

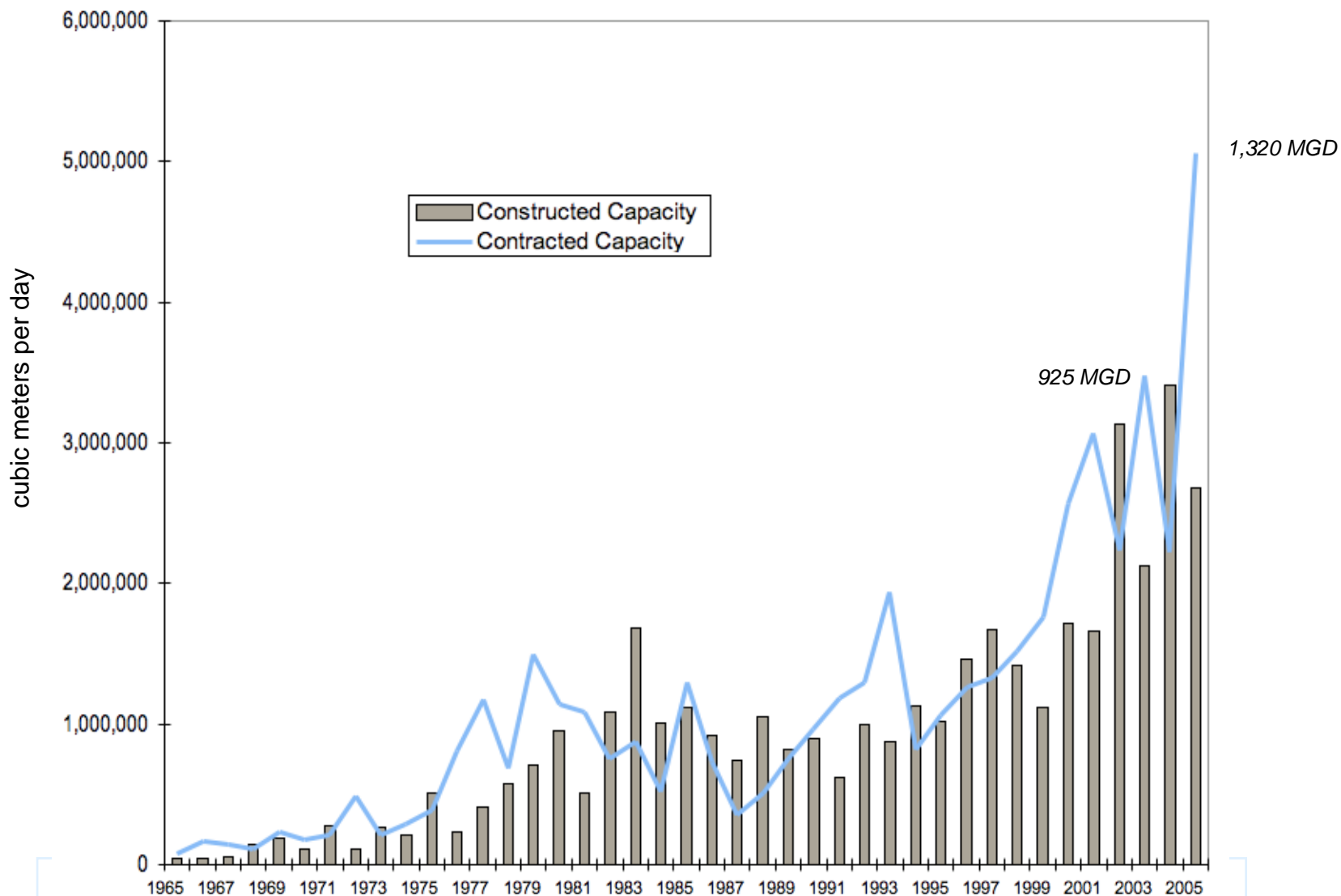


# Global Trends and Challenges in Seawater Desalination

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*6th Multi-State Salinity Coalition  
2008 Salinity Summit — January 2008*

# Global Contracted vs Constructed Desal Capacity



# Desalination Itemized Forecast CapEx

Project Type	2006 - 2010	2011 - 2015
Seawater RO	9.92	15.48
Seawater MED	3.03	4.04
Seawater MSF	8.39	7.07
Small thermal	2.06	2.33
Brackish RO	1.43	2.18
Ultrapure RO	0.21	0.30
<b>Total, \$billion</b>	<b>25.04</b>	<b>31.40</b>

