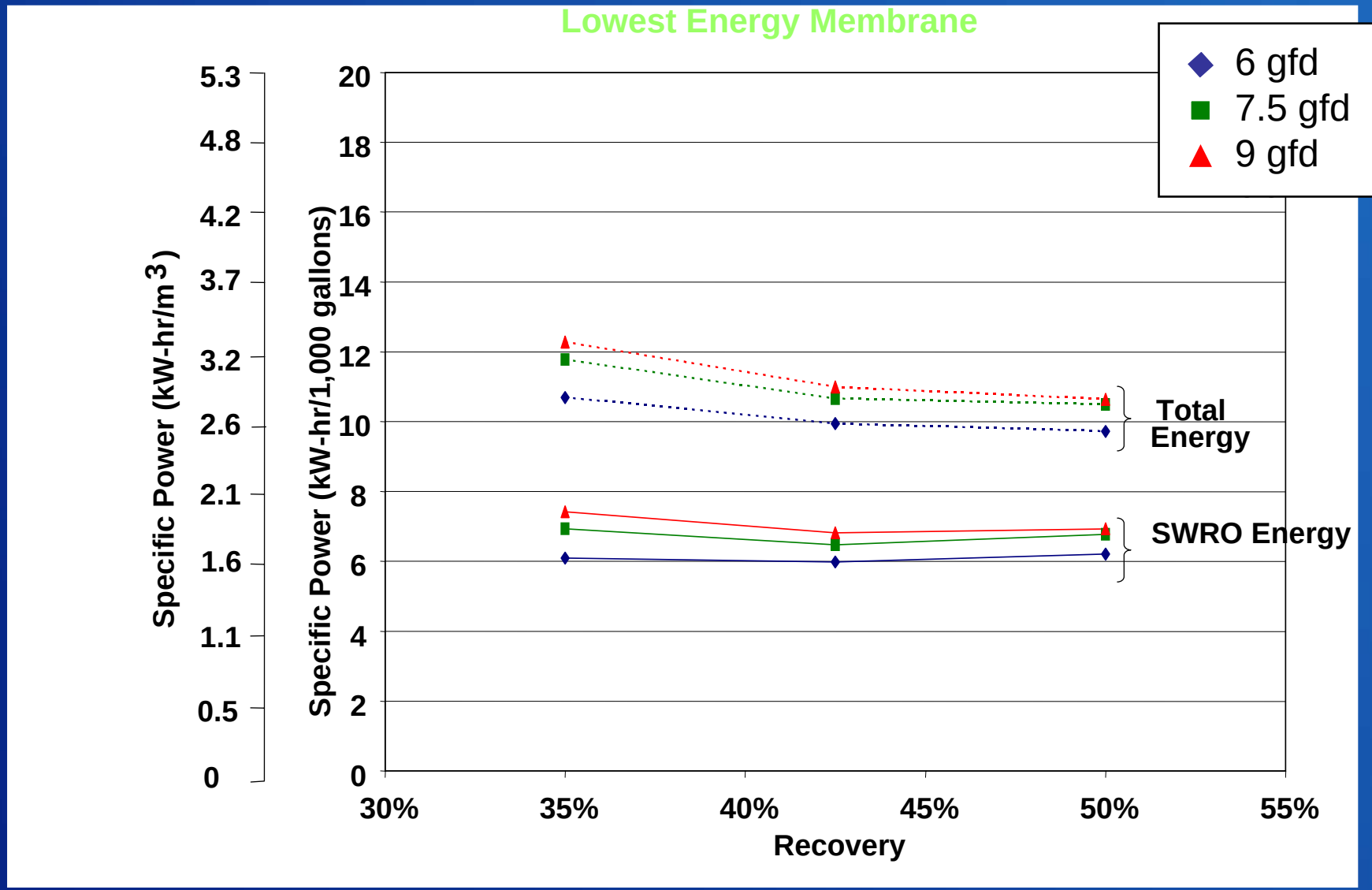
Manufacturer 3



RECLAMATION

Specific Power Consumption

Manufacturer 3



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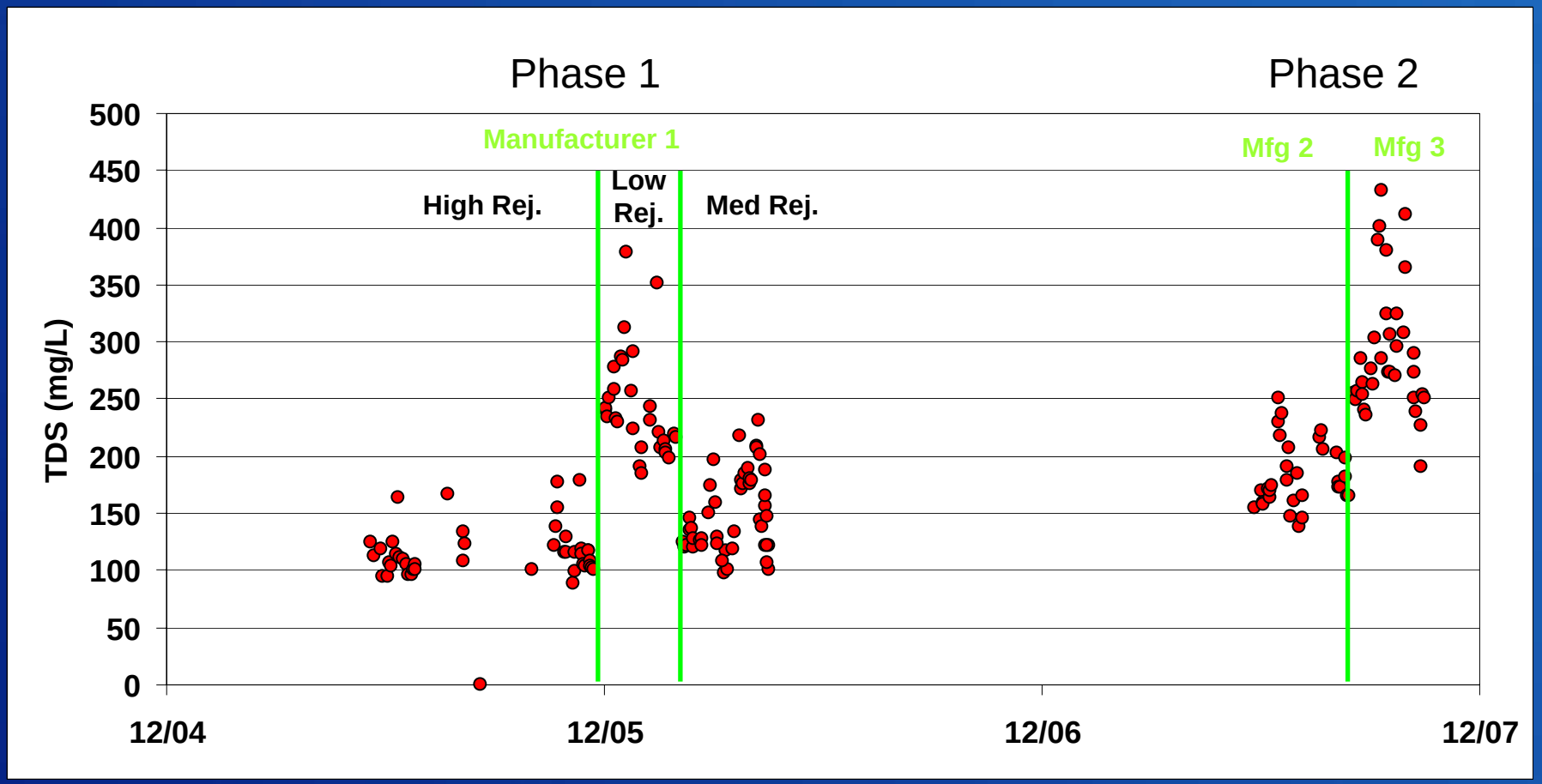
Permeate TDS