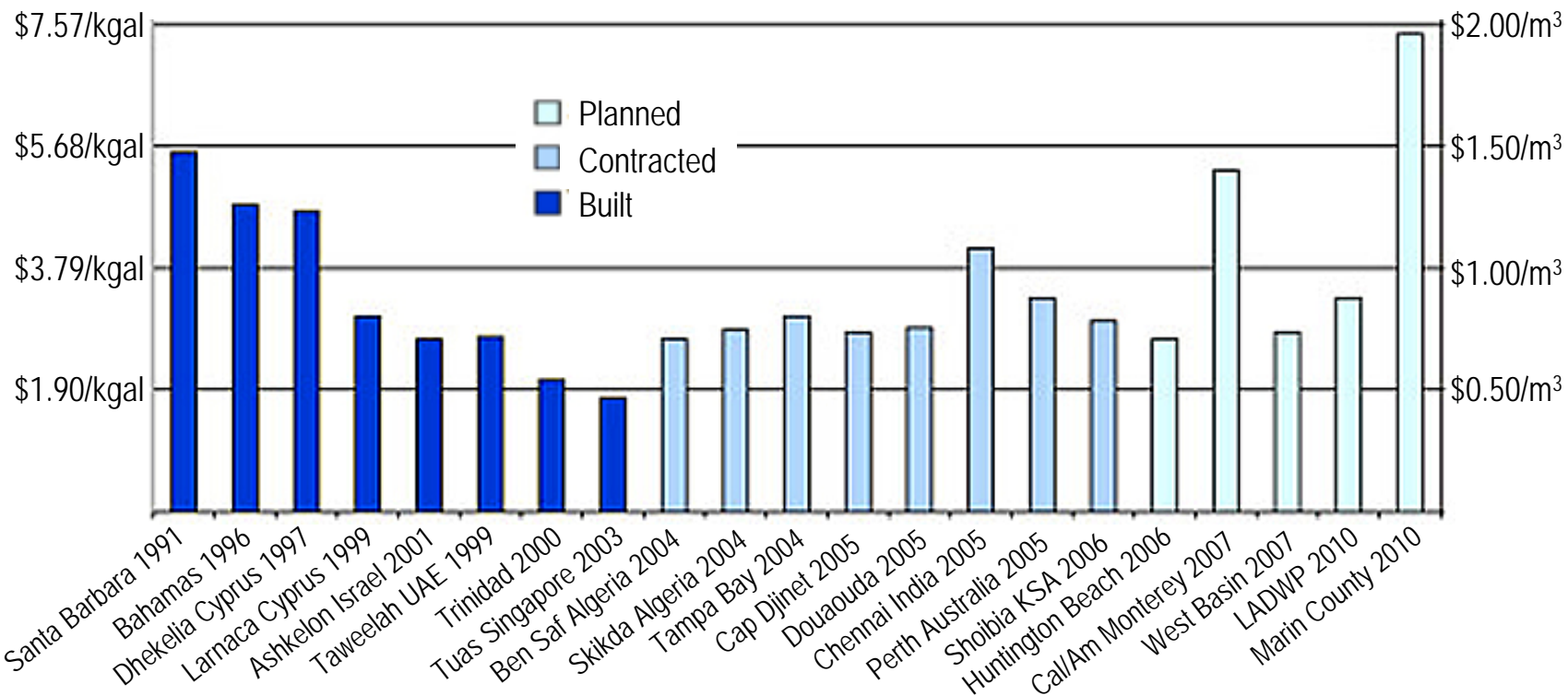
# Global Seawater Desalination Initiatives

- Australia +235 MGD
- Spain +265 MGD
- Libya +265 MGD
- Iran +360 MGD
- China +265 MGD
- US +132 MGD
- Saudi Arabia +1,500 MGD

# What's Changed?

- **Cost Reductions**
  - Limited supply options
  - Process innovations
  - RO Membrane advances
  - Better pretreatment options
  - Energy cost reductions
  - Environmental mitigation
  - Alternate project delivery
  - Success

# Seawater Desalination Water Cost



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# Limited Fresh Water Supply Options

- **Greater storage capacity**
  - *dams expensive, slow, eco-unpopular*
- **Improved conservation**
  - *limited best-case results*
- **Increase reuse**
  - *distribution expensive, often already used*
- **Develop new source**
  - *local supply, drought-proof*