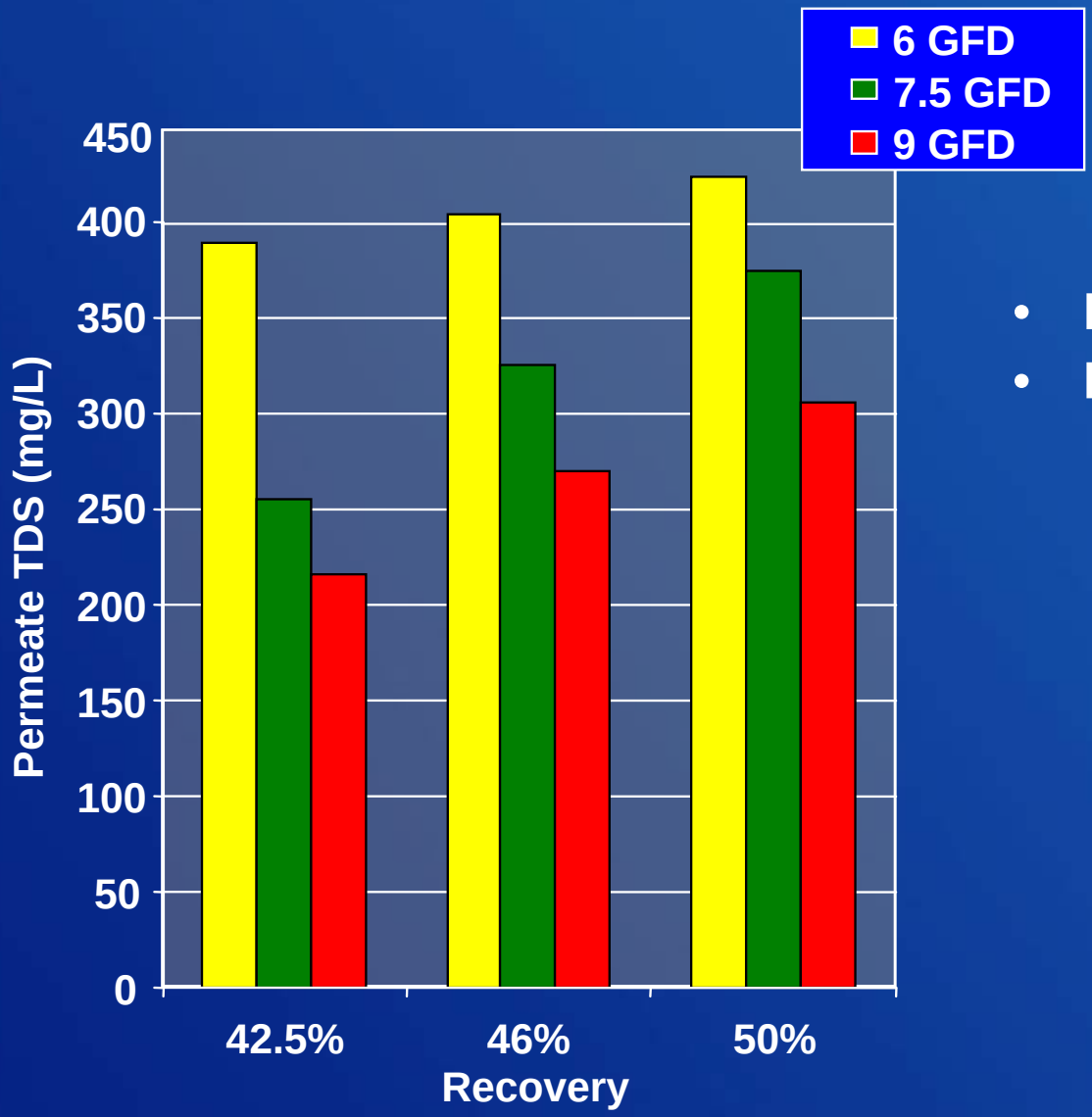


Includes membrane ripening data

RECLAMATION

Permeate TDS

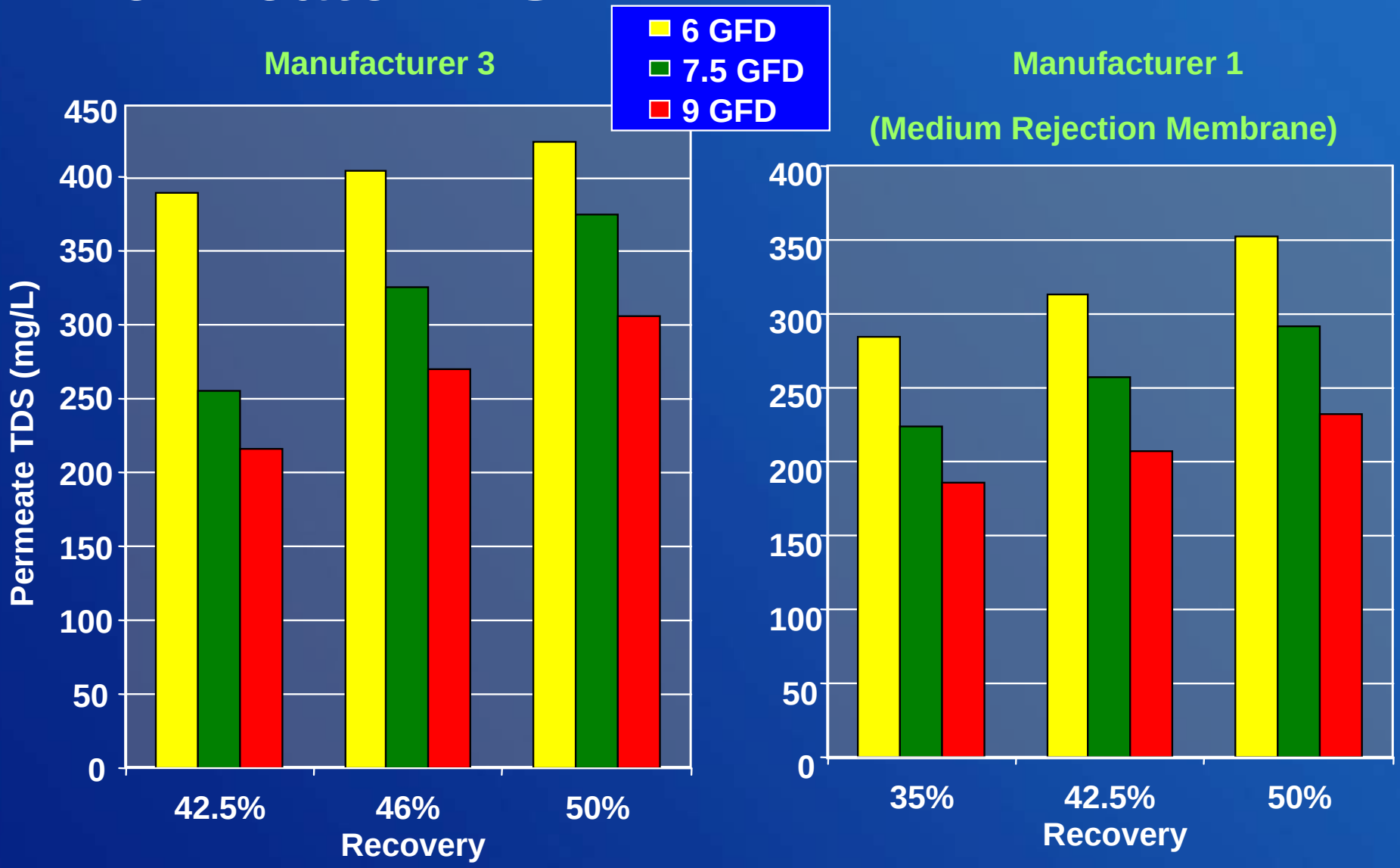
Manufacturer 3



- Flux ↑ = TDS ↓
- Recovery ↑ = TDS ↑

RECLAMATION

Permeate TDS



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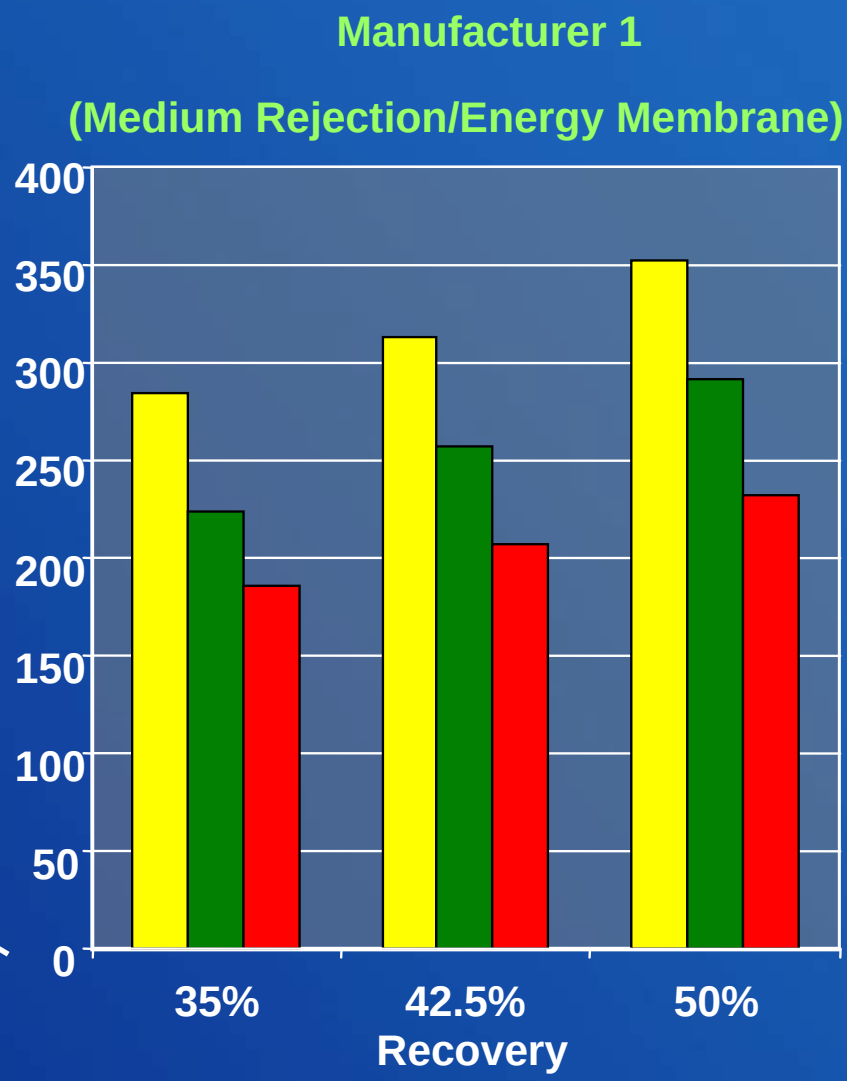
Permeate TDS

- **Low energy membrane produced highest TDS**

↑ Rejection ↑ Energy

- 80 to 175 mg/L
- 95 to 295 mg/L
- 190 to 350 mg/L

↓ Rejection ↓ Energy



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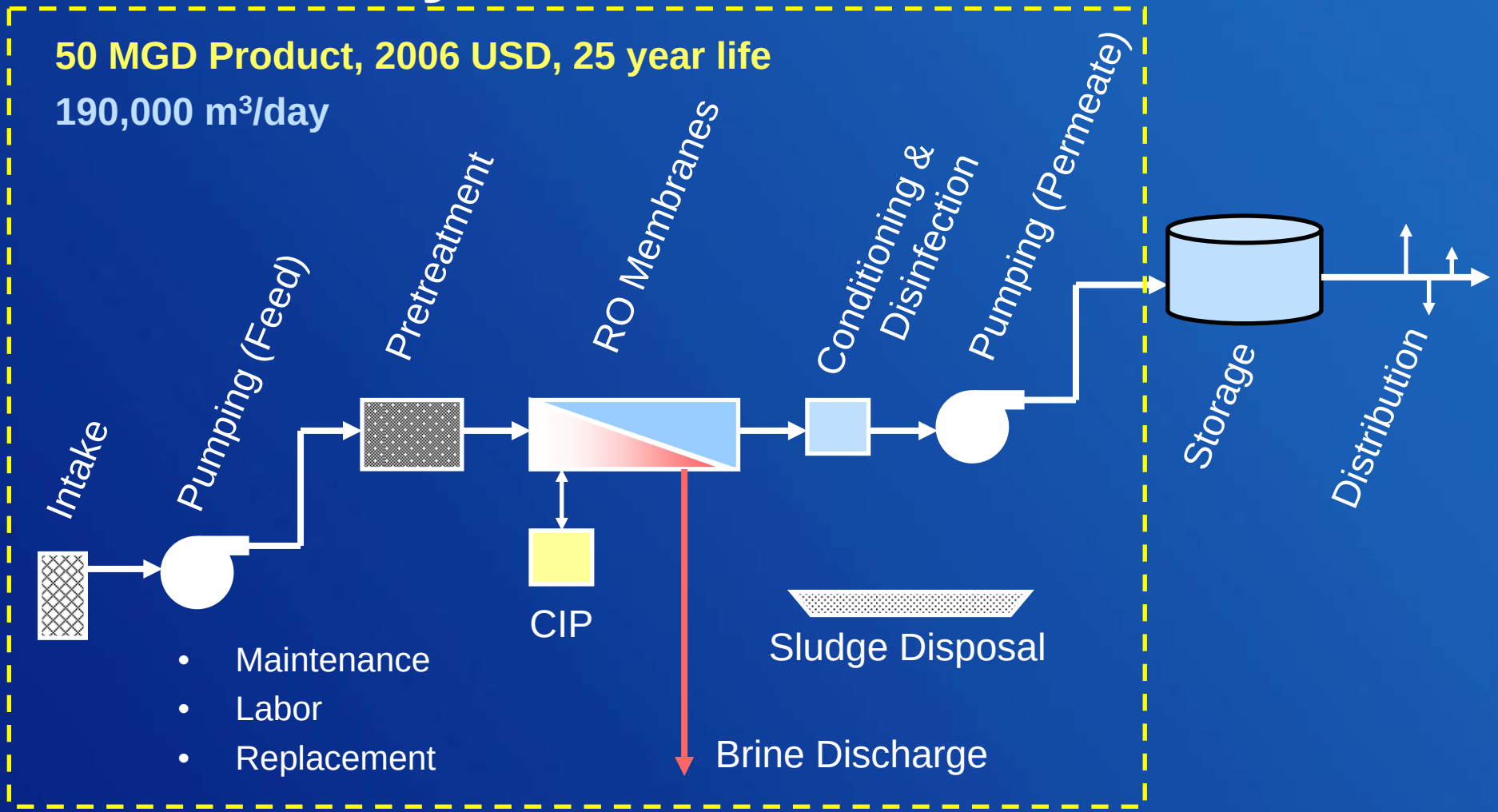
Cost Analysis