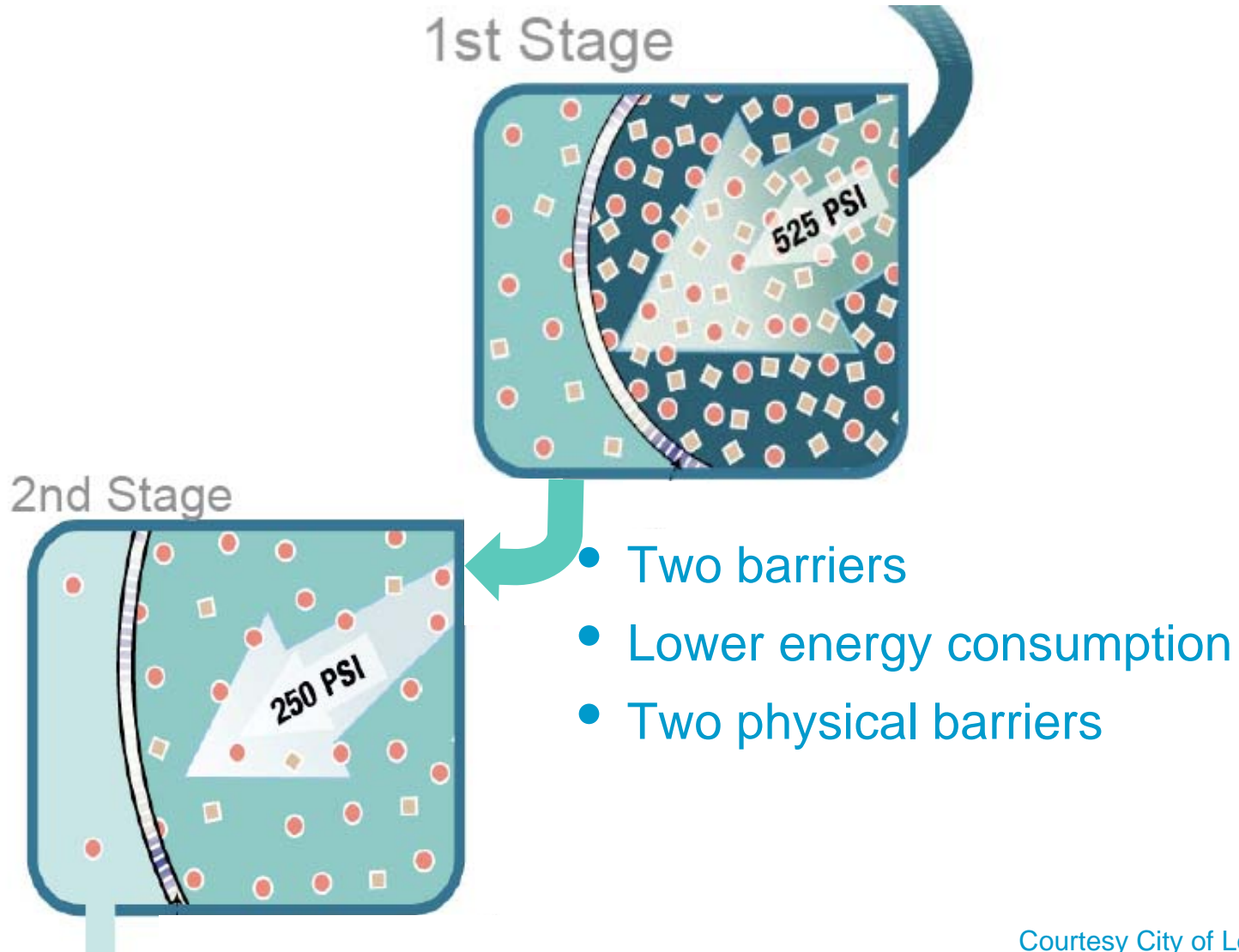
# Seawater Desalination Drivers

- **Coastal population growth**
  - *California, 87%; Australia, 85%*
- **Local supply**
  - *end reliance on imported water, pipeline disruptions*
  - *loss of water rights*
  - *diversify portfolio*
- **Rate stabilization**
  - *reduce future cost uncertainties*
- **Water quality**
  - *deteriorating quality of supplies*
  - *membranes provide improved treatment*

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# Two-stage Nanofiltration



# Tidal Influenced

- Withdraw brackish river water at low tide - 2 x 6hrs/day
- Discharge concentrate during high tides
- Swansea, MA
  - 1.4 MGD
  - HDR (Austin)
- Brockton, MA
  - 5 MGD
  - Inima



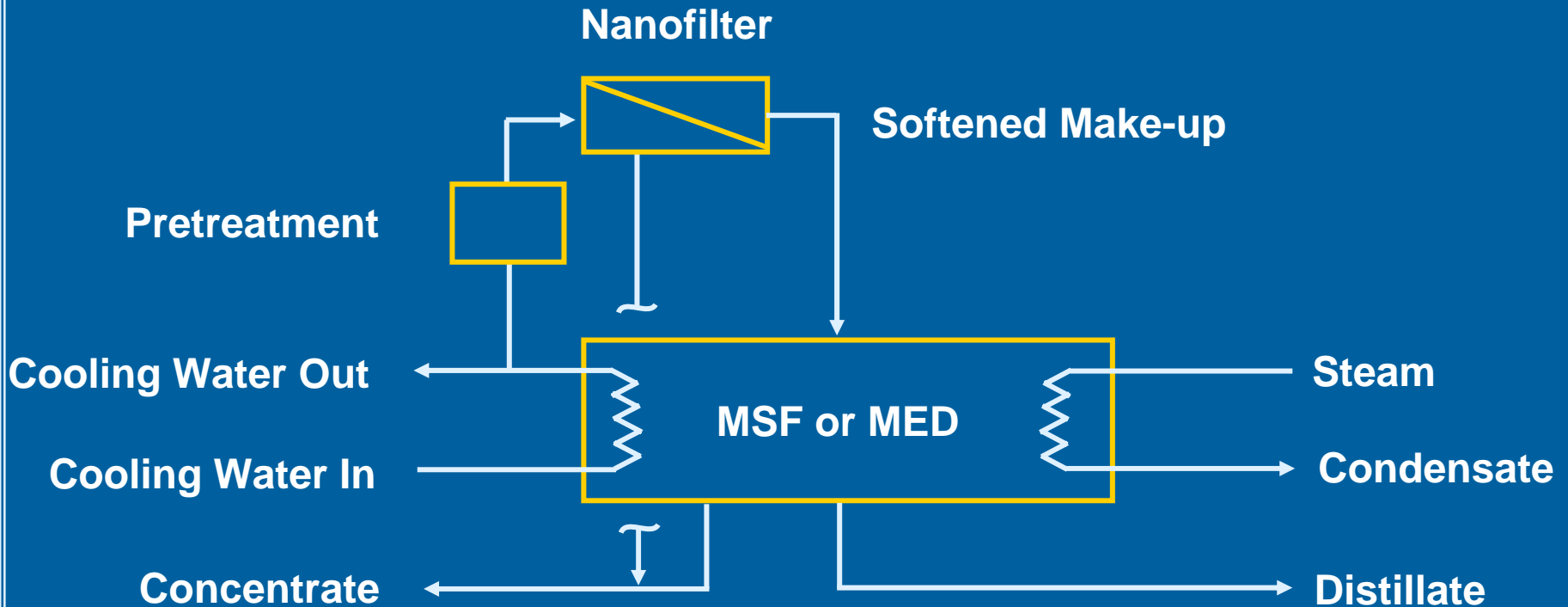
# RO Replaces Distillation

	2006	2010	2015
RO, MGD	6,300	10,400	16,800
MED, Mm <sup>3</sup> /d	1,000	2,000	3,200
MSF, Mm <sup>3</sup> /d	3,200	4,600	5,800
<i>Total, Mm<sup>3</sup>/d</i>	<i>10,500</i>	<i>17,000</i>	<i>25,800</i>