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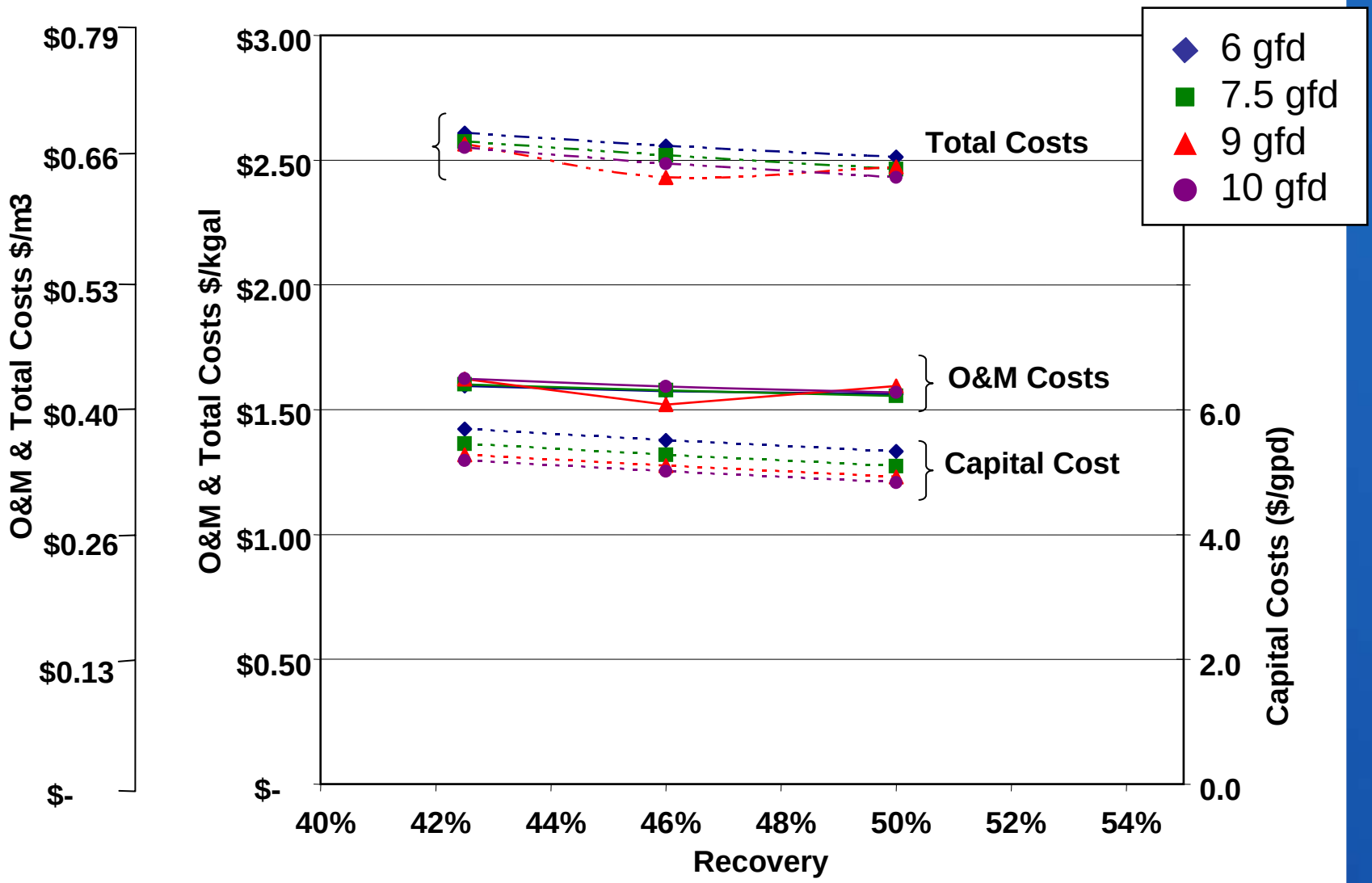
50 MGD Cost Model Results