# Aruba: 75 years of Thermal Desalination...



# Hybrids: Thermal Distiller & Membrane Softening



# MED vs MSF

	<u>MSF</u>	<u>MED-TC</u>
Number Units	5	12
Unit Capacity	68,130 m <sup>3</sup> /d	28,930 m <sup>3</sup> /d
Total Steam	1860 T/h	1860 T/h
Steam Pressure	1.5 bar g	5 bar g
Absorbed Power	42 MW	17 MW
Land Area	127m x 385m	110m x 250m
Est Turnkey Cost	\$375 million	\$265 million

# Reuse of Industrial Waste Heat

- “Heat of dilution” recovery
  - *Ravensthorpe Nickel, Australia*
- Methanol reforming
  - *Cape Horn Methanol, Chile*
  - *Ampco, Equitorial Guinea*
- Coke calcining
  - *Alba, Bahrain*
- Pterephthalic acid heat recovery
  - *Amoco-Mitsui, Indonesia*



# Integrated Water Management

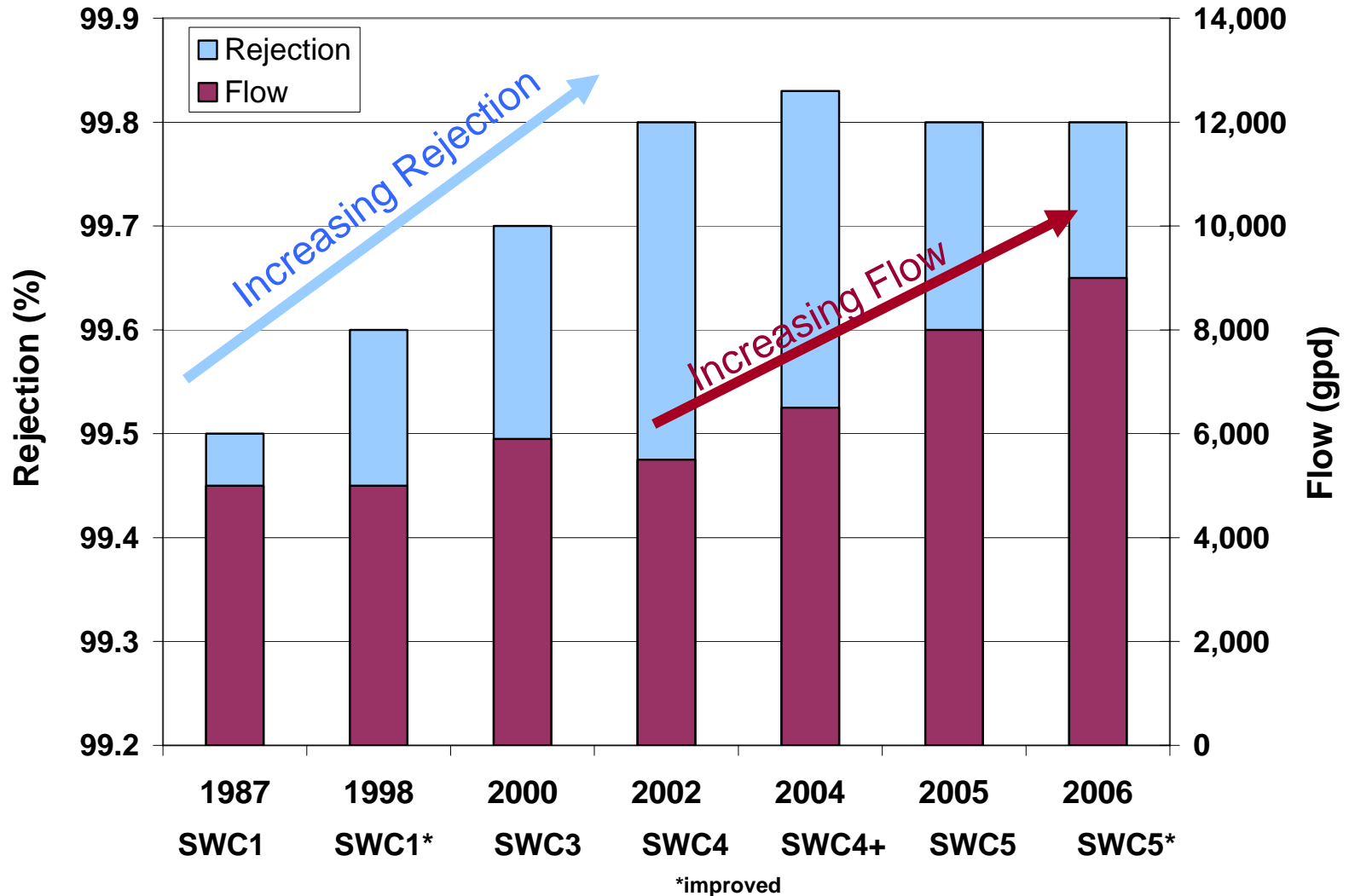


- 660,000 bpd
- 450 MW Captive Power
- 16.5 MGD Desal - 5 MEDs - \$5.90/kgal
  - 11.0 GOR, 0.5 bar steam, <5mg/L distillate
- 0.75 MGD HERO - \$2.23/kgal

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# Increased Salt Rejection & Capacity



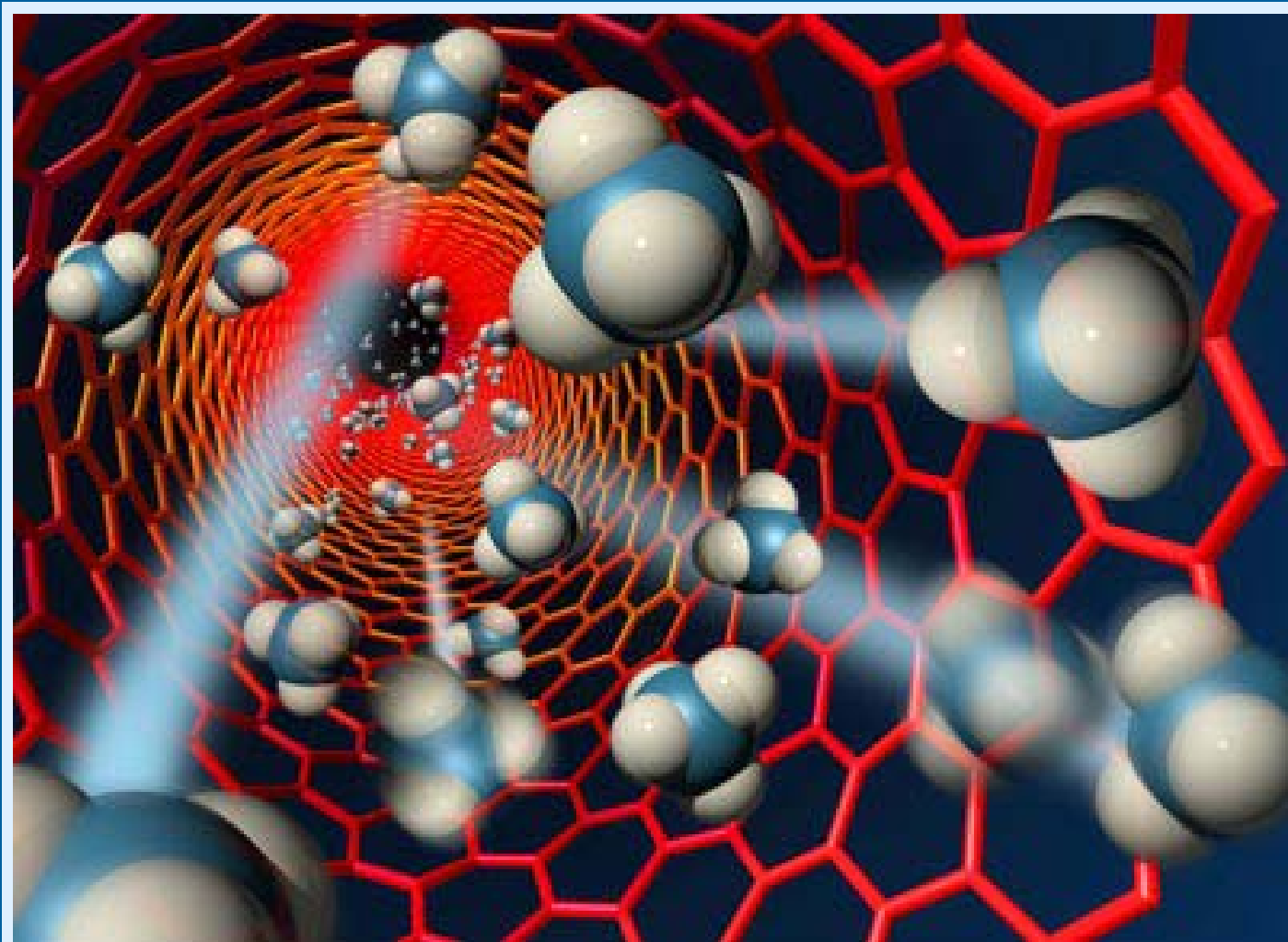
# Large Diameter Membranes

<i>1 MGD Example</i>	Std	Large Dia
Diameter	8 inch	16 - 18 inch
Number Elements	175	25
Footprint	230 sq ft	114 sq ft
Piping Connections	75	15