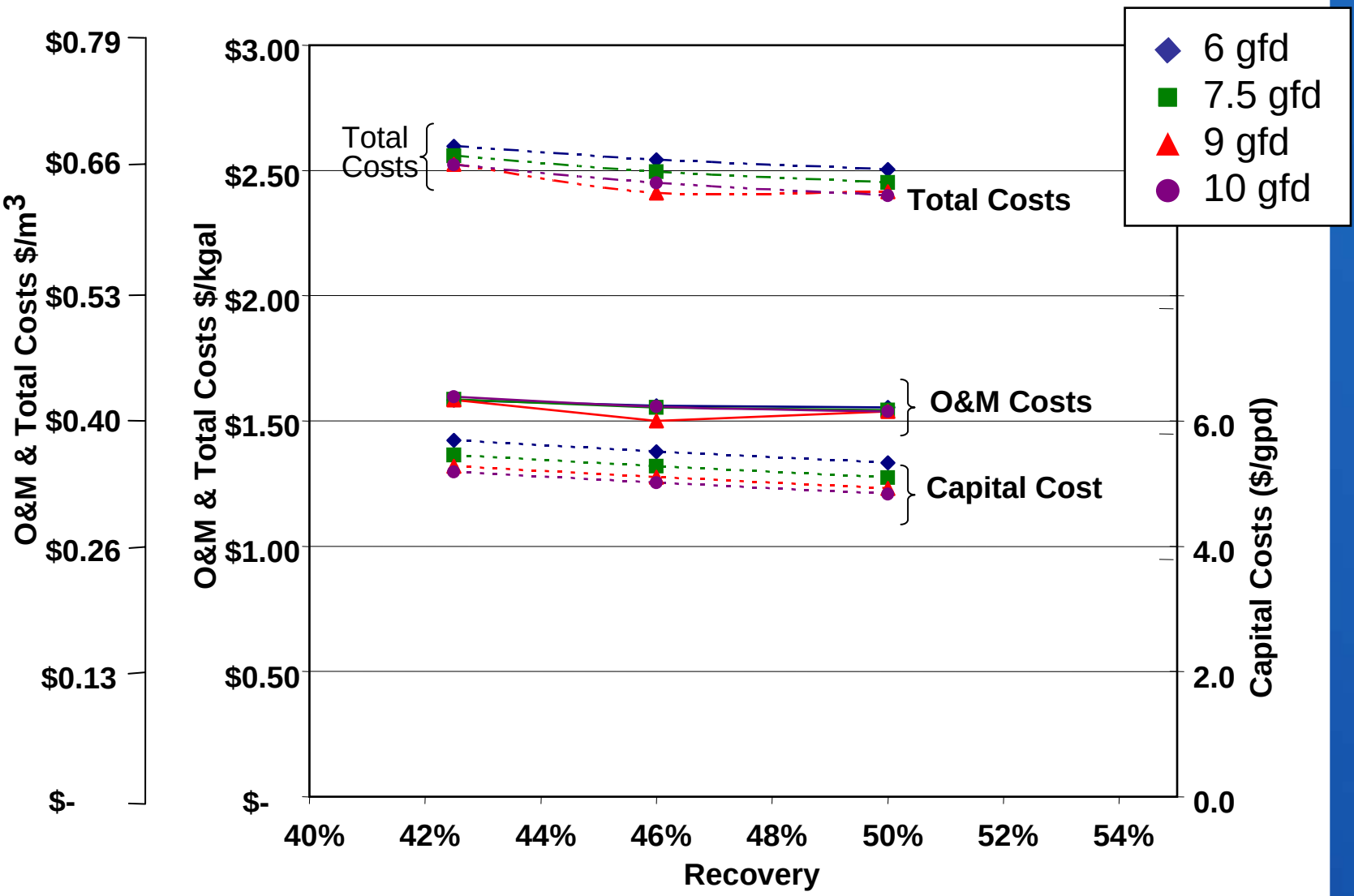
Manufacturer 2



RECLAMATION

50 MGD Cost Model Results

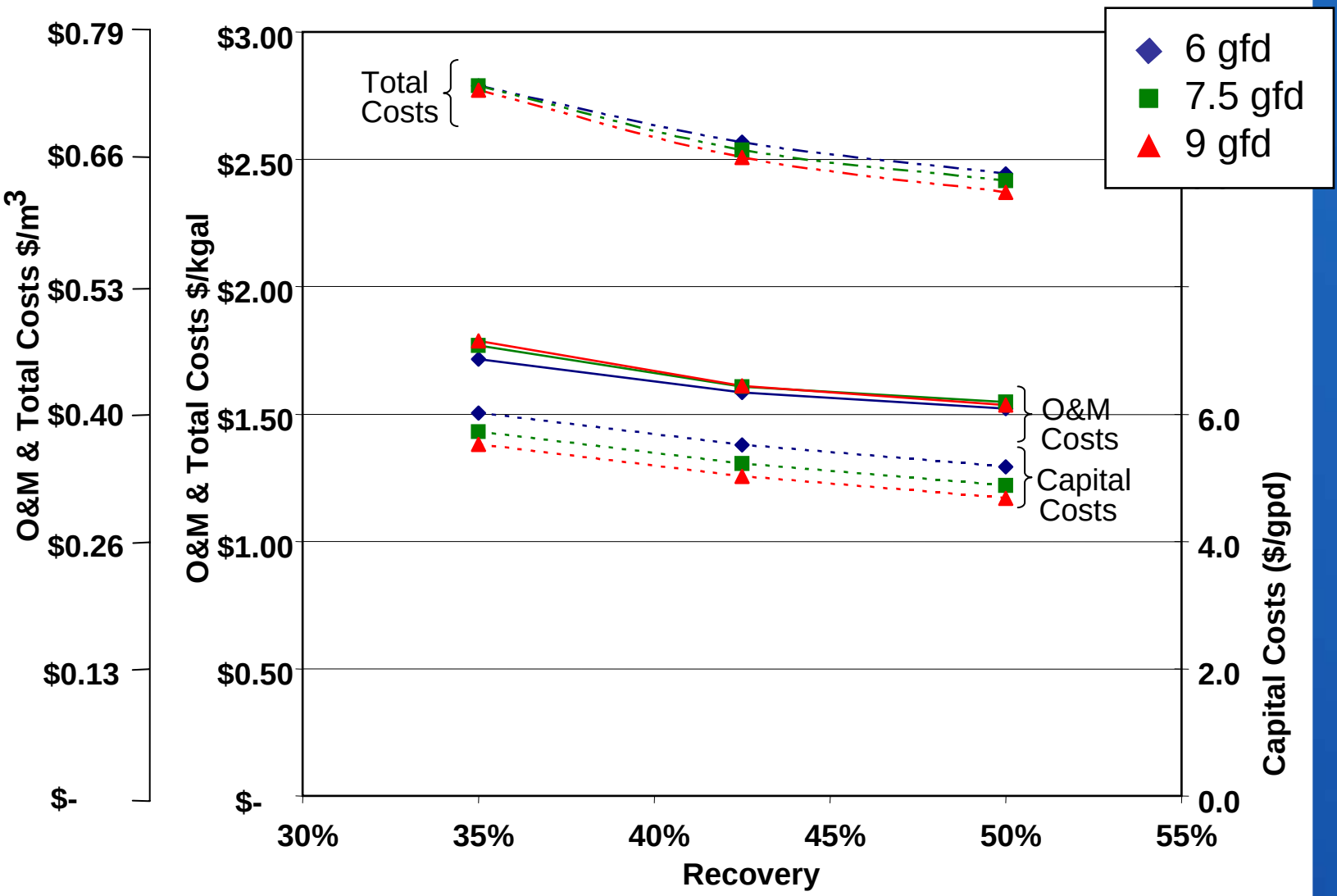
Manufacturer 3



RECLAMATION

50 MGD Cost Model Results

Manufacturer 1



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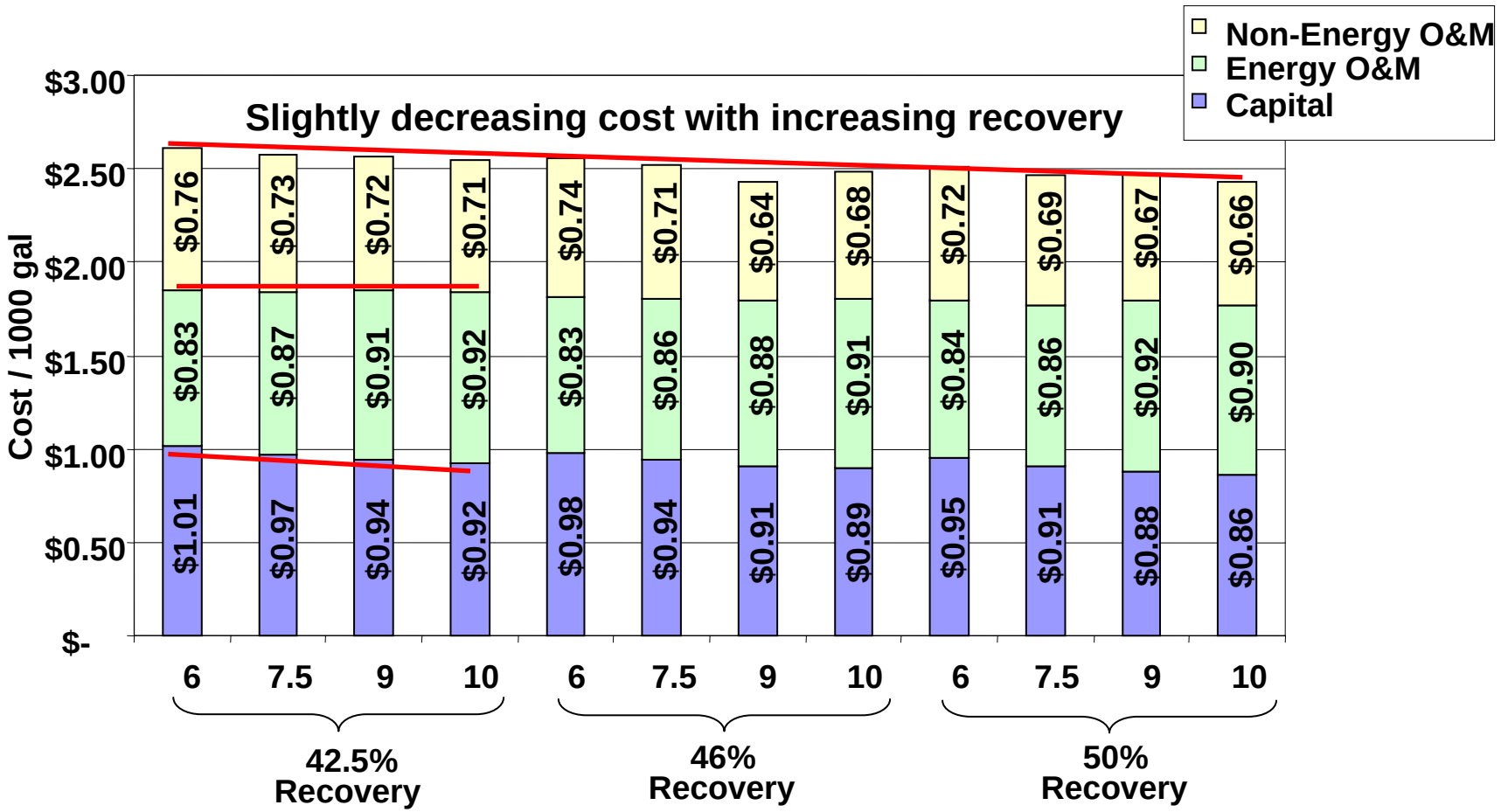
50 MGD Cost Model Results



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Major Accomplishments

5.98 kW-hr/kgal (1.58 kW-hr/m^3)

demonstrated at: 6 GFD, 42.5% Recovery

6.81 to 8.90 kW-hr/kgal (1.80 to 2.00 kW-hr/m^3)

at most affordable operating points - 50% recovery

Outline

- Background
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Next Steps

UF Membrane Pretreatment

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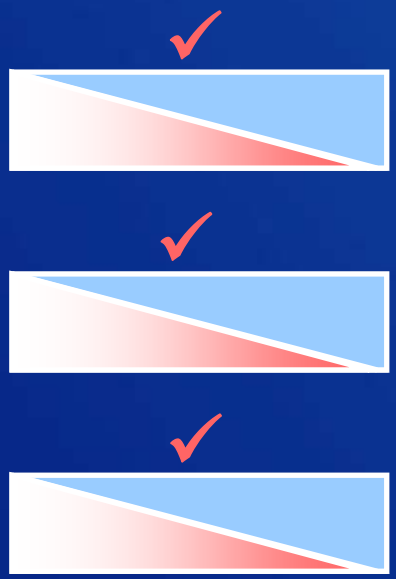
Next Steps

Completion of Multiple Membrane Manufacturer Testing

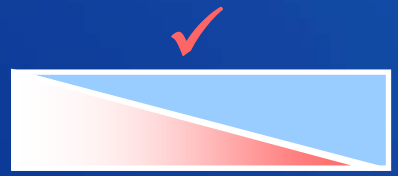
Phase 1

Manufacturer 1

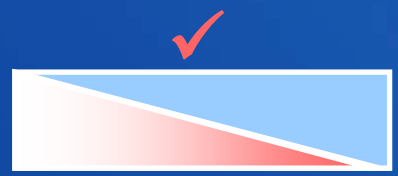


Phase 2

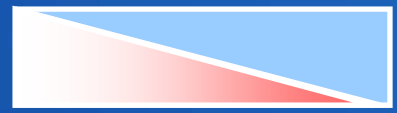
Manufacturer 2



Manufacturer 3



Manufacturer 4



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Next Steps

Internally Staged Membranes

Same flux, same recovery