Courtesy Dow FILMTEC

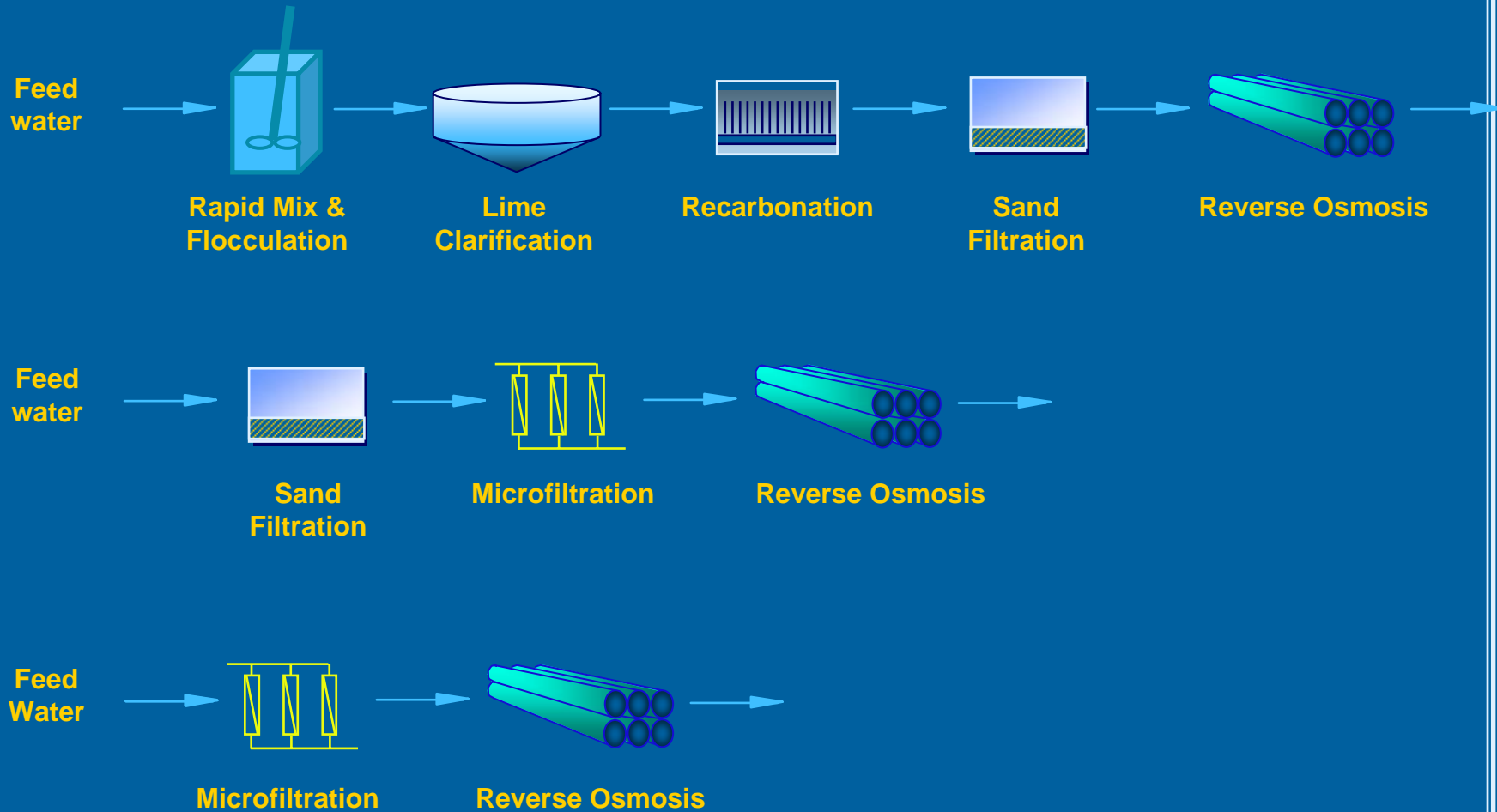
# Membrane Nanotechnology



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# RO Pretreatment Evolution



# MF/UF vs Conventional SWRO Pretreatment

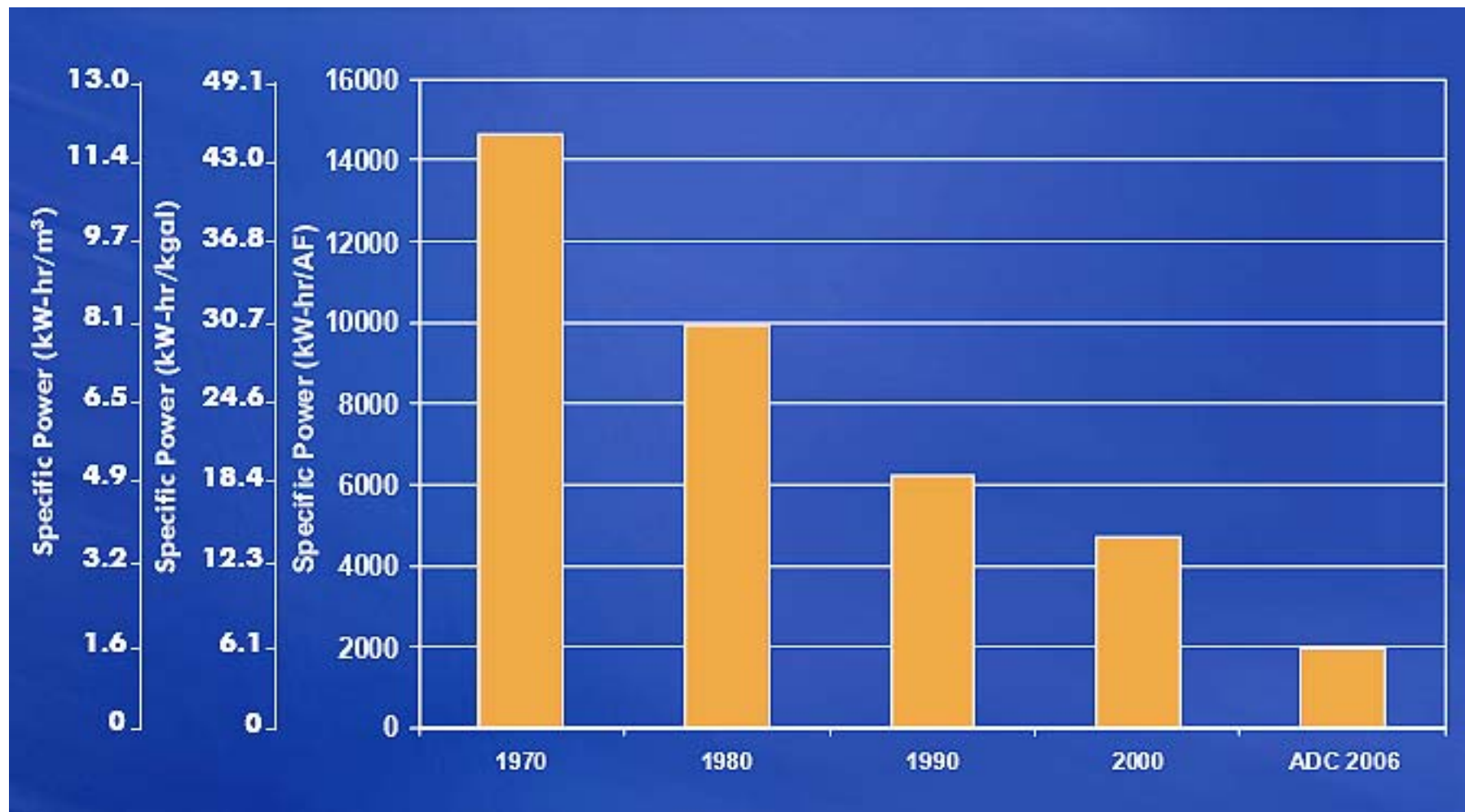
## *Marin County Municipal Water District Pilot Study Results*

- Better filtered water quality
- More consistent quality
- Less fouling of SWRO membranes
- Fewer process chemicals
- Less area
- Lower capital costs
- Lower O&M costs

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# Energy Recovery Improvements



Courtesy Affordable Desalination Collaboration

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- **Environmental mitigation**
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# Increased Environmental Consideration

As the number and size of desalination plant increases, so does the need to mitigate environmental impacts.



# Greenhouse Gas Mitigation

- **Lower energy consumption**
  - Low pressure membranes
  - Improved energy recovery devices
  - High efficiency pumps
- **Renewable energy sources**
  - Wind energy
  - Solar energy
- **Carbon credits**
- **Reforestation**

# Impingement & Entrainment Mitigation

- Vertical beach wells
- Infiltration galleries
- Horizontal directional drilling
- Passive screens
- Offshore velocity caps
- Stand-alone intakes
- Habitat restoration

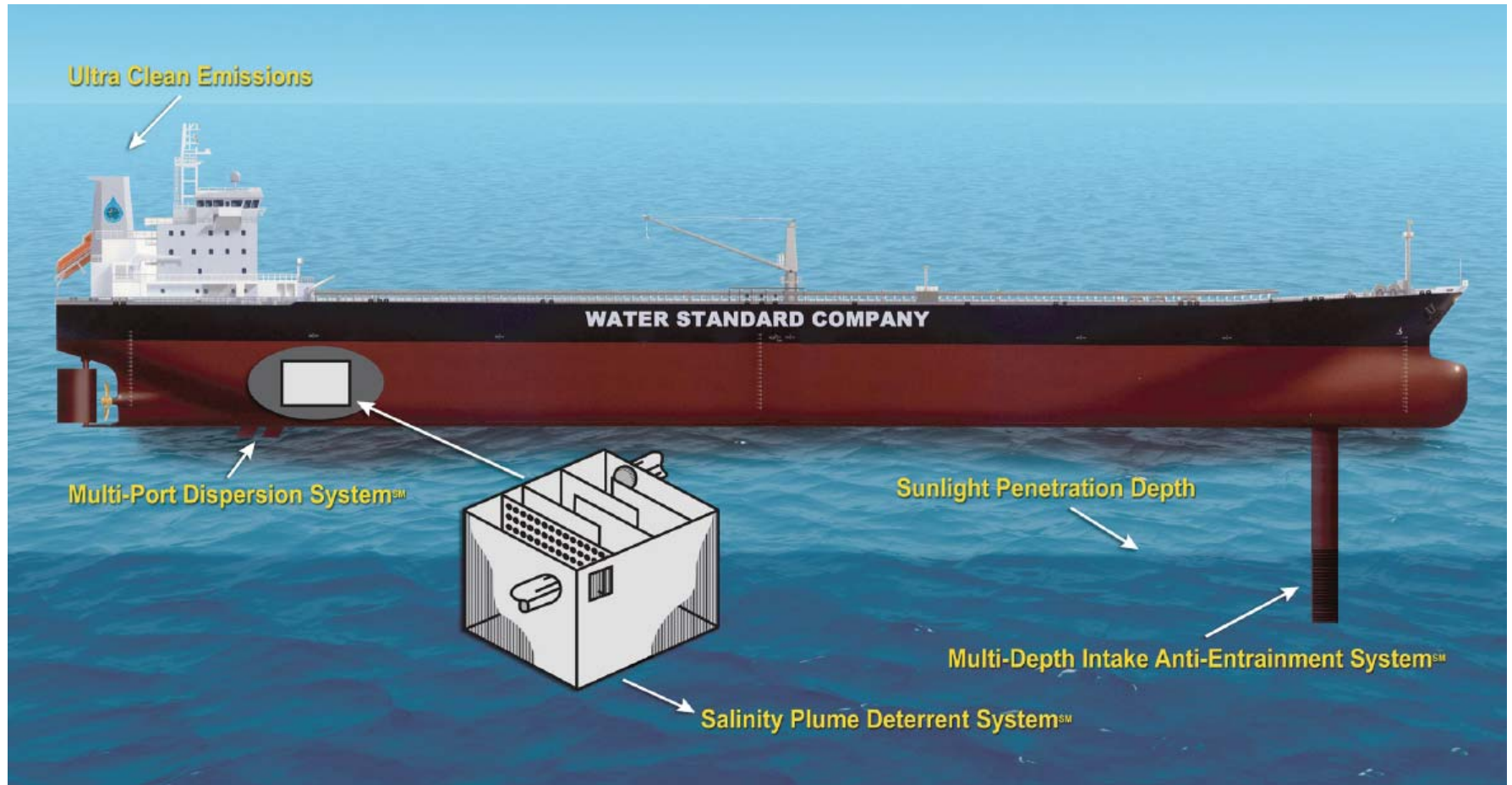
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- **Alternate project delivery**
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# Alternate Project Delivery