- Lower feed pressure (lower operating costs)
- Lower fouling potential (lower operating costs)

Higher flux, same recovery

- Smaller array (lower capital costs)

Same flux, high recovery

- Smaller pretreatment (lower capital costs)
- Less feed water (lower operating costs)

Next Steps

Internally Staged Membranes

Standard SWRO Element Loading

7500	7500	7500	7500	7500	7500	7500

Internally Staged Options

6000	7500	11,000	11,000	11,000	11,000	11,000
6000	7500	7500	11,000	11,000	11,000	11,000
6000	6000	7500	7500	11,000	11,000	11,000
6000	6000	6000	11,000	11,000	11,000	11,000

Values above are Permeate Flow (gpd)

22.7	28.4	41.6

(m^3/day)

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Next Steps

Internally Staged Membranes

Design Chosen

6000	6000	6000	11,000	11,000	11,000	11,000

Chosen to Optimize:
- **Boron Rejection**
- **TDS Removal**
- **Energy**

In the cold Pacific temperatures

Element Characteristics

6000
22.7

Flow: 6000 gpd (22.7 m^3/day)
Salt Rejection: 99.8%
Membrane Area: 400 ft^2 (11.3 m^2)

11,000
41.6

Flow: 11,000 gpd (41.6 m^3/day)
Salt Rejection: 99.7%
Membrane Area: 400 ft^2 (11.3 m^2)

(Test conditions: 32,000 mg/l NaCl, 800 psi (5.5 MPa), 25°C, pH 8, 8% recovery)