- Most projects employ a PPP
- PPP goals reflect desal project requirements
  - *private sector development, technical, cost risk*
  - *expedited schedule*
  - *access to new technology, private capital*
- Many local variations
  - *IWPP in Middle East*
  - *Alliance contract in Australia*
  - *BOO rather than BOT in Caribbean*
  - *public ownership & finance in USA*
  - *local government corporation in Texas*

# Seawater Conversion Vessel



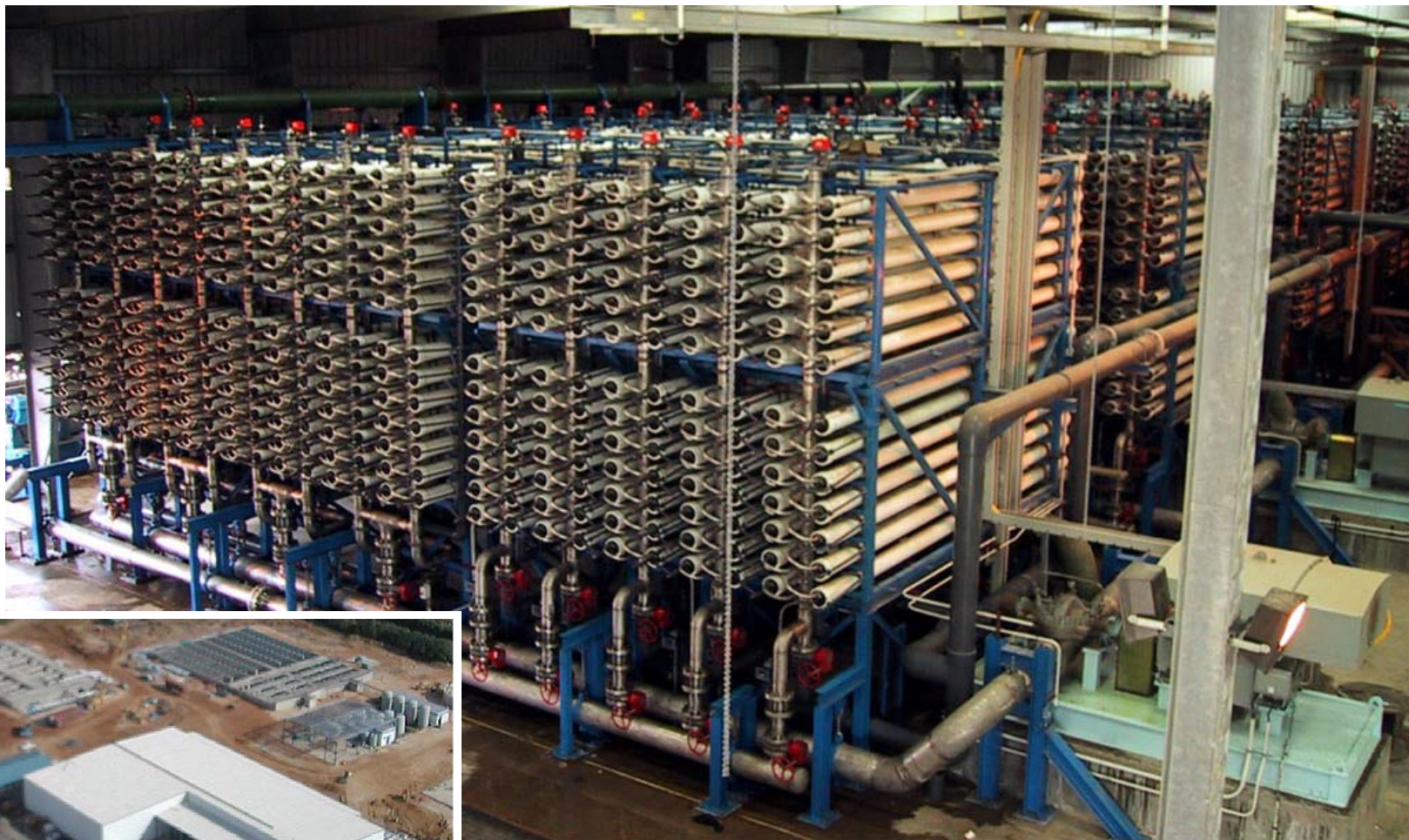
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# Larnaca, Cyprus: 14.3 MGD



# Trinidad: 30 MGD



# Ashkelon, Israel: 86 MGD



# Tampa Bay: 25 MGD



# Conclusion

Even as seawater desalination technologies mature, new innovations are being introduced. Although most changes are incremental, they continue to improve reliability, reduce cost, and mitigate environmental impacts.