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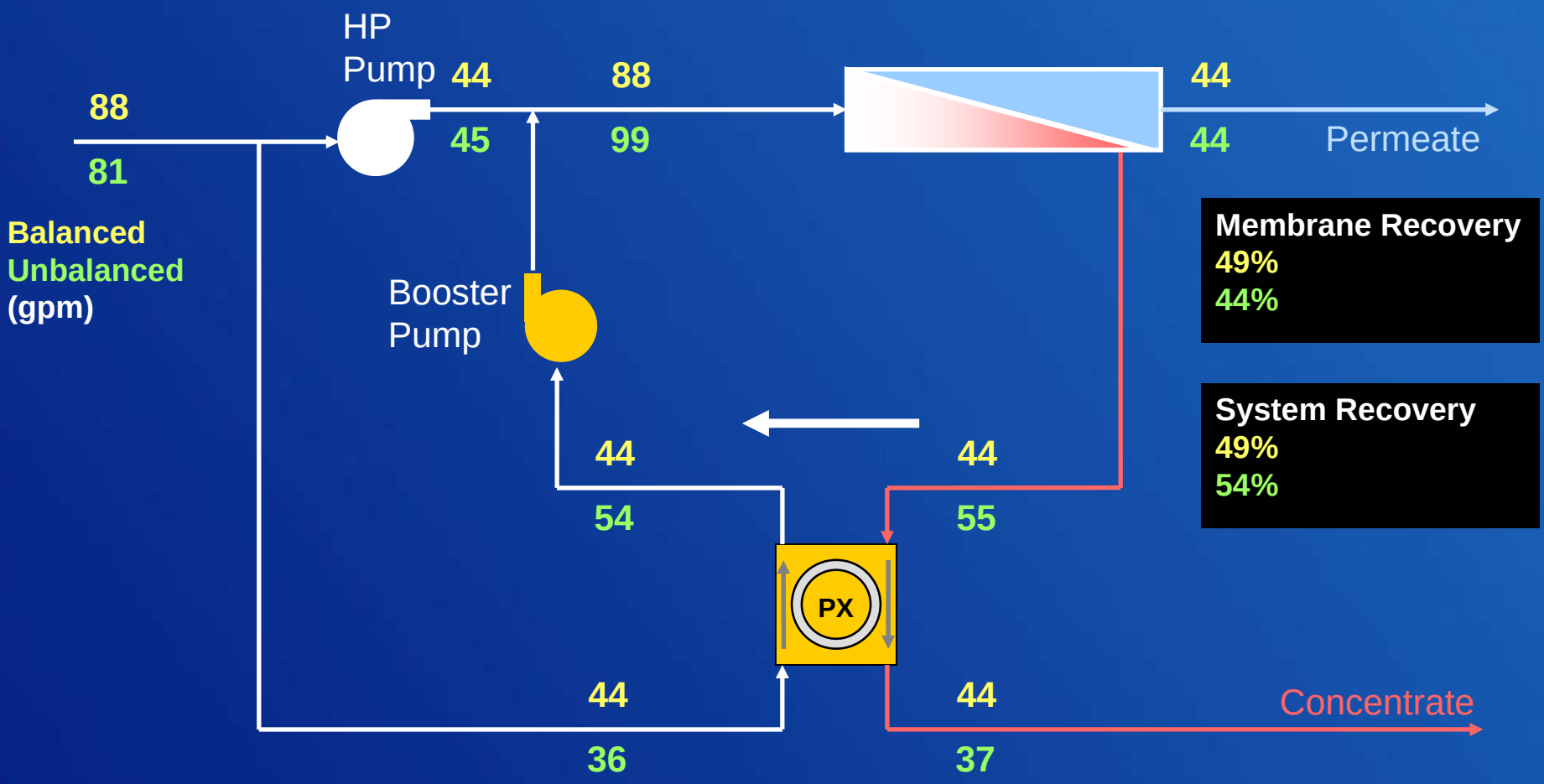
Next Steps

Innovative Flow Regimes

Unbalanced Flow around PX



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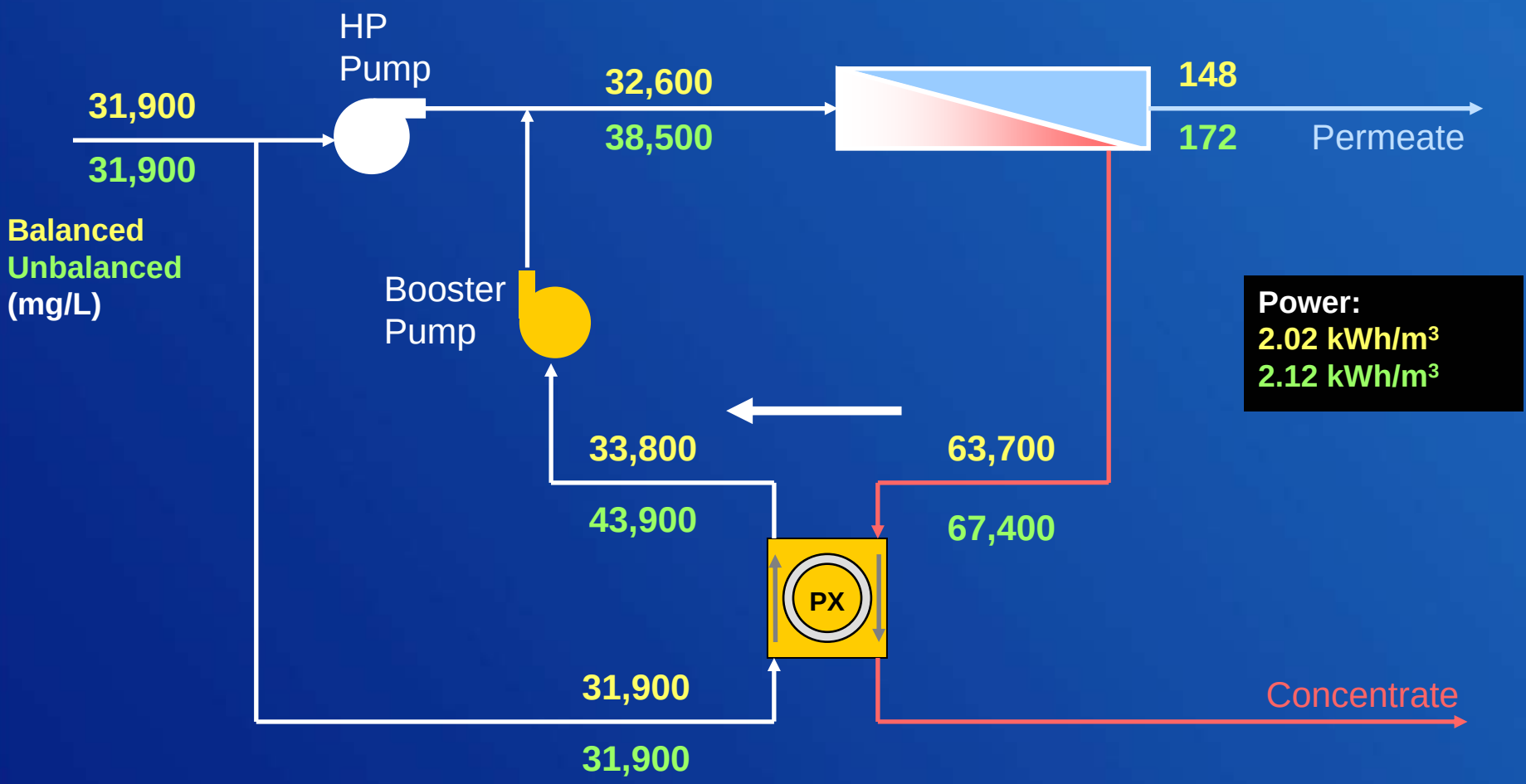
Next Steps

Innovative Flow Regimes

Unbalanced Flow around PX



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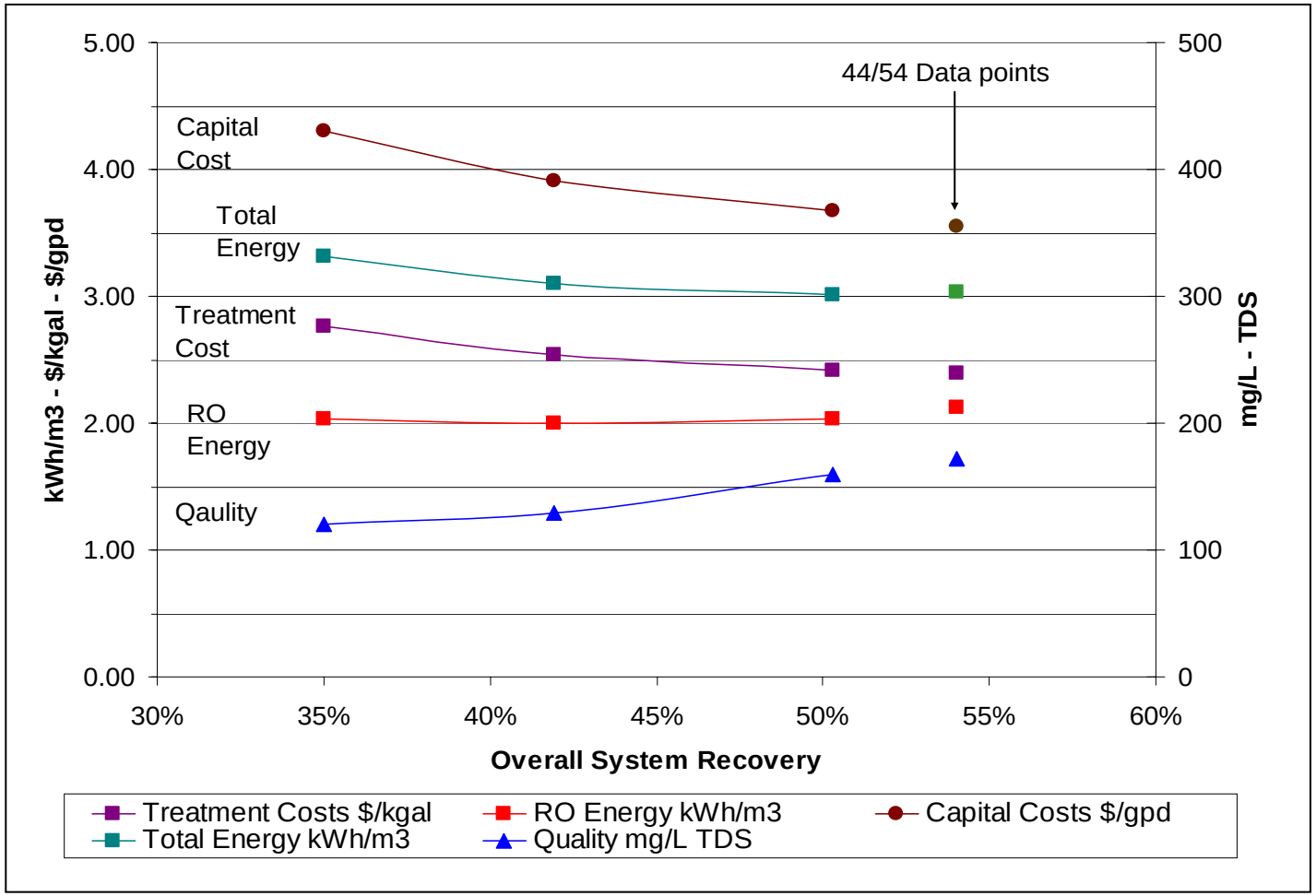
Next Steps

Innovative Flow Regimes

Unbalanced Flow around PX



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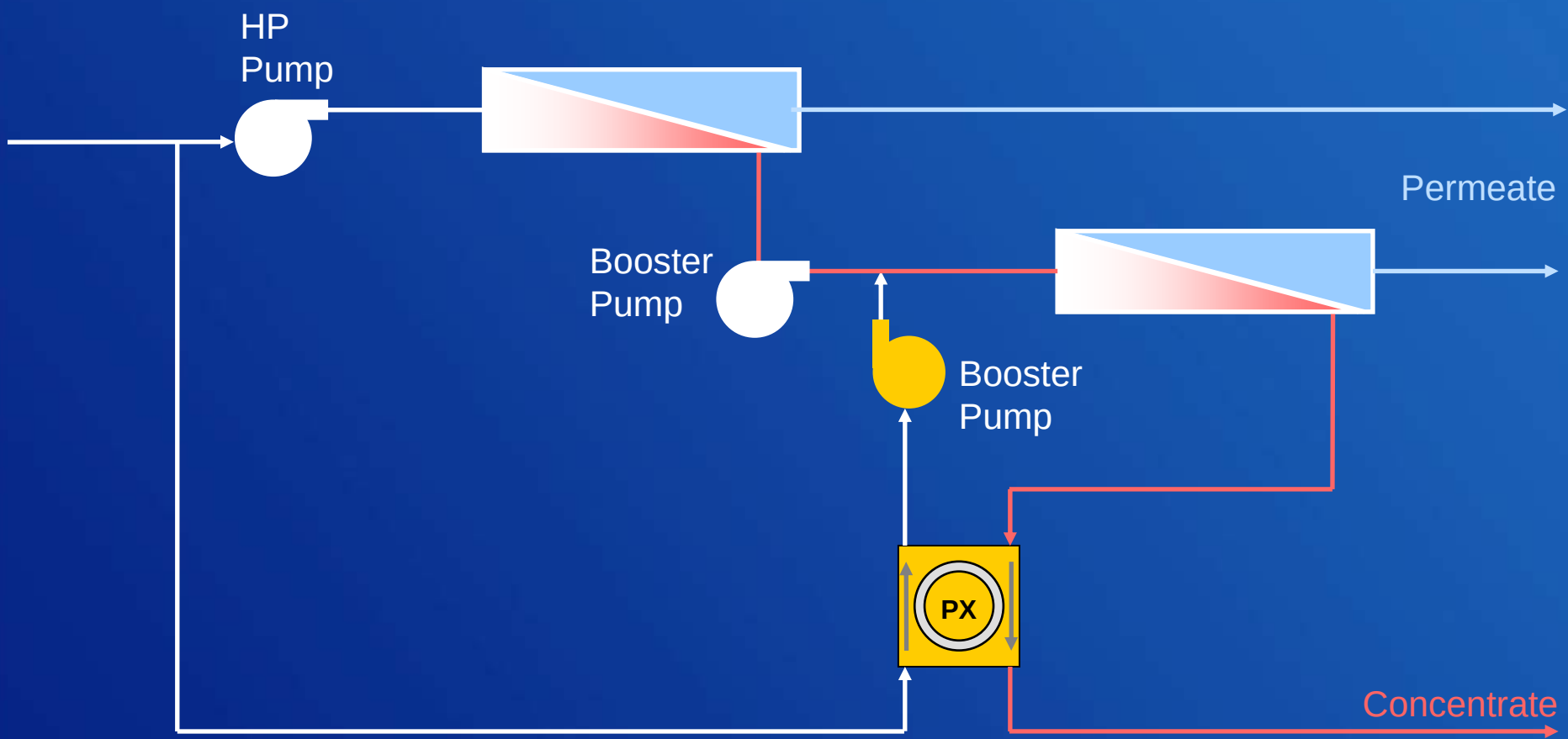
Next Steps

Innovative Flow Regimes

Interstage Booster Pump



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Gracias

Affordable Desalination Collaboration – Phase II Progress

www.AffordableDesal.com

Steve Dundorf

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RECLAMATION

IDA World Congress on Desalination and Water Reuse

Maspalomas, Gran Canaria, Spain

Presented @ 2007 IDA Conference - Spain

Thursday - 10/25/07
Session 06 9:00 AM – 12:30
Presentation Length: 30 minutes (6th presentation)